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Informacijska družba

Zbornik 27. mednarodne multikonference

Information Society

Proceedings of the 27th International Multiconference

Slovenska konferenca o umetni inteligenci
Slovenian Conference on Artificial Intelligence

Kognitivna znanost
Cognitive Science

Odkrivanje znanja in podatkovna skladišča - SiKDD
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Myths and Truths about Environmental Protection

17. Mednarodna konferenca o prenosu tehnologij
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Demografske in družinske analize
Demographic and Family Analyses

Vzgoja in izobraževanje v informacijski družbi
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Konferenca o zdravi dolgoživosti
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Legende računalništva in informatike
Legends of Computing and Informatics

ChatGPT v zdravstvu
ChatGPT in Medicine

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PREDGOVOR MULTIKONFERENCI INFORMACIJSKA DRUŽBA 2024

Leto 2024 je hkrati udarno in tradicionalno. Že sedaj, še bolj pa v prihodnosti bosta računalništvo, informatika (RI) in umetna inteligenca (UI) igrali ključno vlogo pri oblikovanju napredne in trajnostne družbe. Smo na pragu nove dobe, v kateri generativna umetna inteligenca, kot je ChatGPT, in drugi inovativni pristopi utirajo pot k superinteligenci in singularnosti, ključnim elementom, ki bodo definirali razcvet človeške civilizacije. Naša konferenca je zato hkrati tradicionalna znanstvena, pa tudi povsem akademsko odprta za nove pogumne ideje, inkubator novih pogledov in idej.

Letošnja konferenca ne le da analizira področja RI, temveč prinaša tudi osrednje razprave o perečih temah današnjega časa – ohranjanje okolja, demografski izzivi, zdravstvo in preobrazba družbenih struktur. Razvoj UI ponuja rešitve za skoraj vse izzive, s katerimi se soočamo, kar poudarja pomen sodelovanja med strokovnjaki, raziskovalci in odločevalci, da bi skupaj oblikovali strategije za prihodnost. Zavedamo se, da živimo v času velikih sprememb, kjer je ključno, da s poglobljenim znanjem in inovativnimi pristopi oblikujemo informacijsko družbo, ki bo varna, vključujoča in trajnostna.

Letos smo ponosni, da smo v okviru multikonference združili dvanajst izjemnih konferenc, ki odražajo širino in globino informacijskih ved: CHATMED v zdravstvu, Demografske in družinske analize, Digitalna preobrazba zdravstvene nege, Digitalna vključenost v informacijski družbi – DIGIN 2024, Kognitivna znanost, Konferenca o zdravi dolgoživosti, Legende računalništva in informatike, Mednarodna konferenca o prenosu tehnologij, Miti in resnice o varovanju okolja, Odkrivanje znanja in podatkovna skladišča – SIKDD 2024, Slovenska konferenca o umetni inteligenci, Vzgoja in izobraževanje v RI.

Poleg referatov bodo razprave na okroglih mizah in delavnicah omogočile poglobljeno izmenjavo mnenj, ki bo oblikovala prihodnjo informacijsko družbo. “Legende računalništva in informatike” predstavljajo slovenski “Hall of Fame” za odlične posameznike s tega področja, razširjeni referati, objavljeni v reviji *Informatica* z 48-letno tradicijo odličnosti, in sodelovanje s številnimi akademskimi institucijami in združenji, kot so ACM Slovenija, SLAIS in Inženirska akademija Slovenije, bodo še naprej spodbujali razvoj informacijske družbe. Skupaj bomo gradili temelje za prihodnost, ki bo oblikovana s tehnologijami, osredotočena na človeka in njegove potrebe.

S podelitvijo nagrad, še posebej z nagrado Michie-Turing, se avtonomna RI stroka vsakoletno opredeli do najbolj izstopajočih dosežkov. Nagrado Michie-Turing za izjemen življenjski prispevek k razvoju in promociji informacijske družbe je prejel prof. dr. Borut Žalik. Priznanje za dosežek leta pripada prof. dr. Sašu Džeroskemu za izjemne raziskovalne dosežke. »Informacijsko limono« za najmanj primerno informacijsko tematiko je prejela nabava in razdeljevanjem osebnih računalnikov ministrstva, »informacijsko jagodo« kot najboljšo potezo pa so sprejeli organizatorji tekmovanja ACM Slovenija. Čestitke nagrajencem!

Naša vizija je jasna: prepoznati, izkoristiti in oblikovati priložnosti, ki jih prinaša digitalna preobrazba, ter ustvariti informacijsko družbo, ki bo koristila vsem njenim članom. Vsem sodelujočim se zahvaljujemo za njihov prispevek k tej viziji in se veselimo prihodnjih dosežkov, ki jih bo oblikovala ta konferenca.

Mojca Ciglarič, predsednica programskega odbora

Matjaž Gams, predsednik organizacijskega odbora

PREFACE TO THE MULTICONFERENCE INFORMATION SOCIETY 2024

The year 2024 is both ground-breaking and traditional. Now, and even more so in the future, computer science, informatics (CS/I), and artificial intelligence (AI) will play a crucial role in shaping an advanced and sustainable society. We are on the brink of a new era where generative artificial intelligence, such as ChatGPT, and other innovative approaches are paving the way for superintelligence and singularity—key elements that will define the flourishing of human civilization. Our conference is therefore both a traditional scientific gathering and an academically open incubator for bold new ideas and perspectives.

This year's conference analyzes key CS/I areas and brings forward central discussions on pressing contemporary issues—environmental preservation, demographic challenges, healthcare, and the transformation of social structures. AI development offers solutions to nearly all challenges we face, emphasizing the importance of collaboration between experts, researchers, and policymakers to shape future strategies collectively. We recognize that we live in times of significant change, where it is crucial to build an information society that is safe, inclusive, and sustainable, through deep knowledge and innovative approaches.

This year, we are proud to have brought together twelve exceptional conferences within the multiconference framework, reflecting the breadth and depth of information sciences:

- CHATMED in Healthcare
- Demographic and Family Analyses
- Digital Transformation of Healthcare Nursing
- Digital Inclusion in the Information Society – DIGIN 2024
- Cognitive Science
- Conference on Healthy Longevity
- Legends of Computer Science and Informatics
- International Conference on Technology Transfer
- Myths and Facts on Environmental Protection
- Data Mining and Data Warehouses – SIKDD 2024
- Slovenian Conference on Artificial Intelligence
- Education and Training in CS/IS.

In addition to papers, roundtable discussions and workshops will facilitate in-depth exchanges that will help shape the future information society. The “Legends of Computer Science and Informatics” represents Slovenia’s “Hall of Fame” for outstanding individuals in this field. At the same time, extended papers published in the Informatica journal, with over 48 years of excellence, and collaboration with numerous academic institutions and associations, such as ACM Slovenia, SLAIS, and the Slovenian Academy of Engineering, will continue to foster the development of the information society. Together, we will build the foundation for a future shaped by technology, yet focused on human needs.

The autonomous CS/IS community annually recognizes the most outstanding achievements through the awards ceremony. The Michie-Turing Award for an exceptional lifetime contribution to the development and promotion of the information society was awarded to Prof. Dr. Borut Žalik. The Achievement of the Year Award goes to Prof. Dr. Sašo Džeroski. The "Information Lemon" for the least appropriate information topic was given to the ministry's procurement and distribution of personal computers. At the same time, the "Information Strawberry" for the best initiative was awarded to the organizers of the ACM Slovenia competition. Congratulations to all the award winners!

Our vision is clear: to recognize, seize, and shape the opportunities brought by digital transformation and create an information society that benefits all its members. We thank all participants for their contributions and look forward to this conference's future achievements.

Mojca Ciglarič, Chair of the Program Committee

Matjaž Gams, Chair of the Organizing Committee

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PREDGOVOR

Umetna inteligenca doživlja neverjeten in pospešen razvoj, ko se po tričetrt stoletja, ko je Alan Mathison Turing postavil temelje računalništva in umetne inteligence, končno približuje ne le človeški inteligenci, temveč tudi drugim ključnim človeškim lastnostim, kot sta ustvarjalnost, čustvena inteligenca in zavest. Na številnih področjih umetna inteligenca že presega zmogljivosti večine ljudi in celo strokovnjakov. Veliki jezikovni modeli dosegajo tovrstne rezultate tudi pri dosti manj strukturiranih problemih, kot je bilo predstavljivo pred nekaj leti, npr. pri strokovnih izpitih ter besedilnih nalogah iz matematike in programiranja.

Generativna umetna inteligenca že zdaj spreminja svet. Postala je nepogrešljivo orodje v poslovnem svetu, raziskavah in vsakdanjem življenju, saj omogoča pisanje besedil, ustvarjanje kode, generiranje slik in reševanje kompleksnih problemov. Možno je celo, da smo priča začetkom singularnosti – prelomnega trenutka, ko bo umetna inteligenca presegla človeško inteligenco in omogočila revolucijo na področju produktivnosti in inovacij, čeprav bo treba na sodbo o tem še počakati. Optimizem glede prihodnosti je utemeljen: če se bo razvoj nadaljeval s trenutnim tempom, si lahko predstavljamo svet, kjer bo umetna inteligenca povsem preoblikovala gospodarstvo, znanost in način življenja, pri čemer bo omogočila višjo kakovost življenja za vse.

Čeprav nekateri umetno inteligenco vidijo kot grožnjo, njen trenutni razmah resnejših težav še ni prinesel. Nadejamo se, da bo zadosten del raziskav usmerjen v varnost umetne inteligence, da bo tako ostalo. Z morebitnimi škodljivimi učinki umetne inteligence se spopadajo tudi regulatorji, za katere upamo, da bodo uspešno krmarili med tem ciljem in pretiranim zaviranjem razvoja.

Dostopnost velikih jezikovnih modelov, kot so GPT-ji, pomeni, da so naloge, ki zahtevajo razumevanje in generiranje naravnega jezika, lažje kot kadar koli prej. Mnogi raziskovalci verjamejo, da bo prihodnost programiranja prešla iz tradicionalnih jezikov, kot je Python, na velike jezikovne modele, kjer bo umetna inteligenca generirala kodo in rešitve po meri. Čeprav je razvoj teh modelov zahtevna naloga, ki presega zmožnosti večine organizacij, se ljudje navajamo na uporabo tega fenomenalnega orodja. Pričakujemo, da bo umetna inteligenca postala učinkovit in zanesljiv partner človeštva.

Že letos vidimo, da so konference v sklopu Informacijske družbe posvečene prav velikim jezikovnim modelom. V okviru Slovenske konference o umetni inteligenci organiziramo formalno debato dijakov – izkušenih debaterjev, ki se udeležujejo mednarodnih tekmovanj – o tem, kako bo umetna inteligenca oblikovala prihodnost in zakaj bi to lahko bila najboljša prihodnost doslej.

Matjaž Gams
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FOREWORD

Artificial intelligence is experiencing incredible and accelerated development. After three-quarters of a century since Alan Mathison Turing laid the foundations of computing and artificial intelligence, it is finally approaching not only human intelligence but also other key human traits such as creativity, emotional intelligence and consciousness. In many areas, artificial intelligence already surpasses the capabilities of most people and even experts. Large language models are achieving such results even in much less structured problems than was imaginable a few years ago, such as professional exams, and mathematics and programming tasks described in free text.

Generative artificial intelligence is already transforming the world. It has become an indispensable tool in the business world, research, and everyday life, enabling text writing, code generation, image creation, and solving complex problems. It is even possible that we are witnessing the beginnings of the singularity—the pivotal moment when artificial intelligence will surpass human intelligence and enable a revolution in productivity and innovation, although time will show whether this is actually the case. Optimism about the future is well-founded: if development continues at its current pace, we can imagine a world where artificial intelligence completely transforms the economy, science, and way of life, leading to a higher quality of life for all.

Although some see artificial intelligence as a threat, its current rapid progress has not yet led to serious problems. We hope that a sufficient part of the research will be directed towards AI safety so that this remains the case. Regulators are also addressing the potential harmful effects of artificial intelligence, and we hope they will successfully navigate between this goal and excessive hindering of development.

The accessibility of large language models, such as GPTs, means that tasks requiring the understanding and generation of natural language are easier than ever before. Many researchers believe that the future of programming will shift from traditional languages, like Python, to large language models, where artificial intelligence will generate custom code and solutions. Although developing these models is a challenging task beyond the capabilities of most organizations, people are getting accustomed to using this phenomenal tool. We expect artificial intelligence to become an effective and reliable partner for humanity.

Already this year, we are seeing conferences within the framework of the Information Society dedicated to large language models. As part of the Slovenian Conference on Artificial Intelligence, we are organizing a formal debate for high school students—experienced debaters who participate in international competitions—on how artificial intelligence will shape the future and why this might be the best future yet.

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PandaChat-RAG: Towards the Benchmark for Slovenian RAG Applications

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Abstract

Retrieval-augmented generation (RAG) is a recent method for enriching the large language models' text generation abilities with external knowledge through document retrieval. Due to its high usefulness for various applications, it already powers multiple products. However, despite the widespread adoption, there is a notable lack of evaluation benchmarks for RAG systems, particularly for less-resourced languages. This paper introduces the PandaChat-RAG – the first Slovenian RAG benchmark established on a newly developed test dataset. The test dataset is based on the semi-automatic extraction of authentic questions and answers from a genre-annotated web corpus. The methodology for the test dataset construction can be efficiently applied to any of the comparable corpora in numerous European languages. The test dataset is used to assess the RAG system's performance in retrieving relevant sources essential for providing accurate answers to the given questions. The evaluation involves comparing the performance of eight open- and closed-source embedding models, and investigating how the retrieval performance is influenced by factors such as the document chunk size and the number of retrieved sources. These findings contribute to establishing the guidelines for optimal RAG system configurations not only for Slovenian, but also for other languages.

Keywords

retrieval-augmented generation, RAG, embedding models, large language models, LLMs, benchmark, Slovenian

1 Introduction

The advent of large language models (LLMs) has introduced significant advancements in the field of natural language processing (NLP). Although LLMs have shown impressive capabilities in generating coherent text, they are prone to hallucinations [7, 16], i.e., providing false information. Furthermore, they are dependent on static and potentially outdated corpora [9]. Retrieval-augmented generation (RAG) is a method devised to address these challenges by augmenting LLMs with external information retrieved from a provided document collection. Connecting LLMs with a relevant database improves the factual accuracy and temporal relevance of the generated responses. Moreover, RAG contributes to the explainability of the generated answers by providing verifiable sources, which facilitates the evaluation of the system's accuracy [2]. These advantages have spurred quick adoption of RAG systems across various applications. For instance, PandaChat[1] leverages RAG to provide explainable responses with high accuracy in Slovenian and other languages, integrated in customer service bots and platforms that allow LLM-based retrieval of information from texts.

Although RAG benchmarking is a relatively recent endeavor, some initial frameworks have already emerged [3, 5, 7]. However, these benchmarks are only limited to English and Chinese, leaving a gap in the evaluation of RAG systems for other languages. To address this gap, we make the following contributions:

- We present the first benchmark for RAG systems for the Slovenian language. The benchmark is based on the newly developed PandaChat-RAG-sl test dataset[2], which comprises authentic questions, answers and source texts.
- We introduce a methodology for an efficient semi-automated development of RAG test datasets that is easily replicable for the languages included in the MaCoCu [1] and CLASSLA-web corpora collections [10], which include all South Slavic languages, Albanian, Catalan, Greek, Icelandic, Maltese, Ukrainian and Turkish.
- As the first step of RAG evaluation, we evaluate the retriever's performance in terms of its ability to provide relevant sources crucial to retrieve accurate answers to the posed questions. The evaluation encompasses comparison of performance of several open- and closed-source embedding models. Furthermore, we provide insights on the impact of the document chunk size and the number of retrieved sources, to identify optimal configurations of the indexing and retrieval components for robust and accurate retrieval.

The paper is organized as follows: in Section 2, we provide an introduction to the previous research concerning the evaluation of RAG systems; Section 3 introduces the PandaChat-RAG-sl dataset (Section 3.1) and the RAG system architecture (Section 3.2), which is evaluated in Section 4. Finally, in Section 5, we conclude the paper with a discussion of the main findings and suggestions for future work.

2 Related Work

Despite the recent introduction of the RAG architecture, several benchmarking initiatives have already emerged [3, 5, 7, 15]. However, since the RAG systems can be applied to various end tasks, the benchmarks focus on different aspects of these systems. Inter

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[1] https://pandachat.ai/
[2] The PandaChat-RAG benchmark and its test dataset are openly available at https://github.com/TajaKuzman/pandachat-rag-benchmark.

alia, current benchmarks assess their performance in text citation [7], text continuation, question-answering with support of external knowledge, hallucination modification, and multi-document summarization [12].

The closest to our work is the evaluation of the RAG systems on the task of Attributable Question Answering [2]. This task involves providing a question as input to the system, which then generates both an answer and an attribution, indicating the source text on which the answer is based. The advantage of this task over the closed-book question-answering task is that it also measures the system's capability to provide the correct source.

The majority of RAG benchmarks assess RAG systems in English [3, 5, 7, 15] or Chinese [5, 12]. Consequently, the generalizability of their findings to other languages remains uncertain. Furthermore, a limitation of many benchmarks is their reliance on synthetic data generated by LLMs [5, 12, 15]. To avoid potential biases introduced by LLMs and to better represent the complexity and diversity of real-world language use, a more reliable evaluation would be based on non-synthetic test datasets. Despite focusing on a different task, recent research [6] has shown that resource-efficient development of non-synthetic and non-machine translated question-answering datasets is feasible by leveraging the availability of general web corpora and genre classifiers.

3 Methodology

3.1 PandaChat-RAG-sl Dataset

The PandaChat-RAG-sl dataset comprises questions, answers, and the corresponding source texts that encompass the answers. It was created through a semi-automated process involving the extraction of texts from the Slovenian web corpus CLASSLA-web.sl 1.0 [11], followed by a manual extraction of high-quality instances. Since the texts were automatically extracted from a general text collection, the dataset encompasses a diverse range of topics that were not predefined or decided upon.

The CLASSLA-web.sl 1.0 corpus is a collection of texts, collected from the web in 2021 and 2022 [10]. It was chosen due to its numerous advantages: 1) it has high-quality content, with the majority of texts meeting the criteria for publishable quality [17]; 2) it is one of the largest and most up-to-date collections of Slovenian texts, comprising approximately 4 million texts; 3) the texts are enriched with genre labels, facilitating genre-based text selection; and 4) it is developed in the same manner as 6 other CLASSLA-web corpora [10] and 7 additional MaCoCu web corpora in various European languages [1]. This enables easy expansion of the benchmark to other languages, including all South Slavic languages and various European languages, such as Albanian, Catalan, Greek, Icelandic, Ukrainian and Turkish.

The development of the PandaChat-RAG-sl dataset involves the following steps: 1) the genre-based selection of texts from the CLASSLA-web.sl corpus; 2) the extraction of texts that comprise paragraphs ending with a question (80,215 texts); 3) the extraction of questions and answers (paragraphs, following the question); 4) a manual review process to identify high-quality instances. In the genre-based selection phase, we extract texts labeled with genres that are most likely to contain objective questions and answers, that is, *Information/Explanation*, *Instruction* and *Legal*.

In its present iteration, the dataset consists of 206 instances derived from the first 1,800 extracted texts. It is important to note that this effort can easily be continued with further manual inspection of the extracted texts should there be a need to prepare a larger dataset.

Table 1: Statistics for the PandaChat-RAG-sl dataset.

	Number
Instances	206
Unique texts	160
Words (questions)	1,184
Words (texts w/o questions)	83,467
Total words (questions + texts)	84,651

Table 1 provides the statistical overview for the PandaChat-RAG-sl dataset. The dataset consists of 206 instances, that is, triplets of a question, an answer and a source text, derived from 160 texts. The total size of the dataset is 84,651 words, encompassing both the questions and the texts containing the answers.

3.2 RAG System

The RAG pipeline encompasses three main components: indexing, retrieval, and text generation. During the indexing phase, the user-provided text collection is transformed into a database of numerical vectors (embeddings) to facilitate document retrieval by the retriever. This process involves segmenting the documents into fixed-length chunks, which are then converted into embeddings using large language models. The choice of the embedding model and the chunk size are critical factors that can significantly impact the retrieval performance of the model. Selecting an appropriate embedding model is essential to ensure that the textual information is converted into a meaningful numerical representation for effective retrieval. Moreover, the chunk size, in terms of the number of tokens, plays a crucial role in determining the informativeness of the embeddings. Incorrect chunk sizes may lead to numerical vectors that lack important information necessary for connecting the question to the corresponding text chunk, thereby compromising retrieval accuracy [12].

When presented with a question, the retrieval component uses the semantic search (also known as dense retrieval) to retrieve the most relevant text chunks. The search is based on determining the smallest cosine distance between the chunk vectors and the question vector. Lastly, during the text generation phase, the retriever provides the large language model (LLM) with a selection of top retrieved sources. The LLM is prompted to provide a human-like answer to the provided question based on the retrieved text sources. The selection of an appropriate number of top retrieved sources is crucial in this phase: including more than just one retrieved source may enhance retrieval accuracy and address situations where the first retrieved source fails to encompass all relevant information, especially in the case when more texts cover the same subject matter. However, increasing the number of sources also leads to a longer prompt provided to the LLM, potentially increasing the costs of using the RAG system.

In this study, we assess the indexing and retrieval components, focusing on the impact of different embedding models, chunk sizes, and the number of retrieved sources on retrieval performance.

Embedding Models. The evaluation includes a range of multilingual open-source and closed-source models. The selection of open-source models is based on the Massive Text Embedding

Benchmark (MTEB) Leaderboard[3] [13]. Specifically, we choose medium-sized multilingual models with up to 600 million parameters that have demonstrated strong performance on Polish and Russian – Slavic languages that are linguistically related to Slovenian. The models used in the evaluation are:

- Closed-source embedding models provided by the OpenAI: an older model text-embedding-ada-002 (OpenAI-Ada) [8], and two recently published models: text-embedding-3-small (OpenAI-3-small), and text-embedding-3-large (OpenAI-3-large) [14].
- Open-source embedding models, available on the Hugging Face repository: BGE-M3 model [4], base-sized mGTE model (mGTE-base) [19], and small (mE5-small), base (mE5-base) and large sizes (mE5-large) of the Multilingual E5 model [18].

Chunk size. The impact of the chunk size on retrieval performance is assessed by varying chunk sizes of 128, 256, 512, and 1024 tokens, with a default chunk overlap of 20 tokens. In these experiments, the performance is evaluated based on the first retrieved source.

Number of retrieved sources. Previous work indicates that increasing the number of retrieved sources improves the retrieval accuracy [12]. In this study, we examine the retrieval accuracy of embedding models, with a chunk size set to 128 tokens, when the models retrieve 1 to 5 sources. In this scenario, if any of the multiple retrieved sources matches the correct source, the output is evaluated as being correct.

The retrieval capabilities of the RAG system are evaluated on the task of Attributed Question-Answering. The evaluation is based on accuracy, measured as the percentage of questions correctly matched with the relevant source.

The experiments are performed using the LlamaIndex library[4]. The chunk size is defined using the SentenceSplitter method in the indexing phase. Number of retrieved sources (*similarity top k*), the embedding model and the prompt for the LLM model are specified as parameters of the chat engine. The closed-source embedding models are used via the OpenAI API, while the experiments with the open-source models are conducted on a GPU machine.

4 Experiments and Results

In this section, we present the results of the experiments examining the impact of the chunk size, the number of retrieved sources, and the selection of the embedding model on the retrieval performance of the RAG system.

4.1 Chunk Size

Figure 1 shows the impact of the chunk size on the retrieval performance of the RAG systems that are based on different embedding models. The findings suggest that, with the exception of the OpenAI-Ada model, all systems demonstrate the best performance when the text chunk size is set to 128 tokens. Increasing the chunk size hinders the retrieval performance, which is consistent with previous research [12]. These results confirm that smaller chunk sizes enable the embedding models to capture finer details that are essential for retrieving the most relevant text for the given question.

[3]https://huggingface.co/spaces/mteb/leaderboard
[4]https://www.llamaindex.ai/

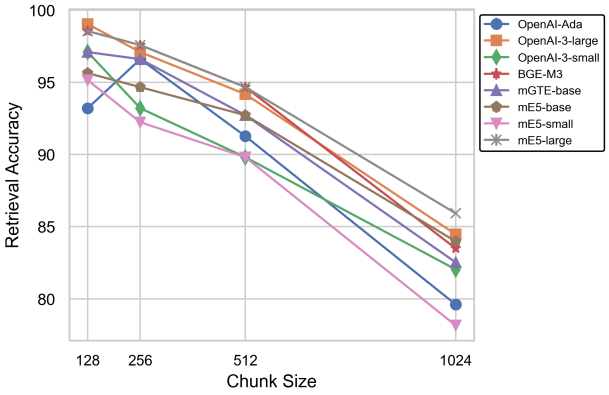

Figure 1: The impact of the chunk size on the retrieval performance.

4.2 Number of Retrieved Sources

Figure 2 shows the performance of the RAG systems when increasing the number of retrieved sources. The results demonstrate that increasing the number of retrieved sources initially improves the performance, however, after a certain threshold, the performance levels off.

Increasing the number of retrieved sources results in larger inputs to the LLM in the text generation component, incurring higher costs. Using more than two retrieved sources does not significantly improve results in most systems. What is more, with the top two retrieved sources, certain embedding models, namely, BGE-M3 and mE5-large, already reach perfect accuracy. Thus, our findings indicate that using more than the top two retrieved sources is unnecessary.

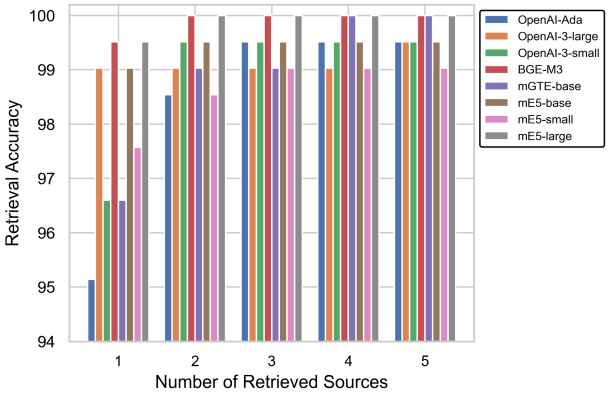

Figure 2: Impact of the number of retrieved sources on the retrieval performance.

4.3 Embedding Models

We provide the final comparison of the performance of systems that use different embedding models. We use the parameters that have shown to provide the best results in the previous experiments: the chunk size of 128 tokens and top two retrieved sources. As shown in Table 2, the retrieval systems that use the open-source BGE-M3 and mE5-large embedding models achieve the perfect retrieval score. They are closely followed by the closed-source OpenAI-3-small and the mE5-base models which achieve

Table 2: Performance comparison between the open-source and closed-source embedding models.

embedding model	speed (s)	retrieval accuracy
BGE-M3	0.58	100
mE5-large	0.58	100
OpenAI-3-small	0.69	99.51
mE5-base	0.29	99.51
OpenAI-3-large	1.19	99.03
mGTE-base	0.31	99.03
OpenAI-Ada	0.63	98.54
mE5-small	0.15	98.54

accuracy of 99.5%. While having slightly lower scores, all other retrieval systems still achieve high performance, ranging between 98.5% and 99% in accuracy.

Additionally, Table 2 provides the inference speed of the models measured in seconds per instance. If inference speed is a priority, the mE5-base model emerges as the optimal selection, as it yields high retrieval accuracy of 99.51% and is two times faster than the two best performing models. In cases where users are restricted to closed-source models due to the unavailability of GPU resources, the OpenAI-3-small model stands out as the most suitable option. Its inference speed is comparable to the OpenAI-Ada model, while it achieves a superior retrieval accuracy.

5 Conclusion and Future Work

In this paper, a novel test dataset was introduced to assess the performance of the RAG system on Slovenian language. A general methodology for efficient creating of non-synthetic RAG test datasets was established that can be extended to other languages. We evaluated the retrieval accuracy of the RAG system, examining the impact of the embedding models, the document chunk size, and the number of retrieved sources. The assessment of embedding models encompassed eight open-source and closed-source LLM models. It revealed that open-source models, specifically, BGE-M3 and mE5-large, reached perfect retrieval accuracy, demonstrating their suitability for RAG applications on Slovenian texts. Furthermore, the evaluation of the optimal chunk size and the number of retrieved sources showed that smaller chunk sizes yielded superior results. In contrast, increasing the number of retrieved sources enhanced results up to a certain threshold, beyond which the model performance plateaued. Certain models already achieved perfect accuracy when evaluated based on the top two retrieved sources.

While the novel test dataset can be used to evaluate all the components of the RAG system, in this paper, we focused on the evaluation of the indexing and retrieval components. In our future work, we will extend the evaluations to the text generation component with regard to fluency, correctness, and usefulness of the generated answers. Furthermore, we plan to expand the benchmark to encompass a wider range of languages. The plans include extending the dataset and evaluation to South Slavic languages and other European languages that are covered by comparable MaCoCu [1] and CLASSLA-web [10] corpora.

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Choosing Features for Stress Prediction with Machine Learning

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Abstract

Feature selection is a crucial step in building effective machine learning models, as it directly impacts model accuracy and interpretability. Driven by the aim of improving stress prediction models, this article evaluates multiple approaches for identifying the most relevant features. The study explores filter-based methods that assess feature importance through correlation analysis, alongside wrapper methods that iteratively optimize feature subsets. Additionally, techniques such as Boruta are analysed for their effectiveness in identifying all important features, while strategies for handling highly correlated variables are also considered. By conducting a comprehensive analysis of these approaches, we assess the role of feature selection in developing stress prediction models.

Keywords

Feature selection, Correlation matrix, Balanced accuracy score

1 Introduction

Machine learning models are increasingly being applied to predict stress, which is critical in various domains such as healthcare, workplace management, and wearable technology. However, one of the major challenges in developing reliable predictive models is identifying the most relevant features from extensive datasets, comprising physiological and behavioural information.

Feature selection plays a key role in addressing this challenge. By selecting only the most informative features, we can reduce noise, prevent overfitting, and enhance model accuracy. As we showed in previous work [8], even simple feature selection techniques can increase the F_1 score of predictive models. This paper builds upon this finding and explores several feature selection techniques, ranging from simple correlation-based methods to more sophisticated wrapper approaches.

The aim of this work is to assess how feature selection can enhance stress prediction models. By comparing different methods, we aim to identify the optimal strategies for feature selection in stress prediction which would lead to more reliable and more easily interpretable machine learning models.

2 Data collection

The data used in this work comes from the STRAW project [1], results of which have been previously presented at Information Society [6, 8]. The dataset includes the data of 56 participants, recruited from academic institutions in Belgium (29 participants) and Slovenia (26 participants). They answered questionnaires named Ecological Momentary Assessments (EMAs) roughly every 90 minutes, with smartphone sensor and usage data continuously collected by an Android application [7], while also wearing an Empatica E4 wristband recording physiological data. In 15 days of their participation, each participant responded to more than 96 EMA sessions, on average, which resulted in around 2200 labels.

3 Target and feature extraction

To fully leverage the potential of the data, we computed a comprehensive set of features. While some sensors only reported relatively rare events, such as phone calls, others had a high sampling frequency, such blood volume pulse which sampled data at 32 Hz. On the other hand, labels were only available every 90 min. Therefore, we preprocessed the data in several steps.

3.1 Target variable

While participants responded to various questionnaires, for this study, we selected their responses to Stress Appraisal Measurement [9] as the target variable. It was used to report stress levels on a scale from 0 to 4, so using it as is the prediction task can be approached as a regression problem.

However, many stress detection studies tend towards a discrete approach, treating stress predominantly as a classification task, often only working with a binary target variable. To convert this into a classification problem, we discretized the target variable into two distinct categories: "no stress", which included all responses with a value of 0, while all others were coded as "stress". With that, we ensured a balanced distribution of the target variable values.

3.2 Features

3.2.1 Data preprocessing. In our work, features were calculated on 30-minute intervals preceding each questionnaire session. From the wide variety of smartphone data and physiological measures, a total of 352 features were extracted and grouped into 22 categories, listed in Table 1. Using physiological data from Empatica wristband, we first calculated specialized physiological features on smaller windows (from 4 s to 120 s, depending on the sensor; see [4] for more details), which were then aggregated over 30 min windows by calculating simple statistical features: mean, median, standard deviation, minimum, and maximum. All of the categorical features were converted into a set of binary features using the one hot encoding technique and the missing values were replaced with the mode.

First, some preliminary data cleaning was performed by excluding one of the feature in pairs exhibiting a correlation coefficient of $|r| \geq 0.95$. Despite this, some of the remaining features still exhibited quite strong correlations as shown in Fig. 1. An interesting observation used in the later stages of feature selection was that high correlation, $|r| \geq 0.8$, was mostly observed

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Table 1: Feature categories with the number of features included in each category in parentheses

1. Empatica electrodermal activity (99)
2. Empatica inter-beat interval (50)
3. Empatica temperature (33)
4. Empatica accelerometer (23)
5. Empatica data yield (1)
6. Phone applications foreground (47)
7. Phone location (18)
8. Phone Bluetooth connections (18)
9. Phone calls (10)
10. Phone activity recognition (7)
11. Phone Wi-Fi connections (7)
12. Phone screen events (7)
13. Phone light (6)
14. Phone battery (5)
15. Phone speech (4)
16. Phone interactions (2)
17. Phone messages (2)
18. Phone data yield (1)
19. Baseline psychological features (7)
20. Language (2)
21. Gender (2)
22. Age (1)

between features of the same category. As an example, correlations between features related to phone application use are shown in Fig. 2.

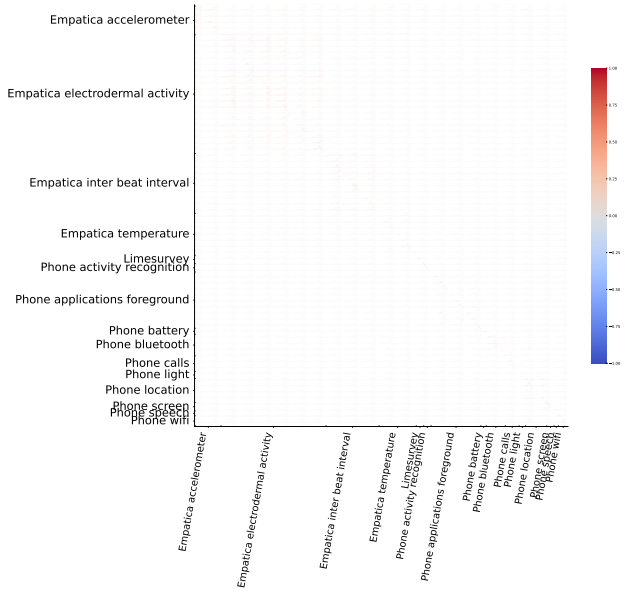

Figure 1: Correlation matrix of the initial feature set. Only feature categories with more than two features are labelled.

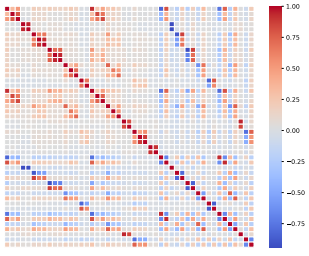

Figure 2: Correlation matrix of the feature set in the Phone applications foreground category.

4 Prediction models

4.1 Model performance and validation

To evaluate the performance of the models we used balanced accuracy score which is defined as the average of recall obtained on each class. When adjusted for random chance, it is calculated as

$$\textit{Balanced accuracy} = \frac{TP}{TP+FN} + \frac{TN}{TN+FP} - 1,$$

in the binary case, where TP is the number of true positives, TN is the number of true negatives, FN is the number of false negatives and FP is the number of false positives. This definition is equivalent to Youden's $\mathcal{J}$ [11], which assigns a 0 to a random classifier (indeed, a dummy classifier achieved a score of 0.0208 in our case), while a perfect classifier would achieve a score of 1.

To evaluate the stress detection models described in the following sections, we considered several ways of data partitioning. Since the variations in the results depending on the data split were significant, in order to achieve more consistent accuracy, we employed shuffled 5-fold cross-validation.

We also considered a leave-one-subject-out cross-validation technique. However, this method yielded poor results: using all available features, balanced accuracy was 0.05, while with the 5-fold cross validation it was 0.45. This suggested that the participants were quite different from each other, making it challenging to generalize predictions for a subject the model had not encountered.

4.2 Baseline model

Our initial approach for building a prediction model was to use all available features. This served as a baseline, which we aimed to improve through feature selection.

We evaluated various predictive models, as shown in Table 2, all as implemented in `scikit-learn` [10]. Among these, the Random Forest model yielded the best performance.

In this work, we aimed to find the best model for predicting stress and improve it using the optimal feature subset. Consequently, we used the Random Forest as the benchmark for comparing feature selection algorithms.

Table 2: Performance of different models for the classification problem. The mean over five folds, its standard error, and the maximum are shown.

Model	Mean	Max	SEM
Logistic Regression	0.077	0.151	0.025
Support Vector Machines	0.090	0.158	0.022
Gaussian Naive Bayes	0.061	0.122	0.020
Stochastic Gradient Descent	0.027	0.054	0.007
Random Forest	0.475	0.558	0.026
XGBoost	0.441	0.473	0.013

In Table 2, SEM represents the Standard Error of the Mean. It measures how far the sample mean of the data is likely to be from the true population mean.

4.3 Correlation-Based Feature Reduction

We began the feature selection process by eliminating highly correlated features. For each highly correlated pair, we removed the feature with the lower rank when sorted by mutual information, setting the correlation threshold at $|r| \geq 0.8$ to maintain a manageable number of features. This reduction left us with approximately 180 features out of the original 352 for model training and evaluation.

While selecting the optimal set of features for stress prediction, we aimed to retain all 22 different categories from Table 1, as

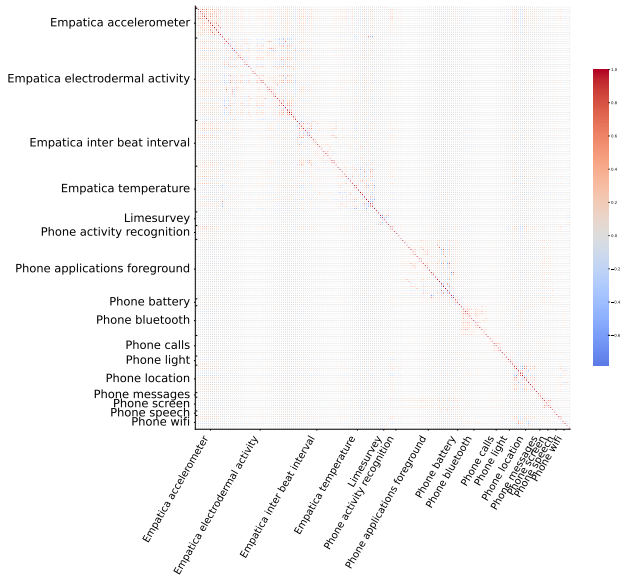

Figure 3: Correlation matrix of the feature set after correlation-based feature reduction. Only feature categories with more than two features are labelled.

each could provide unique information. Comparing Figs. 1 and 3, we were left with about half the number of features which were still moderately correlated.

4.4 Feature Selection using the mutual information scoring function

Before applying more complex feature selection algorithms, it was necessary to reduce computational complexity by further reducing our set of 180 features obtained through correlation-based reduction. Therefore, we used the `SelectKBest` method and the mutual information scoring function to retain the top 100 features. This resulted in features derived from 19 to 20 categories, as categories *language*, *gender*, and, in some cases, *Empatica accelerometer* were not deemed important for predicting stress.

Going forward, we will refer to the elimination of features within highly correlated pairs and the selection of the top 100 features using the mutual information scoring function as the preprocessing step.

4.5 Recursive Feature Elimination with Cross-Validation (RFECV)

One of the previously mentioned complex feature selection methods we employed was Recursive Feature Elimination with Cross-Validation (RFECV) [3]. The feature set we got after the preprocessing step was passed to the RFECV algorithm for thorough evaluation.

RFECV operates by initially fitting a model to the dataset and evaluating its performance through cross-validation. After the initial fit, RFECV ranks feature importance and iteratively removes the least important features based on the models feature importances attributes, which in the case of Random Forest are impurity-based feature importances. This process continues until there is no significant improvement in the model's performance. To ensure a reasonable duration for the feature selection process, we set the cross-validation in RFECV to 3 folds. The number of features selected varied across folds, ranging from 50 to 93 features.

4.6 Sequential Forward Selection

Another feature selection method we employed was Sequential Feature Selector (SFS), a wrapper-based technique [2]. SFS and RFECV differ in their approaches. SFS constructs models for each feature subset at every step, while RFECV builds a single model and evaluates feature importance scores. Consequently, SFS is more computationally expensive, as it must evaluate numerous feature combinations before identifying the optimal subset.

In the absence of specified parameters for number of features to select (`n_features_to_select`) and tolerance (`tol`), the method defaults to selecting half of the available features. The default configuration was used in our analysis, leading the SFS to select the top 50 features.

4.7 Boruta method

The final feature selection technique we employed was the Boruta method [5]. With the assistance of "shadow features", which are original features that have been randomly shuffled, the method identifies a subset of features that are relevant to the classification task at hand. In our case, shadow features were introduced into the feature subset obtained after the preprocessing step.

The updated dataset was trained using the Random Forest model for 100 iterations. In each iteration, all original features ranked higher in importance than the highest-ranked shadow feature were marked as relevant.

Ultimately, a binomial distribution is used to evaluate which features have enough confidence to be kept in the final selection. The number of features selected varied across folds, ranging from 47 to 55 features.

5 Results

In Table 3, the final scores for a Random Forest model built on various feature subsets, as derived from the methods described above, are presented. The data was split using shuffled 5-fold cross-validation, to ensure that the results were not overly dependent on a data split.

Table 3: Adjusted balanced accuracy scores of a Random Forest model, trained on the different feature sets. Last column represents a number of features selected.

Feature set	Mean	Max	SEM	N
All available features	0.464	0.498	0.011	352
Correlation-based reduction	0.483	0.507	0.007	~180
Correlation-based, 100 best	0.486	0.498	0.006	100
Preprocessing, RFECV	0.471	0.511	0.012	50 to 93
Preprocessing, SFS	0.483	0.520	0.017	50
Preprocessing, Boruta	0.481	0.545	0.020	47 to 55
RFECV only	0.465	0.494	0.020	16 to 89
SFS only	0.426	0.468	0.017	30
Boruta only	0.456	0.509	0.015	~75

From Table 3, we can see that the most significant improvement in accuracy came after removing the highly correlated features, with the average adjusted balanced accuracy score rising from 0.46 to 0.48. Best mean accuracy was achieved after the preprocessing step, with only a minor improvement from 0.483 to 0.486.

After eliminating highly correlated features, wrapper methods did not significantly improve the accuracy on average (rows 3 to 6 in Table 3). The Boruta method performed best among the three, with the highest overall maximum accuracy in a single fold. These results led us to investigate whether the wrapper feature selection method alone could manage correlated features without their prior removal and to evaluate the impact of the correlation threshold.

We employed the RFECV, SFS, and Boruta method on the entire feature set of 352 features without applying the preprocessing step. For SFS, only 30 features were selected due to its computational complexity. As shown in the last three rows of Table 3, none of the methods alone were able to improve the result achieved with correlation removal. Highly correlated features were left in the final feature set: for example, we identified three pairs of features with a correlation coefficient exceeding $|r| \geq 0.8$ using SFS alone. Poor results could be attributed either to the importance of the correlation removal step or to the feature subset being too small in the case of the SFS.

5.1 Selecting the best correlation threshold

As previously mentioned, the biggest improvement in score came from removing the feature inside the highly correlated pair. Therefore, we have also experimented with different correlation cut-off values to determine the best threshold.

The highest score was achieved with a correlation threshold of $|r| \geq 0.75$ (Table 4). Considering the impact of cross-validation splits and the relatively minor variance in scores, it appears that our initial threshold of $|r| \geq 0.8$ was also quite effective.

Table 4: Adjusted balanced accuracy scores of a Random Forest model trained on a feature subset excluding features above the correlation threshold. The number of features left after correlation-based feature selection differed over validation folds and its range is shown in the final column.

Threshold	Mean	Max	SEM	N
0.55	0.462	0.506	0.018	28 to 33
0.60	0.467	0.493	0.009	39 to 41
0.65	0.474	0.498	0.008	47 to 50
0.70	0.460	0.501	0.017	61 to 65
0.75	0.498	0.526	0.012	74 to 80
0.80	0.470	0.543	0.022	101 to 107

6 Conclusions

This paper examined different feature selection algorithms to find the most effective subset for stress prediction. The model using the feature subset after correlation removal achieved the highest adjusted balanced accuracy score of 0.483.

Alternative feature selection approaches, including the wrapper methods SFS and RFECV, as well as the Boruta method, applied to the preprocessed feature subset, did not lead to further optimization of the feature subset in terms of model performance. Additionally, applying these methods to the entire set of features did not achieve accuracy levels as high as those obtained after the correlation-based reduction. In the case of SFS, this may be attributed to its selection of only 30 features.

Therefore, our results underscore the critical role of the correlation-based reduction step. In contrast, when this step was omitted wrapper methods alone were unable to effectively perform correlation-based feature reduction. We can therefore conclude that simply relying on feature selection methods, however sophisticated, is not as effective as also considering relationships between features.

It should be noted that the improvements in balanced accuracy are low in all cases. This indicates that results cannot be easily generalized and correlation-based feature selection should not be seen as sufficient in general. Instead, we can speculate that no single feature selection method is the best one and that several should be considered. We should also note that the Pearson correlation coefficient that we used in this work only considers linear relationships between features. Other methods can select features even if they are related in a different way.

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Predictive Modeling of Football Results in the WWIN League of Bosnia and Herzegovina

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Abstract

Predictive modeling in football has emerged as a valuable tool for enhancing decision-making in sports management. This study applies machine learning techniques to predict football match outcomes in the WWIN League of Bosnia and Herzegovina. The aim is to evaluate the effectiveness of various models, including Support Vector Machines (SVM), Logistic Regression, Random Forest, Gradient Boosting, and k-Nearest Neighbors (kNN), in accurately predicting match results based on key features such as shots on target, possession percentage, and home/away status. By (1) gathering and analyzing match data from three seasons, (2) comparing the performance of machine learning models, and (3) drawing conclusions on key performance factors, we demonstrate that SVM achieves the highest accuracy at 83%, outperforming other models. These insights contribute to football management, allowing for data-driven strategic planning and performance optimization. Future research will integrate additional factors such as player injuries and weather conditions to improve the predictive models further.

Keywords

Football match prediction, machine learning, WWIN league, Support Vector Machines, Random Forest

1 Introduction

Accurate predictions of match outcomes can inform a wide range of decisions, from tactical adjustments to player acquisitions, and can improve engagement for fans and stakeholders. While predictive modeling has been extensively applied to top-tier football leagues like the English Premier League, there is limited research on regional leagues such as the WWIN League of Bosnia and Herzegovina. The specificity of the country that is Bosnia and Herzegovina and the WWIN League, which has not been researched in the sphere of sports research, provides context for this step.

The WWIN League of Bosnia and Herzegovina was established in the year 2000 and the same year the WWIN was formed by the merging of three leagues, it became a league covering the entire territory of Bosnia and Herzegovina. Originally, the league consisted of 16 clubs, and, from the 2016-2017 season, the league contains 12 clubs which makes the level of the league higher [25]. The winner is the team that has the most points by the completion of thirty-three rounds; this position will grant a team a place in the UEFA Champions League qualifications [10]; the remaining two teams and the winner of the cup will compete for a place in the UEFA Conference League. Since the founding of the WWIN League of Bosnia and Herzegovina, team with the highest number of titles was HŠK Zrinjski from Mostar who emerged as the winner eight times, followed by Sarajevo which won four times, Zeljeznicar and Borac both won three times, Siroki Brijeg won two times and Leotar and Modrica both won once [12]. Depending on which entity association they belong to, the teams that occupy the last two places in the league at the end of the season are relegated to the league below, with two teams from the First League of the Federation of BiH and the First League of the RS being promoted in their stead. To elevate football in our country to the highest level, we must support in-depth analyses of matches and the factors influencing their outcomes. This will enable coaches to fine-tune strategies for future games, help commentators provide more insightful commentary, and allow fans to develop a deeper understanding and get more pleasure from the match.

The study aims to evaluate the performance of various ML models, including Support Vector Machines (SVM), Logistic Regression, Random Forest, Gradient Boosting, and k-Nearest Neighbors (kNN), in predicting match results. By examining key features such as shots on target, possession percentage, and home/away status, we conduct an analysis based on match data from three seasons of the WWIN League, encompassing 400 matches and key performance metrics.

The remainder of the paper is structured as follows: Section II provides an overview of related work in football ML-based prediction. Section III describes the methodology, including the dataset and models used. Section IV presents the results and analysis of models performance, with a discussion on the practical implications of the findings for football management. Finally, Section V concludes the paper and outlines directions for future research.

2 Literature Review

The prediction of the results of football matches has been recently studied extensively because of its relation to betting and decision-making in sports. Studies examining the employment of ML methods are primarily focused on large European leagues, where extensive and highly detailed data is available. The application of these techniques to regional football leagues, such as the WWIN League of B&H, remains underexplored.

Rodrigues and Pinto [15] used a variety of ML methods, including Naive Bayes, K-nearest neighbors, Random Forest, and SVM, to predict the match outcomes based on previous match data and player attributes. Their studies revealed excellent results in terms of soccer betting profit margins, with the Random Forest approach obtaining a success rate of 65.26% and a profit margin of 26.74%. Rahman [13] dedicated his work to employing deep learning frameworks especially Deep Neural Networks (DNNs) for football match outcome prediction, particularly during FIFA World Cup 2018. The study classified match outcomes

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with 63.3% accuracy with DNN architectures with LSTM or GRU cells. Baboota and Kaur [3] used machine learning approaches to predict English Premier League match results. The models compared included Support Vector Machines, Random Forest; and Gradient Boosting. From their study , they ascertained that Gradient Boosting outperformed other models in accuracy and overall predictiveness. Authors in [16] used machine learning techniques, notably SVM and Random Forest Classifier, to predict English Premier League (EPL) football match results. They got 54.3% accuracy with SVM and 49.8% with Random Forest after evaluating data from 2013/2014 to 2018/2019 seasons. Another study [8] employed a few machine learning algorithms to predict matches of the English Premier League season 2017-2018. Models including Linear Regression, SVM, Logistic Regression, Random Forest, and Multinomial Naïve Bayes classier show that the K-nearest neighbors give the best accurate predictions.

In summary, while existing studies have demonstrated the effectiveness of machine learning in football matches prediction, there remains a gap in the application of these techniques to regional leagues like the WWIN League, due to the availability and quality of data. The characteristics of these leagues, such as smaller datasets and potentially different factors influencing match outcomes, require a tailored approach. In lesser-known football leagues models might perform differently due to variations in competitive structures and gameplay strategies, as well. The study of Munđar and Šimić [11] in which they developed a simulation model using the Poisson distribution to predict the seasonal rankings of teams in the Croatian First Football League, highlighted the predictive power of statistical models and demonstrated the significance of home advantage in determining match outcomes, which is also an important factor in the WWIN League.

3 Materials and Methods

In this section, we describe the study conducted, detailing the data collection and feature selection processes, the machine learning models applied, the evaluation metrics used to assess model performance, and the approach taken to analyze key features influencing match outcomes. As a result of providing numerous procedures that are declared in this section, we represent the graphical illustration of our methodology. The steps involved in predicting the outcomes of the WWIN League of Bosnia and Herzegovina, including data collection, preprocessing, model development, and algorithm evaluation.

3.1 Dataset

The authors created the dataset for this study by consolidating information from rezultati.com [14], 1XBET [1], and Sofascore [24]. The unique dataset represents the seasons 2021/2022, 2022/2023, and 2023/2024 of WWIN League of Bosnia and Herzegovina. The platforms provide a wide range of football match data so it is easy to find important information for examination. The dataset includes key match facts as date, day of the week, time, home team, away team, final as well as half-time goals scored in the game, referee details, shots taken at goal as well as corner kicks resulting from these attempts on target, bookings made during play by both teams and other relevant performance indicators.

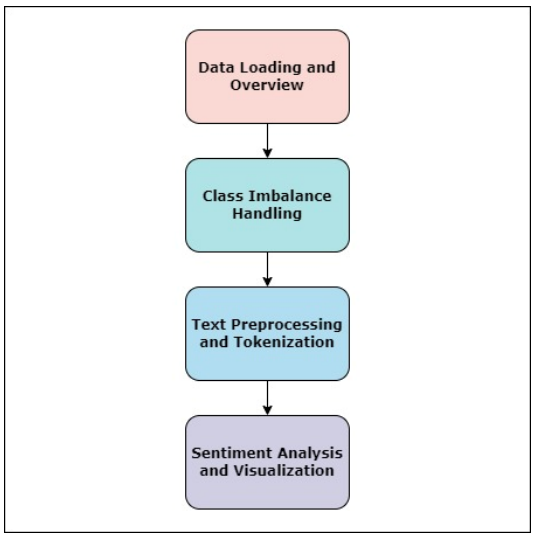

Figure 1: Workflow diagram

Table 1: Class Distribution

Match Type	Count
Home Win	301
Away Win	142
Draw	151

The table sums up a type of match result in terms of its frequency in the dataset.

In the recorded 594 matches, 301 ended in home team victories, 142 in away team victories and 151 were tied. The following pie chart describes the percentage distribution of the match outcome. Curiously, home wins are in the majority, comprising 50.7% of all

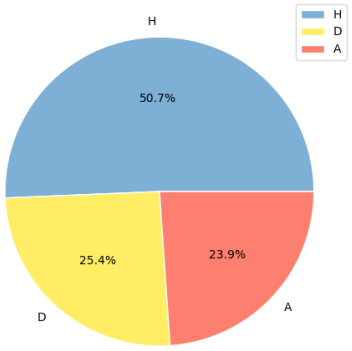

Figure 2: Class distribution of the dataset

matches. However, away victories contribute to approximately 23.9% of all recorded match results, while 25.4% contribute to draw results. The Fig.2 depicts the frequency of each of the match outcomes.

3.2 Machine Learning Prediction

In football, the concept of machine learning prediction entails developing models to forecast match outcomes based on the teams'

and players' histories and other attributes [5]. These models employ such methods as regression analysis, classification, and neural nets to determine the results given the data fed as the input.

3.2.1 Models initialisation, preprocessing, training and testing. While implementing Logistic Regression, we have set the max_iter =1000 and random_state = 42. Again, with the same classifier, the kernel argument was assigned a linear value while the random_state was set to 42 to keep the results predictable. Gaussian Naive Bayes was employed with no modification of its settings because of the model's simplistic nature. For Random Forest, we used the default parameters since the algorithm is capable of changing the setting on its own based on the complexity of given data. We initiated the Gradient Boosting with the default parameters so that the gradients could easily learn and an ensemble could be formed. Last but not least, we left all the parameters of k-Nearest Neighbors (kNN) for default value because the algorithm can find the optimal number of neighbors appropriate for the distribution of the data.

Following that, we proceed with the process of dividing this gathered data into two sets: the training and the testing ones. We split the data into training, where 70% of the data was allocated and the testing data where 30% was allocated.

Subsequently, the phase of model preprocessing is created for which it is essential to filter data effectively to ensure proper model training. In the case of feature transformation, we used scikit-learn's ColumnTransformer [17] to empower the numeric features normalization via the StandardScaler [23] while transforming the categorical variables into the binary format by the use of the OneHotEncoder [18]. This technique pays a lot of attention to ensuring that feature types are standard as well as harmonious. This method ensures consistency by creating a pipeline where preprocessing processes and the model are joined in the same line of work. This means that there is always uniformity in the training and the testing of the model, hence a manageable variability. Assuming the pipeline has been defined and is ready to proceed, we proceed to the next step of model training.

3.2.2 Models in Detail. In this study, many supervised learning classifier techniques that have proven valuable in the sports area for predictive purposes are employed. Logistic Regression is a statistical technique that predicts the probability of a binary classification, using a sigmoid function to map outputs to a [0,1] probability space. Coefficients indicate the strength and direction of relationships between variables, with positive values increasing the likelihood of an event and negative values decreasing it [9].

Random Forest extends the bagging method by generating multiple decision trees using randomly selected data samples. Each tree operates independently, and the final prediction is the average result across all trees, reducing overfitting and improving accuracy in classification tasks [4].

SVM aims to find the best hyperplane to separate data points by class, maximizing the margin between them. It handles nonlinear boundaries by transforming the input data into a higher-dimensional space [2].

Naïve Bayes, based on Bayes' theorem, assumes feature independence, making it fast and easy to implement, especially in applications like spam detection and text classification. Despite the simplicity of this assumption, it performs well in practice [26].

Gradient Boosting combines multiple weak learners (typically decision trees) to create a stronger predictive model, improving accuracy by focusing on correcting errors from previous models [6].

k-Nearest Neighbors (kNN) is an instance-based learning method that classifies data by identifying the majority label among the k closest points. Though simple, it can be computationally expensive as it requires storing all training data and performing real-time comparisons [7].

3.2.3 Evaluation Metrics. Last but not the least, the trained models are assessed by metrics such as accuracy of the models [19], precision of the models [21], the recall of the models [22], and F1-score value of the models [20]. This evaluation enables one to analyze how well each of the models is likely to perform in terms of match outcome prediction.

4 Results and Discussion

In this study, we employed six different classifiers to predict football match outcomes and conducted a comparative analysis of their performance. The effectiveness of each classifier was evaluated based on its accuracy, providing a clear comparison of their predictive capabilities across the dataset.

4.1 Model Performance

Among the classifiers employed, SVM predicted the most accurate results at 83% This model performed almost well, with balanced precision and recall across all three classes (A, D, and H), showing that it can predict match outcomes. In comparison, Random Forest achieved a lower accuracy of 65%, with especially evident deficits in precision and recall for class 'D'. Logistic Regression performed worse than Support Vector Machines, with accuracy of 77%. Despite its simplicity and computational efficiency, Gaussian Naive Bayes had the lowest accuracy of any classifier tested, at 39%. This model struggled to predict class 'D', with low accuracy and recall scores. Random Forest, an established ensemble learning approach, performed not so good, with an accuracy of 54%. This model has generally balanced accuracy and recall across all classes, making it an acceptable alternative for predicting match results. Gradient Boosting, another ensemble learning technique, has a little higher accuracy than Random Forest at 64%. While Gradient Boosting is recognized for its ability to manage complicated connections, it produced poorer recall ratings, especially for class 'D'. Lastly, k-Nearest Neighbors (kNN) resulted in 51% accuracy, showing that the classifier was relatively poor, they had relatively fair precision and recall with all the classes.

For making the match predictions, we employed the following classification models – Logistic Regression, Support Vector Machine, Gaussian Naive Bayes, Random Forest, Gradient Boost and k-Nearest Neighbors. We obtained the results varying from 39% to 83%, in which Support Vector Machines were the most effective. Our findings are partially consistent with prior research because classifiers like Support Vector Machines, Logistic Regression, and Random Forest have manifested robustness in predicting the match outcome across datasets. Nevertheless, the results are not in conformity with some emerging works, particularly concerning the efficacy of Gaussian Naive Bayes, which performed poorly in our study in contrast to other research results. It should be noted that results may vary significantly between different studies depending on the quality, the quantity, and the nature of the data that had been used for creating the models of Gaussian Naive Bayes.

Model	Accuracy	Precision	Recall	F1 score
Logistic Regression	77%	75%	74%	74%
SVM	83%	86%	83%	84%
Gaussian NB	39%	47%	42%	36%
Random Forest	54%	43%	46%	43%
Gradient Boosting	64%	64%	59%	60%
kNN	51%	49%	49%	49%

Table 2: Model Performances

The Table 2 shows how accurate various machine learning models are in predicting WWIN League of Bosnia and Herzegovina match outcomes.

4.1.1 Key factors influencing match outcomes. While this study does not perform formal feature analysis, the observed performance trends allow us to draw conclusions about the key factors influencing match outcomes. In line with prior research, home advantage emerged as a critical factor, with teams winning at home in over 50% of cases (Table 1) which reinforces the psychological and tactical advantages that come with playing on familiar ground.

Offensive metrics, particularly shots on target, also revealed themselves as strong predictors of success. Teams that generated more attempts on goal were significantly more likely to win, reinforcing the widely accepted view that aggressive, forward-driven play translates directly into better results. This trend mirrors observations from other football leagues, where offensive intensity is often directly correlated with victory.

4.1.2 Limitations and future work. Despite the promising results, this study has several limitations. First, the dataset used does not account for external factors such as player injuries, weather conditions, or team morale, all of which can influence match outcomes. Future research should incorporate these factors to improve the accuracy of predictions. Second, while SVM performed well in this context, more advanced models such as deep learning could potentially offer even better predictive performance, particularly when dealing with larger datasets.

Future work will explore the integration of additional domain-specific features, such as player statistics, team form, and environmental conditions, to further refine the predictive models. We will also experiment with more complex algorithms, such as neural networks, to capture the intricate relationships between features that may be missed by traditional machine learning models.

5 Conclusion

This study demonstrates that machine learning, particularly SVM, effectively predicts football match outcomes in the WWIN League of Bosnia and Herzegovina. Support Vector Machine has been found to be the highest accurate classifier with 83% of accuracy rate on match result prediction. SVM has moderate accuracy and recall with all three outcome classes: Home Win, Away Win, and Draw, indicating football prediction applicability. However, it has also revealed that other classifiers' performances are varying with Logistic Regression producing 77% of accuracy and Gaussian Naïve Bayes a poor 39% accuracy. Both Random Forest and Gradient Boosting, which are ensemble learning algorithms, have similar levels of accuracy; 54% and 64% respectively. While further refinement of the models is needed, the current findings establish a strong foundation for data-driven decision-making in football management. Future work should incorporate additional factors such as player injuries and weather conditions to enhance predictive accuracy.

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Sarcasm Detection in a Less-Resourced Language

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Abstract

The sarcasm detection task in natural language processing tries to classify whether an utterance is sarcastic or not. It is related to sentiment analysis since it often inverts surface sentiment. Because sarcastic sentences are highly dependent on context, and they are often accompanied by various non-verbal cues, the task is challenging. Most of related work focuses on high-resourced languages like English. To build a sarcasm detection dataset for a less-resourced language, such as Slovenian, we leverage two modern techniques: a machine translation specific medium-size transformer model, and a very large generative language model. We explore the viability of translated datasets and how the size of a pretrained transformer affects its ability to detect sarcasm. We train ensembles of detection models and evaluate models' performance. The results show that larger models generally outperform smaller ones and that ensembling can slightly improve sarcasm detection performance. Our best ensemble approach achieves an F_1-score of 0.765 which is close to annotators' agreement in the source language.

Keywords

natural language processing, large language models, sarcasm detection, neural machine translation, BERT model, GPT model, LLaMa model, ensembles

1 Introduction

Sentiment analysis is a popular task in natural language processing (NLP), concerned with the extraction of underlying attitudes and opinions, usually categorized as "positive", "negative", and "neutral". Detection of sentiment is challenging if the utterances are ironic or sarcastic. *Sarcasm* is a form of verbal irony that transforms the surface polarity of an apparently positive or negative utterance/statement into its opposite [6]. Sarcasm is frequent in our day-to-day communication, especially on social media [5]. This poses a significant problem for sentiment analysis tools since sarcasm polarity switches create ambiguity in meaning. Sarcasm is highly dependent on its context. For example, the sentence "*I just love hot weather*" could be interpreted as sarcastic, depending on the situation, e.g., during summer heat waves.

Historical developments of sarcasm detection are surveyed by Joshi et al. [3], while recent developments are covered by Moores and Mago [5]. The problem of automatic sarcasm detection in text is most commonly formulated as a classification task. Unfortunately, sarcasm detection is affected by the lack of large-scale, noise-free datasets. Existing datasets are mostly harvested from microblogging platforms such as Twitter and Reddit, relying on user annotation via distant supervision through hashtags, such as *#sarcasm*, *#sarcastic*, *#not*, etc. This method is popular since 1) only the author of a post can determine whether it is sarcastic or not, and 2) it allows large-scale dataset creation. However, this method introduces large amounts of noise due to lack of context, user errors, and common misuse on social media platforms. The sarcasm detection datasets created through manual annotation tend to be of higher quality but are typically much smaller. These problems are further compounded for non-English datasets, both manually labeled and automatically collected. Further, as sarcasm strongly relies on its context, using classical machine translation (MT) from English often produces inadequate results. This makes sarcasm detection in less-resourced languages, like Slovenian, an even bigger challenge. Therefore, developing reliable sarcasm detection models is of crucial importance for robust sentiment analysis in these languages.

We develop a methodology for sarcasm detection in less-resourced languages and test it on the Slovenian language. We address the problem of missing datasets by comparing state-of-the-art machine translation with large generative models. We explore the viability of such datasets and how the number of parameters affects a model's ability to detect sarcasm. We construct various ensembles of large pretrained language models and evaluate their performance.

The rest of this work is organized as follows. In Section 2, we discuss the proposed approach for detecting sarcasm in a less-resourced language such as Slovenian. We present the creation of a dataset, details of the training methodology and deployed ensemble techniques. We lay out our experimental results and their interpretations in Sections 2.3 and 4. In Section 5, we provide conclusions and directions for future work.

2 Sarcasm Detection Dataset

Existing attempts at automatic sarcasm detection have resulted in the creation of datasets in a small number of languages with differing sizes and quality. It is unclear if models trained on these datasets would generalize well to unseen languages [1]. Since no dataset exists for Slovenian, we leverage recent advances in machine translation and large language models (LLMs) to create a dataset for supervised sarcasm detection. We thus apply a translate-train approach when fine-tuning our models.

The prevalence of research done on sarcasm in English means that English datasets are usually larger and of higher quality than their counterparts in other languages. Further, as the translation from (and to) English is usually of better quality, we consider only English datasets.

Preliminary tests showed poor quality and poor translation ability of `Sarcasm on Reddit`[1] dataset, and `News Headlines Dataset For Sarcasm Detection`[2]. Hence, we chose the recent `iSarcasmEval`[3] dataset from the `SemEval-2022` shared task. We

[1] www.kaggle.com/datasets/danofer/sarcasm
[2] www.kaggle.com/datasets/rmisra/news-headlines-dataset-for-sarcasm-detection
[3] github.com/iabufarha/iSarcasmEval

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believe that relatively low performance scores obtained in this shared task could be improved with the use of larger LLMs.

2.1 iSarcasmEval Dataset

`iSarcasmEval` is a dataset of both English and Arabic sarcastic and non-sarcastic short-form tweets obtained from Twitter. We use only the English part, which is pre-split into a train and test set. Both sets are unbalanced, the former having 867 sarcastic and 2601 non-sarcastic examples, while the latter has 200 sarcastic and 1200 non-sarcastic examples. The authors of the shared task claim that both distant supervision and manual annotation of datasets produce noisy labels in terms of both false positives and false negatives [1]. Thus, they ask Twitter users to directly provide one sarcastic and three non-sarcastic tweets they have posted in the past. These responses are then filtered to ensure their quality. The produced dataset is not entirely clean since it contains links, emojis, and capitalized text. We chose to leave all of these potential features in the text, as they commonly occur in online conversations and could be indicative of sarcasm.

Let us mention, that an ensemble approach with 15 transformer models and transfer from three external sarcasm datasets proved to be the most accurate modeling technique for English [9] achieving an F_1-score of 0.605.

2.2 Translating iSarcasmEval

Our preliminary testing using smaller BERT-like classifiers showed that the models learned the distribution of the data and defaulted to the majority classifier (1200/1400 = 0.857 test accuracy). To try to dissuade this, we merged the train and test sets, kept all the sarcastic instances, and randomly sampled an equal number of non-sarcastic examples. This left us with a balanced dataset of 2134 samples.

To enable task specific instructions that would preserve sarcasm, we skipped classical machine translation tools, and tried two alternative translation approaches:

- using a medium-sized T5 model trained specifically for neural machine translation,
- leveraging a significantly larger model via OpenAI's API.

The T5 model uses both the encoder and decoder stacks of the Transformer architecture and is trained within a text-to-text framework. We chose Google's 32-layer T5 model called `MADLAD400-10B-MT`[4], which has 10.7 billion parameters and is pretrained on the `MADLAD-400` [4] dataset with 250 billion tokens covering 450 languages. Fine-tuning for machine translation was done on a combination of parallel data sources in 157 languages, including Slovenian.

As a generative model, we chose OpenAI's decoder-based `GPT-4o-2024-05-13`[5]. Its true size is not known to the public, but it's speculated that it is significantly smaller than `GPT-4`, since it is much faster and more efficient. OpenAI claims that it has the best performance across non-English languages of any of their models, thus making it suitable for our task.

When *prompting* generative decoder-based models, it is necessary to craft clear and specific instructions to achieve the best results. We used few-shot learning [2], and randomly sampled three training instances, manually translated them, and included them in the following prompt where the double forward slash was used as a delimiter between the query and the expected response.

You will be provided with a sarcastic/non-sarcastic sentence in English, and your task is to translate it into the Slovenian language. It should keep the original meaning. Examples:

- *love getting assignments at 6:25pm on a Friday!! // obožujem, ko mi v petek ob 18:25 pošljejo naloge!!*
- *I still can't believe England won the World Cup // Še vedno ne morem verjeti, da je Anglija zmagala na svetovnem prvenstvu*
- *taking spanish at ut was not my best decision 😐 // Učenje španščine na UT ni bila moja najboljša odločitev 😐,*

We manually assessed the outputs of both transformers in order to determine the best translations for fine-tuning detection models.

2.3 Translation Results

During translation, the T5 model sometimes had trouble with examples that had multiple newline characters in a row. It occasionally dropped parts of texts it didn't understand (mostly slang and various types of informal text styles). This shows that a 10B parameter model is not large enough to robustly translate all features of a language such as English into a less-resourced language such as Slovenian.

On the other hand, the GPT model performed surprisingly well in most instances and it seemed to have a more nuanced understanding of phrases used in online speech. It consistently translated entire texts, keeping the original structure and meaning. Consequently, we used GPT's translations when training sarcasm detection models. The translations can be seen in our repository[6].

3 Model Training

We tested the performance of a wide range of LLMs of different sizes. Their overview is contained in Table 1.

Table 1: Summary of used sarcasm detection models.

Model	Parameters
`SloBERTa`	110M
`BERT-BASE-MULTILINGUAL-CASED`	179M
`XLM-RoBERTa-BASE`	279M
`XLM-RoBERTa-LARGE`	561M
`META-Llama-3.1-8B-INSTRUCT`	8.03B
`META-Llama-3.1-70B-INSTRUCT`	70.6B
`META-Llama-3.1-405B-INSTRUCT`	406B
`GPT-3.5-TURBO-0125`	?
`GPT-4o-2024-05-13`	?

3.1 Encoder Models Under 1B Parameters

The four smallest models are encoder-based models that embed input text and use a classification head to assign it a class. They required additional fine-tuning to perform sarcasm detection. For these models, we conducted hyperparameter optimization.

We chose the `SloBERTa` [7, 8] model in order to check whether using a monolingual Slovenian model impacts sarcasm detection performance. We also wanted to compare BERT and RoBERTa-like models, so we used their multilingual variants and fine-tuned them on Slovenian data.

The models were trained for a maximum of five epochs with the use of early stopping, where the training was halted if the validation loss didn't improve after two epochs.

[4] huggingface.co/google/madlad400-10b-mt
[5] platform.openai.com/docs/models/gpt-4o
[6] github.com/GalaxyGHz/Diploma

3.2 Llama 3.1 Models

Since the teams that competed in the 2022 shared task on sarcasm mostly used BERT and RoBERTa models, we extend the testing to include significantly larger models. We chose Meta's open-source Llama family of models, more specifically, their newest Llama 3.1 variants. These come in three different sizes, which was perfect for studying the effects of parameter counts on sarcasm detection. We decided to use the "`instruct`" version of all three models since these were fine-tuned to be better at following instructions.

When prompting LLama and GPT generative models, the following few-shot classification prompt was given, with two positive and two negative examples randomly sampled from our dataset.

You will be provided with text in the Slovenian language, and your task is to classify whether it is sarcastic or not. Use ONLY token 0 (not sarcastic) or 1 (sarcastic) as in the examples:

- *Spanje? Kaj je to... Še nikoli nisem slišal za to? 1*
- *Lepo je biti primerjan z zidom* 😂 *1*
- *To sploh nima smisla. Nehaj kopati. 0*
- *Dne 12. 10. 21 ob 10:30 je bil nivo reke 0,37 m. 0.*

We used full versions of the 8B and 70B parameter models, while the 405B parameter model was loaded in 16-bit precision mode. To minimize the use of resources and costs, we employed LoRA parameter-efficient fine-tuning. We provided the models with training and validation sets and trained them for a maximum of 10 epochs. No hyperparameter optimization was conducted in this case due to time constraints. We used the validation loss to choose the best model, and we used the same early stopping technique as with the smaller models.

3.3 GPT 3 and 4 Models

We also tested two models offered on the OpenAI platform, `GPT-4o-2024-05-13` and `GPT-3.5-TURBO-0125`. We first used them in few-shot mode and classified all our examples without any fine-tuning. When fine-tuning, the platform's tier system limited us to only the smaller `GPT-3.5-TURBO-0125` model. We fine-tuned the model for a maximum of three epochs. In the end, we used the model with the lowest validation loss to classify the examples in the test set.

3.4 Sarcasm Detection Ensembles

When constructing ensemble models, we tried two techniques: stacking and voting. In both cases, we used the predicted probability of the sarcastic class from each model as input features.

3.4.1 Stacking With Regularized Logistic Regression. Our first ensemble used stacking approach, and logistic regression with Ridge regularization as the meta-level classifier. This choice was motivated primarily by the need for feature selection, as we wanted to identify the most important model predictions and determine which models would be assigned a lower weight. The best models were then used for voting.

3.4.2 Standard and Mixed Voting. The second ensembling method was voting. We tried cut-off-based mixed voting inspired by [9]. Formally, we used hard voting when the absolute difference between the number of sarcastic and non-sarcastic predictions was greater than n, and we used soft voting otherwise. We optimized the value of n based on the ensembles performance on our validation set.

When n is set to zero, this approach is equivalent to hard voting, and in the case of n being equal to the predictor count, it is equivalent to soft voting. We report both results. Additionally, we compare the results of voting using all trained models with the results obtained by using only the models with large weights in our regularized logistic regression ensemble.

4 Sarcasm Detection Results

Table 2 summarizes all our results. It is roughly sorted by model size, smaller models being on top and larger ones being on bottom. The `(NFT)` tag indicates that a model was not fine-tuned, while the `(LoRA)` tag means that a model was trained with LoRA. Results are rounded to three decimal places.

Table 2: Summary of performance results for all tested models. The best scores are in bold.

Model	Accuracy	F_1-score
`SloBERTa`	0.621	0.632
`BERT-BASE-MULTILINGUAL-CASED`	0.499	0.666
`XLM-RoBERTa-BASE`	0.578	0.579
`XLM-RoBERTa-LARGE`	0.550	0.597
`Llama-3.1-8B-INSTRUCT (NFT)`	0.560	0.676
`Llama-3.1-8B-INSTRUCT (LoRA)`	0.569	0.682
`Llama-3.1-70B-INSTRUCT (NFT)`	0.660	0.724
`Llama-3.1-70B-INSTRUCT (4-bit-LoRA)`	0.637	0.717
`Llama-3.1-405B-INSTRUCT (16-bit-NFT)`	0.686	0.751
`GPT-3.5-TURBO-0125 (NFT)`	0.564	0.679
`GPT-3.5-TURBO-0125`	0.749	0.760
`GPT-4o-2024-05-13 (NFT)`	0.686	0.746
`L2-LOGISTIC-REGRESSION`	**0.759**	**0.765**
`L2-LOGISTIC-REGRESSION-NON-COMMERCIAL`	0.707	0.749
`HARD-VOTING-ALL`	0.670	0.738
`SOFT-VOTING-ALL`	0.658	0.732
`HARD-VOTING-BEST-5`	0.686	0.749
`SOFT-VOTING-BEST-5`	0.686	0.749

Individual Model Performance

Out of all of the used models, only `BERT-BASE-MULTILINGUAL-CASED` failed to learn any pattern in our data and defaulted to the dummy classifier.

`GPT-3.5-TURBO-0125` sometimes predicts the correct token but then continues to generate additional text, such as 11 and 1\n1. This happens with a small quantity of examples in our testing set. We decided to truncate these responses and only kept the first token as the answer.

The Llama models sometimes refused to generate tokens zero or one. We decided to drop these examples altogether. We report the test accuracy and trained the ensemble models without them.

Smaller encoder models performed poorly when compared to some of the larger models. Only the `SloBERTa` model manages to achieve an accuracy above 0.6. Despite being the smallest of the four small models we tested, `SloBERTa` performed the best. This suggests that the three larger multilingual encoder models may lack sufficient understanding of Slovenian. It also highlights that model size alone does not necessarily correlate with better performance when it comes to sarcasm detection.

The Llama models fared better, achieving accuracies of up to 0.686 with the 405B model being comparable to GPT-4o in performance. They still fell short of the fine-tuned `GPT-3.5-TURBO-0125` model, which managed to successfully classify about three-quarters of our examples with a F_1-score of 0.76.

Some models had significantly higher F_1-scores and lower accuracies. We show the confusion matrix of one of the models

Table 3: Confusion Matrix for non-fine-tuned `Llama-3.1-405B-INSTRUCT` model.

Predicted \ Actual	Positive	Negative
Positive	202	123
Negative	11	91

that exhibited the largest difference in Table 3. These models seem to have a tendency to incorrectly classify non-sarcastic text as sarcastic, leading to a high rate of false positives.

Our testing also showed that loading the `Llama-3.1-70B--INSTRUCT` model in 4-bit mode and fine-tuning it with LoRA does not produce satisfactory results, and it is thus better to conduct full fine-tuning with the smaller Llama model or to use one of OpenAI's models via their fine-tuning API.

`GPT-3.5-TURBO-0125` performed the best among individual models, so if costs associated with the use of OpenAI's API are acceptable, we recommend its use for sarcasm detection in Slovenian. This shows that very large models can effectively identify sarcasm. We believe that with better parameter tuning, Llama 8B could be one of the best (and most economical) options for sarcasm detection in Slovenian, provided that the user has sufficient hardware resources.

Ensemble Model Performance

We observed that the regularized logistic regression mostly relied on the best-performing models. Its focus on the best model (`GPT-3.5-TURBO-0125`), however, suggests that there is significant overlap between the various model predictions.

We decided to discard `BERT-BASE-MULTILINGUAL-CASED` when constructing our voting ensembles since its dummy classification didn't contribute to overall model performance. Both of these two voting classifiers had an odd number of predictors, so there was no need for a tie-breaker mechanism.

Voting proved to be ineffective in our setups, even scoring lower than some of its base models. hard voting generally outperformed soft voting. We also note that there was no benefit in using mixed voting, at least for the sets of predictors that we obtained as hard voting always had a higher accuracy. This was true for both the classifiers that used all and only five of the base models.

Regularized logistic regression managed to improve on the scores of individual models, raising accuracy by one percent, thus achieving the best performance out of all of the tested approaches. This shows that there is still performance to be gained from ensembles; however, it is still necessary to use commercial models for top performance.

5 Conclusion

In this work, we presented the task of sarcasm detection in the less-resourced Slovenian language. Our code and results are freely available[7].

We tackled the missing dataset problem by using two LLMs to perform neural translation of an English dataset into Slovenian. The translations generated by `GPT-4o-2024-05-13` outpaced those generated by a large T5 model specifically trained for neural machine translation in terms of quality.

We used this data to train a plethora of Transformer-based models in various settings. We found that fine-tuning `GPT-3.5--TURBO-0125` via OpenAI's API results in the highest individual Slovenian sarcasm detection power, but we also note that a possible alternative could be local fine-tuning of the `Llama-3.1-8B--INSTRUCT` model. Our testing shows that using aggressive quantization combined with LoRA results in significant performance degradation.

We also constructed ensemble models based on voting and stacking methods. Observations showed that voting didn't result in any performance improvements. On the other hand, stacking with the use of a regularized logistic regression managed to improve on the performance of its base models.

Additional work needs to be done in dataset construction. Sarcastic examples could be extended with context or labels of the types of sarcasm they represent. This might help guide models towards better understanding of sarcasm. Future work could also explore incorporating heterogeneous models into ensembles or the creation of Mixture of Experts (MoE) ensembles, whose baseline models would focus on different aspects of sarcasm.

[7] github.com/GalaxyGHz/Diploma

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Speech-to-Service: Using LLMs to Facilitate Recording of Services in Healthcare

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Abstract

Digital tracking of services is one of the main administrative burdens of the healthcare staff. Here, we present a proof-of-concept study of a so-called speech-to-service (S2S) system that is aimed at facilitating recording of activities, extracting information from the conversation between a healthcare provider and recipient. The system comprises of a speech recorder, a diarization component, an LLM to interpret the conversation, and a recommendation system integrated in a smart tablet that records completed activities and suggests possible other activities that may have still be required. We tested the system on 350 conversations and obtained 95% accuracy, 97% precision and 94% recall.

Keywords

healthcare, LLM, speech recognition, recommendation system

1 Introduction

Healthcare workers, including nurses, technicians, and care personnel form the backbone of the health system as they care for patients and tend to their needs. However, with the standardization and systematization of the healthcare professions and services often becomes a large bureaucratic burden, as healthcare workers have to record all the activities and services they provide to the patients. This process is of course needed as it provides traceability and ensures that all the required activities were taken care of, but the problem is that the interfaces designed for activity logging are often not user-friendly and require the users to choose the activities from a extensive lists of drop-down menus. In total, this amounts to substantial time required only for tedious administrative tasks, time that would be more beneficially spent otherwise.

With the aim to alleviate the administrative burden of activity logging, we explored the possibilities of novel technologies to assist the healthcare staff in their logging tasks. We developed and tested a proof-of-concept system that records the conversation between the healthcare worker and a patient, identifies the activities, and allows the healthcare worker to batch-confirm them on a dedicated smart tablet. Batch-confirmation saves a lot of time by significantly lowering the number of clicks required in the UI. The system is built using open-source or publicly accessible components, particularly a speech-to-text system that transcribes the recorded conversation, and a large language model (LLM) that leverages its natural language processing capabilities. The recommender system shows possible required tasks, serving as a reminder and to suggest tasks that are expected soon, which may lower the number of visits per patient. These recommended tasks are then suggested to the healthcare worker, who can review and confirm them using the LLM-assisted interface. LLMs, such as ChatGPT and Llama, have seen a surge in popularity in a wide variety of topics since their popularization in particular with the unveiling of ChatGPT3 in the autumn of 2022.

Several LLM based systems have been proposed recently, including administrative task automation [6], decision making process [10], improving existing automatic speech recognition (ASR) systems [1], and providing patients with needed information [9]. A recent study [11] concludes that utilising ASR to ease some administrative tasks leads to faster, more efficient work and even increase workers' moods.

2 System Architecture

This paper describes two early prototype systems, both aiming to alleviate the workload of healthcare workers by easing the task of documenting care actions performed. These are the ASR system that logs care actions based on captured dialogue between the healthcare worker and the patient, and a recommender system that predicts the required services at a specific time. This recommender system relies on the historical data, appropriate for long-term patient care facilities.

Both systems are limited in scope and only target the most common healthcare services in the dataset for detection or prediction respectively, which can still greatly easy the workload for medical workers, since the top 10 most common tasks out of around 200 care action types represent around 80% of all services performed.

The recommender system allows the care workers to anticipate tasks in advance and server as a reminder. This aims to lower the number of patient visits, which also alleviates the workload.

2.1 Speech-to-Service ASR

The ASR system consists of a speech diarization model, capable of segmenting the recorded speech based on who is currently speaking, a speech transcription model that transcribes the audio

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to text, and a LLM fine-tuned to extract specific information from the text. Figure 1 shows the architecture of the prototype system.

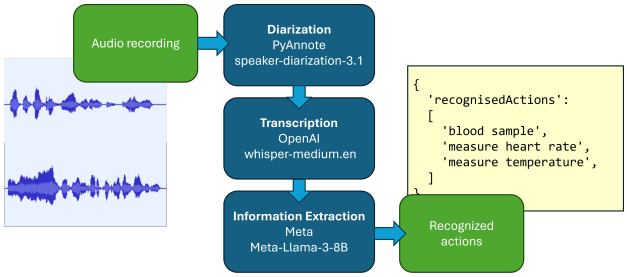

Figure 1: Overview of the ASR system.

We employ speaker-diarization pretrained model [1][4] for diarization, pyannote/speaker-diarization-3.1 pretrained model [7] for transcription, and fine-tuned Llama3 model[2][2] for information extraction via generating JSON formatted output.

2.2 Recommender System

The recommender system prototype is based on machine-learning prediction of events that are expected to occur in a certain time window for a specific patient with addition of tasks that commonly follow predicted tasks. Due to the sensitive nature of the data, we base our predictions only on the time window, patient ID and care type. Thus we consider multi-output binary classifiers that do not require large amounts of data for training. Additional tasks are added to the list based on a Markov chain model that commonly follow, e.g. the task 'clean table' follows the task 'lunch'.

The feature vector includes the time of day, day of week, week of month and month of year as numbers, allowing for capture of periodic events with different periods. Due to lack of patient data, we opted for personalized models, trained for each patient separately. We believe that results can be further improved by adding more patient-related attributes. The model training used five month period of data collected, with cross-validation, and the accuracy was evaluated on the data collected during the sixth month. Due to patients' medical states changing over time, some data drift is expected, which is reflected in our results.

3 Dataset

To fine-tune the information extraction model based on Llama3, we have created a dataset of conversations in text form and appropriate outputs for each of them, as the task on hand is very specific and we did not find any existing appropriate dataset. We automated the process and manually removed any bad examples. A real dataset, ideally recorded in the target environment, is needed for for final implementation - LLM generated datasets used for training LLMs are only appropriate in preliminary studies.

To generate the dataset, we prepared a BERT [3] LLM via prompting [5]. A training sample was generating by first randomly selecting 2 of the 10 target actions, and programmatically generating the target output JSON. The BERT model was then tasked with generating a conversation, in which these two tasks are mentioned as done during the conversation. We generated several hundred conversations that way, and manually checked for mistakes in the model output. Many conversations were removed due to selected actions not being mentioned or other reasons. Finally, the resulting dataset contains 350 conversations and JSON formatted lists of tasks.

For the prediction of services required during a visit, we have acquired a log of all services performed in one long-term patient care facility over a period of 6 months, with the next version expanding to data from six facilities. The tasks in dataset include measurements (body temperature, heart rate, blood pressure, ...), medical tasks (monitoring medicine intake, performing examinations, turning the patient in bed) and care tasks (breakfast, lunch, cleaning). There are over 200 different tasks mentioned. The dataset includes limited patient information—patient ID, care type, and a detailed chronological history of services received. Care types (CareType I, CareType II, CareType III/A, CareType III/B, CareType IIII) represent an estimate of how much assistance a person requires. Legal restrictions on accessing sensitive health data prevented us from obtaining more detailed patient records, so we developed prediction models based on these limited data points, balancing accuracy with regulatory constraints.

The data preprocessing involved determining each patient's presence in the facility by identifying the timestamps of their first and last recorded service. Patients with a stay of less than four months were excluded from the analysis to ensure sufficient data for reliable predictions.

4 Methods

This section describes the methodology used to develop the ASR system and the recommender system.

4.1 Clustering

The primary goal of the clustering process was to group patients with similar patterns in terms of the type and frequency of services they received, allowing us to predict relevant services more effectively for each cluster (since it was not clear, even among experts, whether care type and actual care provided were correlated).

The clusters, as shown in Figure 2, demonstrate that patients within the same care type tend to receive similar services. Some deviations, where multiple classifications appear within a cluster, are likely due to temporary conditions we could not fully exclude (for instance, an individual categorized under "Care Type II" may temporarily receive services typical of "Care Type III/A" (e.g. due to a broken arm), while their care type classification remains unchanged). Despite this, the care types differentiate well enough across clusters, leading us to use "CareType" as one of the key attribute for further service predictions.

In the clustering process, we excluded CareType IIII because this group is characterized by highly diverse healthcare needs due to specific diseases, and experts advised us to omit it for this part of the analysis.

4.2 Recommender System

To recommend the required services, we constructed the training dataset using a detailed log of care actions performed over a 6-month period. For each patient, the data was divided into consecutive 4-hour time windows. In each window, we examined whether specific care actions were performed, marking them as "positive" if they occurred within that time frame. This granular approach allowed us to capture the temporal dynamics of

[1] pyannote/speaker-diarization-3.1
[2] meta/meta-llama-3-8b
[3] google-bert/bert-base-multilingual-cased

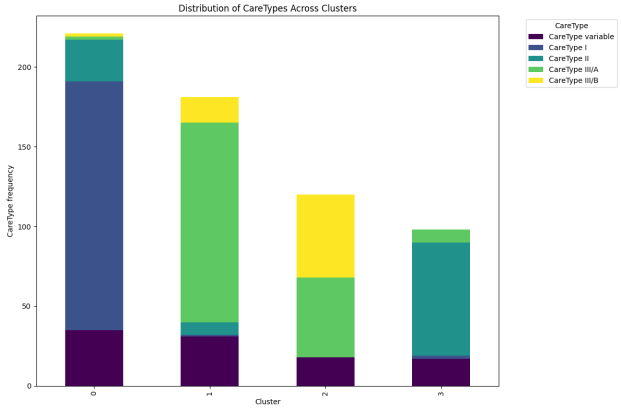

Figure 2: Clustering of patients closely aligns with pre-existing care type assignments, ranging from minimal personal assistance (CareType I) to moderate assistance (CareType II), and full or intensive personal assistance (CareTypes III/A and III/B) for those with more severe care needs.

service delivery, ensuring that for each time window, we had a clear record of the services provided. As a result, we generated over 1000 labeled examples per patient, with each example representing a specific time window and its associated care actions. This enabled the model to learn patterns in service requirements throughout the day and week.

To identify the best predictive model, we evaluated various classification algorithms, including Random Forest, Decision Tree, K-Neighbors, Support Vector Classifier (SVC), Gradient Boosting, and Naive Bayes. Each model was trained using a multi-output classification approach, with features including the frequency of the top services provided and the relevant time attributes. To ensure robust model evaluation, we implemented 5-fold cross-validation and subsequently tested the models on the sixth month's data to assess their predictive performance.

4.3 Speech Recognition and Information Extraction

Due to limited availability of training data, only the information-extraction model based on Llama3 was fine tuned using few-shot LoRA (low-rank adaptor) supervised training. The diarization and transcription models are used unchanged.

The diarization model used is speaker-diarization [4]. Initial experiments with few-shot LoRA fine tuning [3] did not improve the performance, hinting at the need for a larger training dataset. The model's performance is satisfactory at the task of segmentation, but less so at the task of identifying which segments belong to which speaker, especially for longer conversations. For a two-speaker situation, the model seems to assume the speakers take turns speaking, causing mistakes when a single speaker pauses before continuing to speak.

The transcription model used is whisper [8]. The model transcribes each segment separately. As mentioned above, the speakers are not robustly recognised, and we cannot reliably assign a speaker to each line of text. Still, labeling each line of text even with an ambiguous label improves the downstream task of information extraction. The transcribed lines of text are concatenated, and at the start of each utterance a label marking it as such is added. Thus, the transcribed text resembles a play with unknown characters speaking.

The information extraction model is Llama3 [2], and fine-tuned utilising a LoRA few-shot fine tuning. Our approach was to fine-tune the model for the task of extracting information about specific care actions and generate the output in a JSON format, providing structured data directly. A small training dataset was prepared as described in the section 3.

5 Results and Discussion

5.1 LLM Based Infromation Retrieval Model

The Llama3 based information extraction model is evaluated using a 5-fold cross validation, achieving **95% accuracy**, **97% precision**, and **94% recall**. For evaluation the model's JSON-formatted strings were deserialized to objects and tested against known correct objects to be able to interpret the results as multi-label binary classification.

The LLM infromation extraction model sometimes generates invalid JSON after fine-tuning, most commonly due to duplicated keys or getting stuck in a loop, generating same elements until maximum output size is generated. The generated strings are therefore post-processed to fix these mistakes via simple string manipulation, however this indicates that experiments with different output formats or avoiding generating the answers should be performed.

The whole ASR pipeline including diarization and transcription has not yet been evaluated and falls within the scope of future work.

5.2 Recommender System

Tables 1 and 3 present the classification results. Table 1 reports the average performance across all patients, including standard deviations for the different models, while Table 3 shows classification accuracy by care type, with averages and standard deviations across all patients within each care type, based on the model with the best results, which in this case is K-Neighbors (KNN).

Results are reported in two ways, tables 1 and 3 show accuracy considering all target attributes, only considering a prediction correct when all targets are predicted correctly. The table 2 show average of accuracies for each target attribute.

Table 1: Cross-validation and test accuracy (mean ± standard deviation) across all patients for various classification models.

Model	CV Accuracy	Test Accuracy
RandomForest	0.71 ± 0.14	0.66 ± 0.16
DecisionTree	0.65 ± 0.16	0.66 ± 0.16
KNeighbors	**0.73 ± 0.13**	**0.71 ± 0.16**
SVC	0.63 ± 0.12	0.63 ± 0.14
GradientBoosting	0.68 ± 0.12	0.66 ± 0.15
NaiveBayes	0.57 ± 0.17	0.55 ± 0.20

The K-Neighbors (KNN) classifier outperformed other models, achieving an average CV accuracy of 73%, a test accuracy of 71%, and R^2 score of 0.44. This made it the most effective model for predicting service plans. Random Forest also performed reasonably well, achieving a test accuracy of 66%, though it did not surpass KNN in overall performance.

Table 2: Majority Class Percentage and Task-wise Test Accuracy (mean ± standard deviation) across all patients for various classification models.

Model	Majority Class Percentage	Task-wise Accuracy
RandomForest	0.72 ± 0.19	0.89 ± 0.10
DecisionTree	0.72 ± 0.19	0.89 ± 0.11
KNeighbors	**0.72 ± 0.19**	**0.91 ± 0.10**
SVC	0.65 ± 0.16	0.88 ± 0.10
GradientBoosting	0.65 ± 0.16	0.89 ± 0.09
NaiveBayes	0.72 ± 0.19	0.85 ± 0.15

Table 3: Classification performance of K-Neighbors (KNN) by CareType, showing cross-validation and test accuracy (mean ± standard deviation), averaged across all patients within each care type.

CareType	CV Accuracy	Test Accuracy
CareType I	0.79 ± 0.12	0.76 ± 0.16
CareType II	0.79 ± 0.11	0.78 ± 0.13
CareType III/A	0.68 ± 0.13	0.66 ± 0.15
CareType III/B	0.70 ± 0.14	0.68 ± 0.17
CareType IIII	0.68 ± 0.10	0.67 ± 0.12

Since all predictive accuracy values exceed the 70% majority class baseline, this is an excellent result. In multi-label classification, where multiple services are predicted simultaneously, it's important to not only focus on overall accuracy but also on the accuracy of each individual task. By achieving 90% accuracy on the most common tasks, the model ensures that key services are reliably predicted.

The lower test accuracy compared to cross-validation can be explained by temporal changes in patient conditions, as the test set only included the last month of data. As patient care needs shift over time, predicting long-term patterns is more challenging than shorter-term cross-validation, where care remains more stable.

The test accuracy also reflected noticeable differences across care types. CareType I and CareType II showed higher accuracy rates, while more complex types, such as CareType III/A, III/B, and IIII, exhibited a drop in accuracy of around 10%. This is likely due to the more diverse and unpredictable care needs in these groups, making service prediction more challenging.

This approach, particularly with the strong performance of our K-Neighbors (KNN) model, demonstrated the potential of machine learning to enhance personalized planning in healthcare. In future work, including additional patient-specific features beyond time-based data, such as health-related attributes, could further improve accuracy, particularly for the more complex care types.

6 Conclusions

This is early work and further improvements are underway. The whole ASR pipeline needs to be evaluated and we expect noticeably worse performance comparing to only the information extraction model due to larger complexity and possibility for failure at each step. The information retrieval model itself is not inefficient considering computational time and memory required, but diarization and transcription steps are. The required service prediction should also be further improved. Using current dataset an alternative approach that may improve performance is using sequence modelling or event prediction approaches. Finally, the two models could work in tandem - predicting the required actions and using that information in the ASR pipeline could be beneficial.

Based on the proof-of-concept study, we conclude the suggested approach is in principle feasible and can be beneficial to healthcare providers. However, in view of regulations, special caution has to be paid during the implementation of any sort of such system in a real-world setting. Recording and diarizing conversations between healthcare staff and the patients is likely to include highly personal data, which falls under the EU relevant legislation, specifically the GDPR (*General Data Protection Regulation*) [4] and the EU AI Act (*Artificial Intelligence Act (Regulation (EU) 2024/1689)*) [5]. Furthermore, indiscriminately recording conversations and feeding them into an LLM will likely be considered as "high risk" in view of the AI Act. This means that implementing such services will require extensive screening, documentation, clear division of ownership and access roles, and other compliance with legal requirements.

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Performance Comparison of Axle Weight Prediction Algorithms on Time-Series Data

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Abstract

Accurate vehicle axle weight estimation is essential for the maintenance and safety of transportation infrastructure. This study evaluates and compares the performance of various algorithms for axle weight prediction using time-series data. The algorithms assessed include traditional machine learning models (e.g., random forest) and advanced deep learning techniques (e.g., convolutional neural networks). The evaluation utilized datasets comprising time-series data from 10 sensors positioned on a single lane of a bridge, with the goal of predicting each vehicle's axle weights based on the signals from these sensors. Each algorithm's performance was measured against the OIML R-134 recommendation, where a prediction was classified as accurate if the error was within ±4 percent for two-axle vehicles and ±8 percent for vehicles with more than two axles. Tests were conducted on several bridges, with this paper presenting detailed results from the Lopata bridge. Findings indicate that deep learning models, particularly convolutional neural networks, significantly outperform traditional methods in terms of accuracy and their ability to adapt to complex patterns in time-series data. This study provides a valuable reference for researchers and practitioners aiming to enhance axle weight prediction systems, thereby contributing to more effective infrastructure management and safety monitoring.

Keywords

time-series data, axle weight, machine learning, neural network

1 Introduction

Accurate axle weight prediction plays a pivotal role in the maintenance and safety of transportation infrastructure [7]. The precise estimation of axle weights is essential for various applications, including road maintenance planning, traffic management, and the prevention of overloading, which can lead to premature road wear and increased accident risks [8]. Traditional methods for axle weight measurement often rely on static scales or weigh-in-motion (WIM) systems. While these methods provide direct measurements, they are susceptible to limitations such as high installation and maintenance costs, potential measurement inaccuracies due to environmental factors, and the need for frequent calibration.

In recent years, the advent of advanced computational techniques has opened new avenues for improving axle weight prediction. Machine learning (ML) and deep learning (DL) algorithms, in particular, offer promising alternatives by leveraging time-series data to model complex, non-linear relationships inherent in vehicular weight patterns. These methods can enhance prediction accuracy, handle large volumes of data, and adapt to varying conditions, making them suitable for real-world applications where traditional methods may fall short.

This study systematically evaluates and compares the performance of various axle weight prediction algorithms using time-series data. We focus on a diverse set of algorithms, including machine learning models like random forests (RF) [6] and advanced deep learning techniques such as convolutional neural networks (CNN) [4].

The objective of this research is to explore the potential of combining traditional WIM systems with advanced ML and DL models to enhance axle weight predictions. By comparing the performance of different methodologies, including the SIWIM traditional model, random forest (IJS RF), a hybrid approach (AVERAGE(IJS, SIWIM traditional)), and a CNN-based model, this study aims to identify the most effective strategies for accurate and reliable axle weight estimation. Additionally, it examines the impact of synthetic data generation on the performance of these models, providing a comprehensive evaluation of their practical applicability in real-world scenarios.

The study aimed to predict the axle weights of vehicles using ten input signals from sensors placed under the Lopata bridge.

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Each predictive algorithm's performance was evaluated according to the OIML R-134 recommendation, which is deemed accurate if the error margin for predicting the axle weight is within ±4% for vehicles with two axles and within ±8% for vehicles with more than two axles.

The dataset comprised 1478 samples, i.e. passing of a vehicle, each containing 10 signals per vehicle. For each sample, a static weight for each axle was assigned as the target value. Static weight refers to the weight measured by a scale when the vehicle is stationary.

This paper is structured as follows: Section 2 reviews several state-of-the-art approaches. Section 3 details the preprocessing steps necessary before applying machine learning methods. In Section 4, algorithms used for predicting axle weights are presented. Section 5 presents the final results of the axle weight predictions. Finally, Section 6 summarizes the findings and proposes ideas for future research.

2 Related Work

The prediction of axle weights using time-series data has often been studied in recent years, resulting in a substantial body of related work. Below, several state-of-the-art (SOTA) approaches are described.

Zhou et al. [10] differentiated between high-speed and low-speed weigh-in-motion (WIM) systems and analyzed the characteristics of axle weight signals. They proposed a nonlinear curve-fitting algorithm, detailing its implementation. Numerical simulations and field experiments assessed the method's performance, demonstrating its effectiveness with maximum weighing errors for the front axle, rear axle, and gross weights recorded at 4.01%, 5.24%, and 3.92%, respectively, at speeds of 15 km/h or lower.

Wu et al. [8] introduced a modified encoder-decoder architecture with a signal-reconstruction layer to identify vehicle properties (velocity, wheelbase, axle weight) using the bridge's dynamic response. This unsupervised encoder-decoder method extracts higher features from the original data. A numerical bridge model based on vehicle-bridge coupling vibration theory demonstrated the method's applicability. Results indicated that the proposed approach accurately predicts traffic loads without additional sensors or vehicle weight labels, achieving better stability and reliability even with significant data pollution.

Xu et al. [9] applied wavelet transform for denoising and reconstructing the WIM signal, and used a back propagation (BP) neural network optimized by the brain storm optimization (BSO) algorithm to process the WIM signal. Comparing the predictive abilities of BP neural networks optimized by different algorithms, they found the BSO-BP WIM model to exhibit fast convergence and high accuracy, with a maximum gross weight relative error of 1.41% and a maximum axle weight relative error of 6.69%.

Kim et al. [5] developed signal analysis algorithms using artificial neural networks (ANN) for Bridge Weigh-in-Motion (B-WIM) systems. Their procedure involved extracting information on vehicle weight, speed, and axle count from time-domain strain data. ANNs were selected for their effectiveness in incorporating dynamic effects and bridge-vehicle interactions. Vehicle experiments with various load cases were conducted on two bridge types: a simply supported pre-stressed concrete girder bridge and a cable-stayed bridge. High-speed and low-speed WIM systems were used to cross-check and validate the algorithms' performance.

Bosso et al. [1] proposed a method using weigh-in-motion (WIM) data and regression trees to identify patterns in overloaded truck weights and travel. The analysis reveals that truck type is the key predictor of overloading, while time of day is crucial for axle overloading, with most incidents occurring late at night or early morning. These insights can enhance enforcement strategies and inform pavement management and design, optimizing infrastructure longevity and safety.

He et al. [2] introduced a new method that uses only the flexural strain signals from weighing sensors to identify axle spacing and weights, reducing installation costs and expanding BWIM applications. The method's accuracy is validated through numerical simulations and laboratory experiments with a scaled vehicle-bridge interaction model, showing promising results for accurate axle spacing and weight identification.

3 Data Preprocessing

Before applying various algorithms to the dataset, several preprocessing steps were necessary. Due to the differing lengths of signals from each sample, padding was performed to standardize them to the length of the longest signal. Samples with a gross weight below 5 kN were excluded from both the training and test datasets. Each signal was cropped by removing data to the left of the leftmost peak value minus 100 and to the right of the rightmost peak value plus 100. The peak values were calculated in advance.

To address the limited availability of data required for deep learning, which typically necessitates tens of thousands of samples for effective training, synthetic data generation was employed. The original dataset comprised 1,478 samples (from January 2022 to December 2023) i.e. passing of a vehicle, each containing 10 signals per vehicle. An additional 20,000 synthetic samples were generated using a specific algorithm. This algorithm operates by iterating 20,000 times, during each of which a random training sample and a random strain factor were selected. The strain factor is a random value ranging between 0.5 and 0.99. The selected signal from the training sample was then scaled by the chosen strain factor. This scaling process effectively models the feature that doubling the amplitude of the signal corresponds to doubling its weight.

A crucial aspect of data preprocessing involved the normalization of sensor signals to ensure uniformity across the dataset. Each signal was normalized to have a mean of zero and a standard deviation of one, which helps in improving the convergence of machine learning algorithms by ensuring that each feature contributes equally to the learning process.

The selection of training and test data was conducted using a rolling window approach [3]. Specifically, for each testing month, the training data comprised all available data up to but not including the testing month. For instance, if May 2023 was designated as the testing month, the training dataset consisted of data from January 2022 through April 2023. This process was systematically repeated for each testing month from March 2022 to December 2023.

4 Methodology

Four methods were identified as applicable for predicting vehicle axle weights. The first method, known as SIWIM traditional [11], calculated the number of axles, axle lengths, and axle weights by utilizing influence lines to model the signal and determine the correct output. For validation purposes, each predicted output

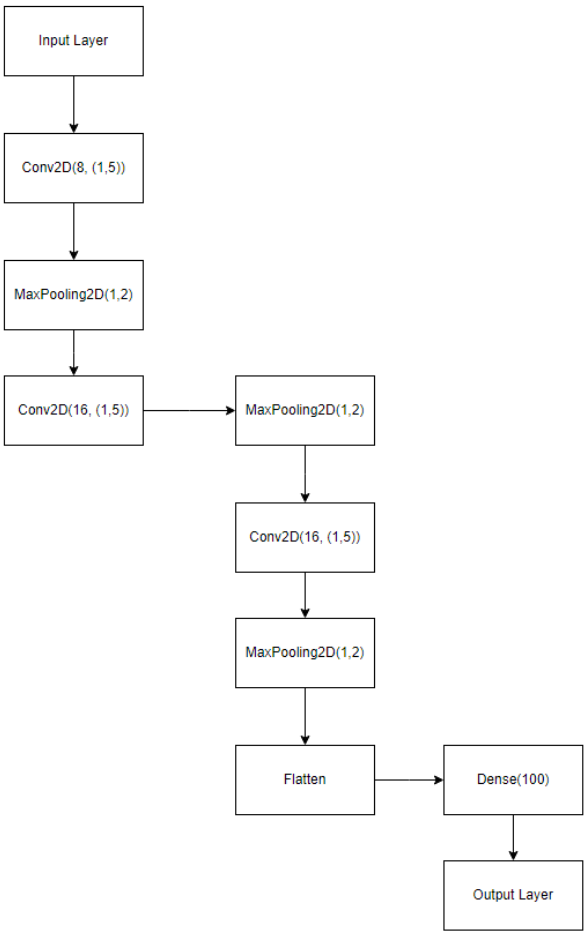

Figure 1: Architecture of CNN for predicting axle weights.

was stored in a separate file alongside the signal data, enabling direct comparison with the actual values.

The second method used the random forest [6] (named IJS RF) for predicting vehicle axle weights. The model relied on accurately identifying the positions of peaks to function correctly. Peak values were determined using the *find_peaks* method from the SciPy library, which identifies peaks based on a specified minimum height. Once the peaks were identified, the algorithm extracted values within a ±5 range of each peak. These extracted values were then used as input features for the random forest model. Additionally, the random forest model incorporated temperature, axle distances and gross weight as input features. Random forest algorithms are not inherently suited for time series data; however, they perform effectively with numerical data such as temperature, axle distance, and gross weight. Therefore, this algorithm was chosen for analyzing this type of input data.

The third method integrated the first two approaches by averaging the outputs from the SIWIM traditional and IJS RF models (named AVERAGE(IJS, SIWIM traditional)). This approach is motivated by the concept that combining multiple models can often yield more accurate results than relying on a single model alone [12].

The final method employed a convolutional neural network (CNN) to predict axle weights. The CNN utilized synthetic data, as detailed in section 3, during the training phase. This method processed all 10 signals as input to calculate the axle weights. The detailed architecture of the CNN is shown in Figure 1. 2D Convolutional layers (Conv2D) were used instead of 1D Convolutional layers due to the input data consisting of 10 sensor signals. The number of filters and kernel size are specified within the parentheses of each Conv2D layer, while the pooling size is defined in each 2D MaxPooling layer parentheses (MaxPooling2D). The last Dense layer has 100 neurons. To mitigate overfitting, a Dropout layer was added after the final Dense layer. Additionally, Batch Normalization was applied after each 2D Convolutional layer to further reduce the risk of overfitting.

Although Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) neural networks could be used for this task, a Convolutional Neural Network (CNN) was chosen instead because of its strengths in capturing spatial hierarchies and local patterns within the data. CNNs are highly effective at extracting local features and detecting patterns, while LSTM and GRU are better suited for handling temporal dependencies, which are not that relevant to this specific task.

5 Results

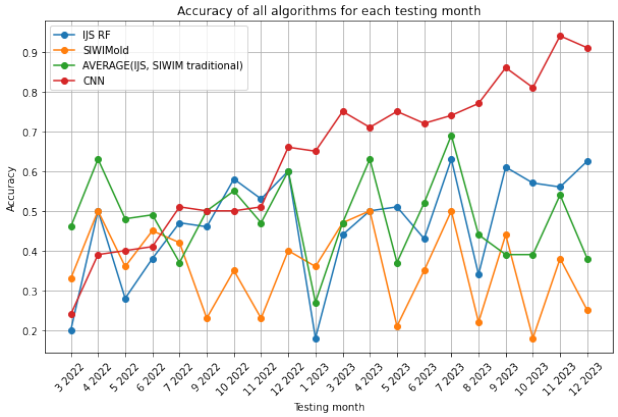

Figure 2: Accuracies of all algorithms for each testing month.

The results of each method described in Section 4 are illustrated in Figure 2. Among the methods evaluated, SIWIM traditional exhibited the poorest performance, with fluctuating trends observed throughout the entire two-year period. The CNN began to outperform the other three approaches after December 2022. Conversely, the AVERAGE(IJS, SIWIM traditional) method showed superior performance during the initial testing months from March 2022 to June 2022.

The performance of the CNN improved with an increasing amount of data, whereas the IJS RF and AVERAGE(IJS, SIWIM traditional) methods were more effective during the initial phase when less training data was available. However, the improvement in CNN's accuracy was not linear. This non-linear trend can be attributed to the random initialization of the CNN's weights before each training session, occasionally leading to suboptimal convergence.

An additional analysis was conducted to compare the performance of the models under varying environmental conditions, such as temperature fluctuations and differing traffic patterns. This analysis revealed that the CNN model maintained its accuracy more consistently across different conditions, indicating its

robustness and adaptability. Furthermore, the inclusion of synthetic data in training the CNN model contributed to its superior performance, as it allowed the model to learn from a more diverse set of examples. Future research should focus on expanding the range of synthetic data and exploring additional ensemble techniques to further enhance prediction accuracy.

Despite achieving high accuracy with the CNN model, with the highest accuracy reaching 0.94, this most accurate method still falls short of meeting the OIML R-134 recommendation by 4.4%. Furthermore, the results show that more static data could be needed for the learning phase. Having 1000 static samples which were augmented might not be sufficient to reach the OIML R-134 recommendation.

In summary, the results indicate that while traditional methods such as IJS RF and AVERAGE(IJS, SIWIM traditional) perform well with limited data, convolutional neural networks (CNNs) demonstrate superior performance as more data becomes available, despite some variability in their convergence. In addition, a sufficient number of training examples is needed to approach the desired OIML R-134 recommendation.

6 Conclusion and Discussion

In this study, a performance comparison of various axle weight prediction algorithms using time-series data collected from 10 sensors positioned on the Lopata bridge was conducted. The algorithms evaluated encompassed traditional machine learning models, such as random forests, and advanced deep learning techniques, notably convolutional neural networks.

The major findings reveal that CNNs achieved significantly better results in predicting axle weights during the latter months of the experiment. The CNNs' ability to adapt to and learn from complex patterns within the time series data was a key factor in their superior performance. Despite achieving high accuracy with the CNN model, reaching a peak accuracy of 0.94, this method still falls short of meeting the OIML R-134 recommendation by 4.4%.

Overall, there are three implications of this study. First, it demonstrates the potential of deep learning techniques to enhance the accuracy of axle weight predictions where sufficient data is available, thereby facilitating more reliable infrastructure management. Second, for smaller datasets, it is more effective to use classical machine learning systems in combination with methods like SIWIM traditional. Third, it provides a valuable benchmark for researchers and practitioners, guiding the development and implementation of more effective axle weight prediction systems.

To achieve the OIML R-134 recommendation, two options are possible:

- Just add more data - if the trend continues, adding another half a year of measurements would enable achieving the standard. Another option would be to apply measurements on a bridge with more traffic.
- Improve the methods by incorporating advanced ensemble techniques.

To introduce the ensemble approaches, one potential improvement involves modeling each sensor individually. This approach entails building a separate CNN model for each of the ten sensors, allowing for more specialized and potentially more accurate predictions from each sensor's data. By focusing on the unique characteristics and data patterns of each sensor, the models can be better tailored to capture specific nuances in the time-series data.

After developing individual models for each sensor, the next step would be to combine the predictions from these models into a single final prediction. This can be achieved using an ensemble method, such as a random forest classifier. The random forest classifier would take the ten individual predictions (one from each sensor model) as input features and produce a consolidated final axle weight prediction.

This method not only holds the potential to improve the accuracy and robustness of the axle weight predictions but also provides a scalable framework that can be adapted to different datasets and sensor configurations. Future work should explore the implementation of this approach, including the optimization of individual sensor models and the integration of their predictions through an ensemble method.

By advancing the CNN model in this manner, it is anticipated that the performance gap relative to the OIML R-134 recommendation could be further reduced, bringing the predictions closer to the required accuracy levels with a smaller amount of data and enhancing the overall efficacy of the axle weight prediction system.

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Comparison of Feature- and Embedding-based Approaches for Audio and Visual Emotion Classification

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Abstract

This paper presents a comparative analysis of feature- and embedding-based approaches for audio-visual emotion classification. We compared the performance of traditional handcrafted features, using MediaPipe for visual features and Mel-frequency cepstral coefficients (MFCCs) for audio features, against neural network (NN)-based embeddings obtained from pretrained models suitable for emotion recognition (ER). The study employs separate uni-modal datasets for audio and visual modalities to rigorously assess the performance of each feature set on each modality. Results demonstrate that in the case of visual data NN-based embeddings significantly outperform handcrafted features in terms of accuracy and F1 score when training a traditional classifier. However, for audio data the performance is similar on all feature sets. Handcrafted features, such as facial blendshapes, computed from MediaPipe keypoints and MFCCs, remain relevant in resource-constrained settings due to their lower computational demands. This research provides insights into the trade-offs between traditional feature extraction methods and modern deep learning techniques, offering guidance for the development of future emotion classification systems.

Keywords

emotion recognition, embeddings, hand-crafted features

1 Introduction

Automated emotion recognition (ER) often focuses on two modalities – video and audio. This is akin to human emotion recognition, as we heavily rely on audio-visual characteristics, such as facial expressions and audio cues, to deduce emotional state [7]. Both audio and video are relatively simple to obtain using sensors, as such sensors are unobtrusive and easily available (e.g., webcameras) and can be used to train machine learning (ML) models for emotion recognition.

In the past decade deep-learning (DL) approaches achieved state-of-the-art (SOTA) results in many domains, including emotion recognition [16]. However, despite the superior performance of such models, many doubts have been cast on their black-box nature, lacking explainability and interpretability of the internally derived features [9]. Furthermore, while some research suggests superior performance of embeddings compared to traditional features [20], this is not universally agreed upon [8], especially when taking into account potentially much higher computational complexity of deriving embeddings with deep artificial neural networks (ANNs).

Our research question is thus, whether it is better to compute embeddings using SOTA pretrained DL models instead of using hand-crafted features, as ANN embeddings promise to increase detection accuracy at the cost of interpretability and computational complexity. In this work we compared the performance of hand-crafted features and embeddings obtained with pretrained SOTA models for the down-stream task of emotion recognition. We independently compared ER performance of audio and video modality, using established benchmark datasets for each. Handcrafted features were chosen based on literature and embeddings were computed with task-suitable pretrained models available in existing Python libraries. Both were formatted in a way that allowed us to then train a set of traditional ML models, listed in Section 3.3, for ER, using hand-crafted features, embeddings, or a union of both as inputs.

2 Related Work

Performance comparison of hand-crafted features and learned embeddings has been discussed in depth in computer vision domain. Schonberger et al. [15] demonstrated that hand-crafted features (e.g., SIFT) still perform on par or better than learned embeddings in image reconstruction. They warned of high variance across datasets when using learned embeddings as features. Similarly, Antipov et al. [2] reported similar performance of hand-crafted features (e.g., HOG) and learned embeddings when classifying pedestrian gender from images using small datasets. They also highlighted superior generalization performance of embeddings across (unseen) datasets. In emotion recognition from audio, Papakostas et al. [13] compared using hand-crafted MFCC-based features with embeddings from a custom convolutional neural network (CNN) trained on spectrograms. The latter slightly outperformed hand-crafted features by 1% on average in terms of F1 score, again showing similar performance. Ye et al. [21] recently showed that using a union of both hand-crafted features and learned embeddings achieves superior performance in user identification, compared to using each input individually.

There is moderate (but not universal) agreement in recent literature that performance between hand-crafted features and

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learned embeddings is similar, however, most work comparing their performance is limited to a single modality or task. We compared performance between two different modalities for the task of ER and investigated potential performance improvements of feature-level fusion (hand-crafted + embeddings).

3 Methodology

Our task consisted of two parts – hand-crafted features and embeddings computation, and ER model training for classification. Both were done on (separate) audio and visual modality and will be described per-modality in the following sections.

3.1 Datasets

As mentioned previously, the ER task is most-often audio-visual, so we decided to use an audio and a visual dataset to independently evaluate the performance of different feature sets. While many datasets exist that contain both modalities, they often have a problem of imprecise coarse emotion labelling [18], as labels are video-based, while emotions can be exhibited and changed in much shorter windows. Splitting video into frames yields a large number of (different) instances with the same label, so we wanted a dataset with individual image labels. As our focus was on comparing the performance of hand-crafted and embedding-based features, we chose two well-established benchmark datasets dedicated to audio and visual emotion classification. These datasets contain short audio clips and individual images with precise short-term and per-frame labels, circumventing the mentioned per-video labelling problem.

3.1.1 Audio Dataset. For evaluation on audio data we decided to use the crowd-sourced emotional multimodal actors dataset (CREMA-D) [4]. It contains short clips of 91 actors between the ages of 20 and 74 coming from a variety of races and ethnicities, who exhibited six different emotions (*Anger, Disgust, Fear, Happy, Neutral, Sad*). Each actor produced about 80 clips (small variation), saying specific sentences exhibiting different emotions. The distribution of labels was balanced, each class representing approx. 16% of the data. The intended emotions were verified with 2,443 crowd-sourced human raters as baseline. These raters predicted emotions based on audio only, video only, or both, achieving 40.9%, 58.2% and 63.6% recognition of intended (acted) emotion respectively.

3.1.2 Visual Dataset. For visual data we chose the extended Cohn-Kanade dataset (CK+) [11], which a staple dataset in ER evaluation from facial expressions. It contains images of 118 adults, aged between 18 and 50, again of different ethnicities. Participants were instructed to perform a series of 23 facial displays, relating to one of seven emotions (*Anger, Contempt, Disgust, Fear, Happy, Sad, Surprise*). The distribution of classes in CK+ is not balanced – *Surprise* is the majority class at 25% and *Contempt* the minority class at 6%, with others in between. This distribution also changes between subjects. CK+ images were reshaped to 48x48 pixels, put in grayscale format and cropped using frontal face Haar cascade classifier [1] as part of preprocessing. The emotion labels were validated by experts via facial activation unit rules (e.g., *Happy* = Activation unit 12 must be present = Lip corner puller active).

3.2 Feature Computation

For selection of hand-crafted features we relied on literature and previous work in ER for each modality. For embeddings on the other hand, we chose SOTA pretrained models trained for related tasks. We extracted embeddings at a model-specific point before the learning layers, and formatted them using principal component analysis (PCA) in order to reduce their dimensionality while maintaining the relevant information.

3.2.1 Audio Features. MFCCs are historically well-established in ER from audio [10], as they give a good approximation of the human auditory system's response. For each audio clip, we computed a common set of statistical aggregate features (averages, standard deviations) for MFCCs, Root Mean Square (RMS) energy (volume), Zero-Crossing Rate, Spectral Bandwidth, Spectral Contrast, and Spectral Roll-off, using the `librosa` python library.

For embeddings we decided to investigate models pretrained on similar audio tasks (e.g., emotion recognition) and use them to the point where embeddings are available, which typically means the upper part of the ANN architecture, responsible for computation of embeddings representing the features. Three pretrained models were investigated in our evaluation, all based on the wav2vec2 architecture, which is a self-supervised model for learning speech representations proposed by Facebook AI Research (FAIR) [3]. Full wav2vec2 pretraining framework comprises a latent feature encoder, a context network using the transformer architecture, a quantization module and contrastive loss (pre-training objective). For our purposes the feature encoder is important, which is a 7-layer 1D CNN reducing the dimensionality of audio inputs into a sequence of feature vectors. The initial model version was pretrained on the LibriSpeech dataset, another version was fine-tuned on IEMOCAP dataset specifically for ER, and finally a large general cross-lingual model (XLSR) was trained on millions of hours of unlabeled audio data in 53 (later extended) languages [5]. These three variants were used to extract their corresponding embeddings. Since the input data from CREMA-D is of inconsistent shape (varying by < 1 sec), we had to employ an additional adaptive average pooling layer to ensure consistently shaped outputs. We designed this pooling layer so that we lost minimal information (short segment length for pooling) and the outputs were then flattened. PCA was employed to subsequently reduce them to 10 dimensions. The number of dimensions was chosen arbitrarily and could be changed, however, we believe that 10 dimensions offer a good balance between retained information and computational (and spatial) requirements. Moreover, this number of PCA components is on the same order of magnitude as the number of hand-crafted features, making them more comparable.

3.2.2 Visual Features. For visual features, we focused on the movement of specific facial keypoints, such as the corners of the mouth and eyebrows, which form the basis of the Facial Action Coding System (FACS) – a taxonomy that categorizes human facial expressions based on muscle movements [6]. We employed the MediaPipe (MP) framework [12] to extract values representing the activation of various facial blendshapes, which correspond approximately to the regions defined in FACS. In this paper, we classify MediaPipe features as "handcrafted" because, despite being neural network-based, they quantify predefined facial areas with human-interpretable metrics. This contrasts with CNN-based embeddings, which capture patterns without direct interpretability.

For comparison, we used embeddings from two pretrained models: FaceNet [17] and EfficientNet [19] from the HSEmotion library [14]. FaceNet architecture is based on GoogleNet, which is a variant of deep CNN, and is trained using triplet loss. It

was optimized for facial recognition, verification, and clustering. EfficientNet comprises several inverted bottleneck convolutional residual blocks. It achieved SOTA results on the AffectNet ER dataset, while being relatively light-weight. Again, PCA was used to reduce the embeddings to 10 dimensions.

3.2.3 Computational and Spatial Requirements. In order to have a clear overview of the trade-off between computational and spatial requirements of each feature computation method, and their classification performance discussed in the next section, we first report the average times to compute and disk sizes of the output (per one instance) for each method in Table 1.

Table 1: Average time and disk space needed for feature computation using each method.

Modality	Feature method	Avg. Time	Avg. Space
Audio	MFCC stats	**19 ms**	**< 1 kB**
	wav2vec2 LibriSpeech	99 ms	194 kB
	wav2vec2 XLSR	274 ms	258 kB
	wav2vec2 IEMOCAP	101 ms	5 kB
Video	MediaPipe	10 ms	**< 1 kB**
	FaceNet	29 ms	2 kB
	EfficientNet	**2 ms**	5 kB

When interpreting the results in Table 1, it must also be considered that DL-based methods require additional computational time when doing PCA on top of the raw embeddings.

3.3 Emotion Classification

Data splitting is a crucial step in evaluation of ML models, as it must be done in a way to avoid overfitting and provide a robust evaluation of generalization capabilities of a model. The aim of this research was primarily not to evaluate the absolute performance of ER, but rather compare the performance when using hand-crafted vs. embedding features. Therefore it was crucial to consistently ensure that the same data splits and models were used in each experiment, for each of the compared inputs. We decided for the most robust leave-one-subject-out (LOSO) evaluation, always using default model hyperparameters. Such experimental setup minimized overfitting and also gave a good overview of generalization performance of emotion classifiers.

4 Experiments and Results

The outputs of the previous step were used as inputs (features) to train a traditional ML model for emotion classification. We evaluated several options: taking the 10 PCA components of embeddings obtained from each pretrained model as inputs, taking only hand-crafted features as inputs, and taking union of both as input. Each of these cases was evaluated for audio and visual modality separately, using the LOSO experimental setup. Several popular ML models were compared (with default hyperparameters), including k-nearest Neighbours (kNN), Random Forest (RF), Support Vector Machines (SVM) with linear kernel, and eXtreme Gradient Boosting (XGB). We monitored classification accuracy and macro F1 score as metrics of the model performance. All results were compared with baseline majority classifier and are reported as averages across all iterations of LOSO, where majority was always taken from the train data (all except left-out).

4.1 Audio Emotion Classification

As mentioned in Section 3 we investigated the following options as feature inputs:

(1) Hand-crafted statistical features relating to MFCCs
(2) 10-component PCA of wav2vec2 embeddings from a model trained on LibriSpeech
(3) 10-component PCA of wav2vec2 embeddings from a model trained on IEMOCAP
(4) 10-component PCA of wav2vec2 embeddings from a cross-lingual XLSR model
(5) Union of hand-crafted and best-performing embeddings (from above)

These were compared in experiments as described in Section 3.3, using a set of four ML models. Results of best-performing model for each set in terms of accuracy and F1 are given in Table 2. Fused data was acquired by concatenating the feature sets.

Table 2: Best performing models for each feature set and corresponding accuracy and F1 scores for audio data. Note that embeddings were represented with 10 components obtained from PCA.

Feature set	Best model	Accuracy	F1 score
N/A	Majority	0.17±0.00	0.05±0.00
MFCC stats	RF	0.46±0.08	0.43±0.09
wav2vec2 LibriSpeech	SVM	0.47±0.08	0.45±0.09
wav2vec2 XLSR	SVM	0.30±0.05	0.27±0.05
wav2vec2 IEMOCAP	SVM	0.47±0.08	0.42±0.09
MFCC + **best** wav2vec2	SVM	**0.52±0.09**	**0.50±0.10**

4.2 Image Emotion Classification

To stay consistent with the audio experiments we performed the same LOSO experiments described in Section 3.3. We compared model performances using the following features as inputs:

(1) MediaPipe blendshapes
(2) 10-component PCA of FaceNet embeddings
(3) 10-component PCA of EfficientNet embeddings
(4) Union of MP and FaceNet embeddings
(5) Union of MP and EfficientNet embeddings

Accuracy and F1 scores for the best performing models for each set of features are again reported in Table 3

Table 3: Best-performing models for each feature set and corresponding accuracy and F1 scores for visual data. Note that embeddings were represented with 10 components obtained from PCA.

Feature set	Best model	Accuracy	F1 score
N/A	Majority	0.25±0.00	0.40±0.00
MediaPipe	RF	0.62±0.28	0.51±0.29
FaceNet	SVM	0.45±0.30	0.36±0.30
EfficientNet	RF	**0.93±0.16**	**0.90±0.20**
Mediapipe + FaceNet	XGB	0.70±0.28	0.60±0.29
Mediapipe + EfficientNet	XGB	**0.93±0.17**	**0.90±0.21**

4.3 Discussion

From Tables 2 and 3 we can observe that for audio the best performance is achieved when using union of hand-crafted and embedding features, while for visual ER the performance of only embeddings or union is nearly identical. The improvement of feature union is thus generally small, as for visual data we get the same result as using only the best embeddings (1% difference in standard deviation), while for audio data the improvement in

both metrics is about 5% compared to individual feature sets. All results substantially outperform the baseline majority classifiers.

For audio data we can see that the best embedding set (wav2vec2 LibriSpeech) performs nearly the same as hand-crafted features (MFCC stats), which is in agreement with some literature [13]. It is surprising that LibriSpeech embeddings slightly outperform IEMOCAP ones, since the latter were trained specifically for emotion recognition, while the former were not. The subpar performance of XLSR is expected, since it is a more general cross-lingual unsupervised model, while investigated data is spoken in English. For visual data on the other hand the best embeddings (EfficientNet) substantially outperform hand-crafted facial expression features (MediaPipe) and those obtained from FaceNet. This is expected, as EfficientNet was trained specifically for emotion recognition, while FaceNet was trained for face recognition. In terms of ML models, we consistently observed best performance of SVM for ER from audio data, while for video data the best model is not as homogeneous. Importantly, performance of different models (RF, SVM and XGB) was often within 1%.

Another important observation is the relative stability of results across subjects when classifying from audio, with standard deviations around 8%. The same was not observed in the evaluation from visual data, with much higher standard deviations, indicating lower stability and greater variation between subjects.

To address our initial research question, we observed similar performance of hand-crafted features and embeddings from SOTA DL models for audio-based ER, with union of both achieving the best results. The image-based visual ER achieved much better performance with learned embeddings as inputs, while the union of features showed no improvement. However, the cost of hand-crafted features and embeddings in terms of computational power required to compute, and spatial requirements to save, is not the same. While hand-crafted features are usually computed quickly and represented with a few numbers, as reported in Table 1, the embeddings require loading a (commonly large) pretrained ANN, which performs a large number of matrix multiplications, resulting in high-dimensional embeddings (e.g., 64×512). This in turn requires additional dimensionality reduction, such as PCA employed in this work. Our results indicate that for image-based visual ER, the additional cost is worthwhile, due to large improvements in performance, while audio-based ER achieved much smaller improvement, making the use of embeddings from pretrained models less attractive.

Finally, hand-crafted features mostly offer direct interpretability (e.g., audio loudness), while embeddings are commonly black-box in nature, lacking explainability without suitable mechanisms on top. The clear meaning of hand-crafted features can be helpful when training traditional ML models, where feature importance can be compared and subsequently interpreted.

5 Conclusion

In summary we compared using hand-crafted features, embeddings of pretrained SOTA models, or union of both, as inputs for ER models using audio and visual data. We found that embedding-based approach is substantially superior with visual data, outweighing the computational cost – the latter is in fact the lowest when using EfficientNet. For audio data, the improvement was only seen in union of inputs, and was relatively low.

As future work it would be worthwhile to compare merged audio-visual features and embeddings in a single ER problem on the same dataset having both modalities. Furthermore, currently used data was simulated/acted, so interpretation of these results must take that into account. Numbers are expected to decrease on a more realistic dataset, as emotions in everyday life are quite subtle [18]. It would thus make sense to run similar experiments on more realistic data as well, although such data is more scarce.

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Multi-modal Data Collection and Preliminary Statistical Analysis for Cognitive Load Assessment

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Abstract

To mitigate distractions during complex tasks, ubiquitous computing devices should adapt to the user's cognitive load. However, accurately assessing cognitive load remains a significant challenge. This study aims to present sophisticated, multi-modal data collection, which can enable accurate estimation of cognitive load using wearable and contact-free devices. A total of 25 participants participated in six cognitive load-inducing tasks, each presented at two levels of difficulty. Simultaneously, physiological and behavioral data were collected from a multi-modal sensory setup, including: Empatica E4 wristband, Emteq OCOsense glasses, an eye tracker, a thermal camera, a depth camera and an RGB video camera. Additionally, participants provided subjective measures of cognitive load by completing standardized NASA Task Load Index (NASA TLX) and Instantaneous Self-Assessment (ISA) questionnaires following each cognitive task. Preliminary statistical analyses were conducted on participant demographics, performance metrics, and the perceived difficulty of tasks, as reported in the completed questionnaires.

Keywords

cognitive load inference, wearable sensors, contact-free unobtrusive sensors

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1 Introduction

Human attention is a critical resource that is increasingly targeted by mobile applications, online services, and other forms of digital engagement. In an era of constant connectivity, capturing and retaining user attention has become a primary objective for many technologies. However, as users engage in cognitively demanding tasks, distractions can lead to performance degradation and increased stress. Therefore, to minimize interruptions and maintain productivity, ubiquitous computing systems must become capable of recognizing and adapting to the user's cognitive load in real time.

Cognitive load, defined as the mental effort required to process information and perform tasks, triggers a series of physiological responses in the human body. These responses are largely governed by the activation of the sympathetic nervous system. When cognitive load increases, measurable changes can be observed in physiological markers, including blood pressure, brain activity, eye movements, electrodermal activity (EDA), respiration rate, heart rate variability, etc. Furthermore, changes are also reflected in facial expressions, posture, and other behavioural patterns.

This study seeks to offer a unique multi-modal dataset with a rich set of wearable and unobtrusive sensors to capture the subtle changes that occur with the gradual activation of the sympathetic nervous system. Rather than solely focusing on maximizing data accuracy through the use of numerous devices, this approach also aims to identify the minimum set of sensors required to achieve reliable cognitive load assessment. To that end, rich multi-modal data was collected from a myriad of sensors, including wearables

(OCOsense glasses and Empatica E4 wristband) and contact-free unobtrusive sensors such as an advanced eye tracker, a thermal camera, a depth camera, and an RGB video camera. To the best of our knowledge, no prior dataset exists containing such rich multi-modal data obtained with such an elaborate sensory setup.

2 Related Work

The challenge of cognitive load estimation has been extensively studied across various fields. Significant emphasis has been placed on reducing cognitive load in dynamic environments, such as aviation [1]. Recent research has increasingly focused on transitioning from direct measurements, such as electroencephalography (EEG), to indirect methods of cognitive load assessment. For instance, ocular metrics, including pupil diameter and blink rate, have been shown to accurately estimate cognitive load [2, 3, 4]. Additionally, facial temperature variations have been widely correlated with cognitive workload, providing another non-invasive means of assessment [5, 6]. Novak et al. demonstrated that biometric indicators, such as galvanic skin response and skin temperature, can signal increased cognitive load; however, these measures are insufficient to distinguish between varying levels of cognitive load [7]. Wang et al. demonstrated that visual cues—including face pose, eye gaze, eye blinking, and yawn frequency—can serve as indicators of cognitive load [8].

This research aims to address the complexities of cognitive load estimation by integrating a wide range of psychophysiological signals, offering a more comprehensive approach to this task.

3 Experimental Setup

The objective of our data collection was to capture participants' cognitive load under varying levels of difficulty imposed by cognitive load-inducing tasks. The study was conducted in a quiet, temperature-controlled room, with participants tested individually. At the beginning of each session, participants were seated in a comfortable chair in front of a 24” monitor and given instructions about the experiment and their expected role. The Empatica E4 wristband was then fitted to the participant's non-dominant hand, and the OCOsense glasses for emotion recognition were equipped in line with product instructions.

Data collection was further enriched through the use of unobtrusive sensing technologies, including a Tobii Spark eye tracker (60 frames per second), an Intel RealSense Depth Camera D455 (providing depth data at 30 fps), a Logitech BRIO stream 4k webcam at 10 fps with HDR and noise-canceling microphones and a FLIR Lepton 3 thermal camera delivering a full 160x120 pixel thermal resolution with 8 fps. We used this set of devices to continuously monitor participants throughout the recording session. The experimental setup can be observed in Figure 1.

4 Data Collection Protocol

Prior to the experiment, participants completed a brief sleep questionnaire to gather information about their sleep patterns (e.g., hours slept the night before and usual sleep duration) and rated their levels of fatigue and focus on a scale of 1 to 10.

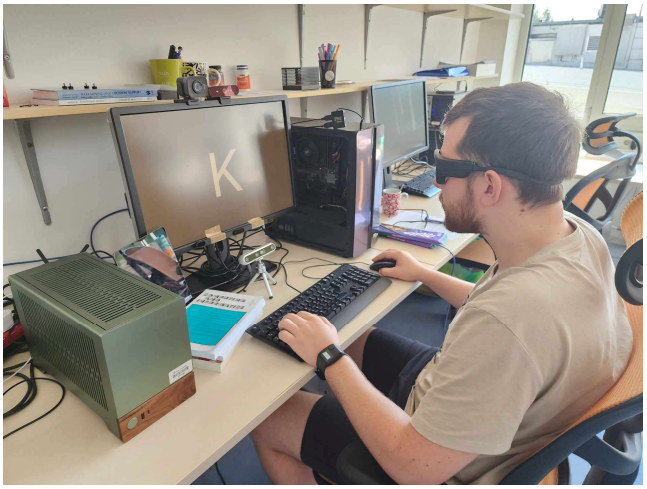

Figure 1: Experimental setup

Calibration data for the OCOsense glasses was then recorded by having participants replicate four facial expressions — smiling, frowning, brow raising, and eye squeezing — three times each. Calibration for the eye tracker followed, during which participants tracked a moving dot with their eyes. This calibration aimed to optimize participant's seating position for accurate eye-tracking.

The experiment's main phase involved participants completing cognitive load-inducing tasks that tested three aspects of cognition: attention, memory, and visual perception. For each cognitive domain, two widely recognized tasks were presented, each with two levels of difficulty (easy and difficult). This design allowed for the differentiation of cognitive load levels. Following each category of cognitive tasks, participants engaged in relaxation tasks that were not expected to induce cognitive load, such as meditation with open eyes, listening to music to relieve stress and passive viewing of aesthetically pleasing images. These tasks provided baseline data for periods of minimal cognitive load.

In summary, each recording session included six cognitive load-inducing tasks (with two levels of difficulty) and three relaxation tasks, totaling 15 tasks. After each task, participants completed the NASA Task Load Index (NASA TLX) questionnaire, a validated instrument for assessing cognitive load across six dimensions: mental demand, physical demand, temporal demand, performance, effort, and frustration [9]. Each question was rated on a scale of 0 to 100. In this study, the unweighted version of the NASA TLX, known as the Raw NASA TLX, was used. Additionally, participants completed a single-item Instantaneous Self-Assessment (ISA) of workload, providing a subjective measure of the cognitive load induced by the task [10]. These questionnaires served as subjective assessments of cognitive load and as reference points for the difficulty of each task [11].

The tasks were implemented using PsychoPy, an open-source software package commonly used in neuroscience and experimental psychology research [12]. For attention-related tasks, participants completed the N-back and Stroop tests. In the N-back task, participants were presented with a sequence of letters and asked to determine whether the current letter matched the one

presented N trials earlier (with task difficulty increasing as N increased) [13]. Participants completed both a 2-back and a 3-back task. In the Stroop test, participants identified whether the word matched the color in which it was written, with the easier version involving two colors (red and blue) and the more difficult version incorporating five colors [14].

Memory-related tasks included a memory game and a question-answering task based on a previously shown image. In the memory game, participants recalled as many words as possible from a set, with the easier version comprising seven words and the more difficult version consisting of 15 words. In the question-answering task, participants focused on an image and then answered questions about it (e.g., remembering the number of particular objects in the image), with the hard version using an image with greater detail.

The visual perception tasks included a "spot the difference" task and a pursuit test. In the "spot the difference" task, participants were presented with two images and were asked to identify as many differences as possible within a one-minute time frame. The difficulty of this task varied, with the more challenging version involving an image that contained greater detail compared to the simpler, easier version. The pursuit test required participants to visually track irregularly curved, overlapping lines. As with the "spot the difference" task, the pursuit test was administered at two levels of difficulty. The more difficult version featured a more intricate image, with longer and more tangled lines, as opposed to the less complex image used in the easier version of the task.

5 Statistics

In this section, we present some descriptive demographic and task-related statistics for the participants involved in the experiment. The average age of participants was 29.28 years, with a standard deviation of 8.31. In terms of educational background, the majority of participants (44 %) had obtained a Bachelor's degree (BSc), followed by those with a Master's degree (MSc), 28 %. A smaller portion had completed only high school (16 %) or had earned a PhD (12 %). Additionally, 60 % of the participants were male.

We then looked at the descriptive statistics derived from the performance of the participants in each task. These indicate that participants performed consistently well on tasks such as the 2-back task, both easy and difficult versions of the Stroop test, the easy memory task (where participants recalled an average of 5 out of 7 words), the easy version of the "spot the difference" task (with an average detection rate of approximately 90 % of all the differences), and both versions of the pursuit test. Notably, participants performed slightly better on the difficult version of the Stroop test, likely due to their increased familiarity with the task.

However, performance was lower on tasks such as the 3-back test (which most participants perceived as highly or extremely difficult), the difficult memory task (with an average recall rate of 39 %), and both the easy and difficult question-answering tasks. The difficult version of the "spot the difference" task also showed lower performance, with participants detecting only 25 % of the differences on average. Consistent performance among subjects (with low standard deviation) was observed across all tasks except for the N-back tasks. Notably, the N-back tasks were always presented first to participants, suggesting that they may have required additional time to adjust to the testing environment and fully engage with the task.

Next, an inferential statistical analysis was performed on the relationship between task scores and various variables of the sleep pattern. To investigate the potential influence of tiredness on performance, responses from the sleep patterns questionnaire were analyzed. A non-parametric Kruskal-Wallis test was performed to determine whether there was a statistically significant difference in overall scores across different levels of tiredness (low, medium, and high). The resulting p-value (0.91) indicated no significant difference in performance between these groups. Thus, tiredness levels did not show a statistically significant impact on performance within a 95 % confidence interval.

Similarly, the effect of focus level (low vs. high) on overall performance was examined using a non-parametric Mann-Whitney test. The p-value was 0.12, indicating no statistically significant difference in performance between low and high focus groups at the 5 % significance level.

Furthermore, the relationship between hours of sleep the night before the experiment and participant performance was examined using Spearman's correlation. The p-value was 0.42, indicating no statistically significant correlation between overall performance scores and hours of sleep the night before the experiment.

The potential influence of participants' highest education level on overall performance was also investigated. To assess this, a non-parametric Kruskal-Wallis test was conducted. The results (p-value of 0.33) indicated no statistically significant difference in performance scores across different education levels among the participants.

Overall, the small sample size may have constrained the ability to detect significant effects. The limited variability in the sample's educational background and other factors likely contributed to the lack of observed differences, emphasizing the need for a larger, more diverse sample to better understand the impact of these variables on cognitive load performance.

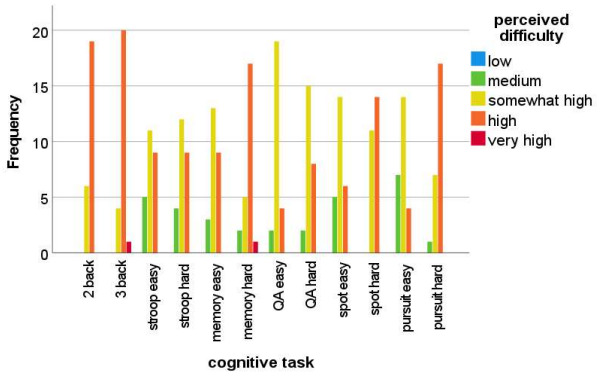

Figure 2: Reported perceived difficulty per cognitive task

As shown in Figure 2, participants consistently perceived the difficulty of the two N-back tasks and the difficult version of the "spot the difference" task as somewhat high or high. This suggests a general consensus regarding the difficulty of these tasks. In contrast, the NASA TLX-based perceived difficulty of remaining tasks, exhibited significant variability among participants.

To assess differences in performance across task difficulties and evaluate the potential for differentiating cognitive load using machine learning models, we conducted additional inferential statistical analyses. The Wilcoxon signed-rank test was used to compare participant performance on the easier and more difficult versions of each cognitive task.

Statistically significant differences in performance were found between the two difficulty levels for all tasks. For the N-back, "spot the difference", and pursuit tasks, participants performed significantly better on the easier versions, indicating that increased difficulty negatively impacted performance. Conversely, for the Stroop, memory, and question-answering tasks, participants performed better on the more difficult versions.

The statistical analysis conducted in this study provides initial evidence supporting the validity of the data collection protocol, particularly with respect to the selection of tasks and task difficulty levels. The tasks chosen for this experiment varied significantly in terms of their cognitive demands, as reflected by the substantial differences in performance between the easier and more difficult versions of each task. These results indicate that cognitive load and performance are task-specific, and the significant differences observed support the feasibility of using machine learning models to differentiate between varying levels of cognitive load.

6 Conclusion and Future Work

This study employs a novel approach to data collection for cognitive load inference by combining psychophysiological data obtained from multi-modal sensory setup, including wearable and unobtrusive contact-free sensors. The decision to utilize a diverse set of devices was motivated by the hypothesis that integrating data from multiple sources could provide a more accurate assessment of cognitive load, while also aiming to identify the minimal sensor configuration required to achieve reliable results. This is particularly relevant in dynamic and high-stakes environments, such as driving, where accurate cognitive load assessment could have life-saving implications. To the best of our knowledge, no prior research has incorporated such a comprehensive and multifaceted setup for cognitive load evaluation.

The statistical analyses conducted thus far offer promising validation for the data collection protocol. The selection of tasks and task difficulty levels proved effective in eliciting a range of cognitive load levels, as evidenced by the significant performance differences between task difficulties.

To further enhance the validity of the data collection protocol, several changes could be implemented in potential subsequent collections. Refining task difficulty levels could offer more granularity in cognitive load differentiation, ensuring a clearer distinction between varying levels of cognitive load. Furthermore, increasing the diversity of participants in terms of age, educational background, and other demographic factors is desirable to enhance the generalizability of the findings.

In future work, the collected data will be processed and utilized to train machine learning models aimed at estimating cognitive load. Ground truth for the machine learning models can be derived from various sources, including perceived task difficulty reported through the standardized questionnaires, the designed difficulty level of the tasks or the participants' performance on the tasks. These machine learning models will leverage sophisticated ML techniques to effectively integrate and analyze multi-modal data, aiming to enhance the accuracy of cognitive load predictions. We also plan to further expand the dataset with another phase of data collection, offering a rich dataset both in terms of modalities, as well as in terms of participants. The collected dataset will serve as a stepping stone towards robust multi-modal cognitive load assessment, allowing for creation and benchmarking of ML models and will be made available to general public after the collection is finalized.

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Predicting Health-Related Absenteeism with Machine Learning: A Case Study

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Abstract

Health-related absenteeism, or sick leave, is a complex issue with significant financial and operational implications for businesses. We present a machine learning approach to predict employee absenteeism in a Slovenian company. The study involved preprocessing and augmenting the dataset by incorporating domain knowledge, and evaluating various machine learning models. Gradient Boosted Regression Trees emerged as the most effective model, significantly outperforming the baseline model which merely predicted the previous year's absenteeism rate. Key attributes influencing absenteeism were identified, notably including current absenteeism, performance evaluations, and various job type and location-related features. Results highlight the potential of machine learning in proactively managing absenteeism and offer recommendations for future research, such as modeling absenteeism as a time series and incorporating additional data sources. We also show that the current data is not detailed and granular enough to further improve the results.

Keywords

absenteeism, data analysis, data augmentation, machine learning

1 Introduction

Absenteeism — temporary absence from work due to health reasons — is awidespread issue. In Slovenia, it has been on the rise since 2014 (Figure 1), with an average of 56,128 individuals absent daily in 2022, representing approximately 5.91% of the workforce [8]. This carries substantial financial burdens: direct costs like sick pay and indirect costs from overstaffing, reduced productivity and service quality [2]. The complexity of absenteeism, rooted in personal and organizational factors, makes it challenging to predict and manage effectively [10].

Recent years have witnessed a growing interest in leveraging artificial intelligence (AI) and machine learning (ML) to address the absenteeism challenge [5]. Various machine learning techniques, including neural networks, decision trees, random forests, and gradient boosting, have been employed to predict absenteeism and identify its underlying causes [3, 9]. These studies have demonstrated the potential of machine learning in providing valuable insights for proactive absenteeism management.

This paper presents a case study conducted in collaboration with a Slovenian IT company[1] aiming to improve absenteeism prediction and management. The study includes preprocessing and augmenting the company's employee data by incorporating domain knowledge, and evaluating various machine learning models. The findings highlight key attributes influencing absenteeism and offer recommendations for future research and interventions.

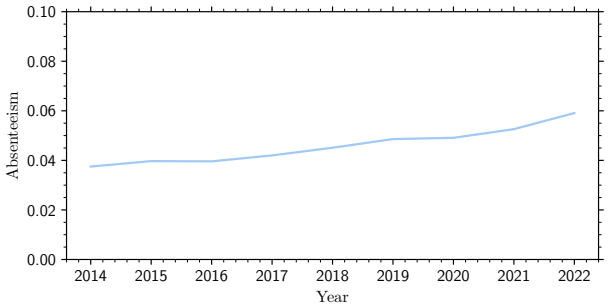

Figure 1: The increase in absenteeism rate in Slovenia between 2014 and 2022 [8]. We can observe a steady increase throughout the years.

The significance of our work extends beyond Company X, offering a blueprint for organizations tackling absenteeism. By showcasing machine learning's efficacy in predicting absenteeism and revealing its drivers, we contribute to the broader field and pave the way for data-driven interventions promoting a healthier, more productive workforce. This aligns with the growing trend of using AI and ML to address complex organizational challenges. Insights from such analyses can aid in strategic workforce planning, optimize resource allocation, and ultimately contribute to a more sustainable and resilient organization.

In section 2 we detail the data and preprocessing, section 3 outlines the methodology, section 4 presents the results, and section 5 discusses the findings and concludes the study.

2 Materials

The data used in our work spanned six years, from 2017 to 2022, and initially comprised 13,798 instances (aggregated employee records) with up to 49 attributes each. They include demographic details, work-related factors, performance evaluations and the current year's absenteeism rate for each employee, but no particulars about sick leave and other personal data.

The initial dataset required substantial preprocessing to prepare it for analysis and machine learning [6]. The data cleaning process involved addressing inconsistencies in attribute values, such as removing extraneous spaces and converting text to lowercase for uniformity. A significant challenge in the dataset was the presence of missing values, denoted by '/'. Their meaning and handling were discussed with a company representative to determine their origins and ensure appropriate treatment. In some

[1]The company asked to remain anonymous, so it is referred to as Company X.

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cases, missing values were imputed based on the average values of similar instances. For example, missing values in 'Kilometers to work' were attributed to errors in data entry and were imputed using the average value for employees living in the same location and working at the same place. On the other hand, missing values in performance evaluations were due to employee's absence on evaluation days.

The target variable — health-related absenteeism rate in the following year — is a continuous variable ranging from 0 to 1. It signifies the proportion of workdays an employee is absent due to health reasons compared to the total number of workdays. The distribution of this target variable is heavily skewed to the right, with most values clustered near zero, indicating that the majority of employees have low absenteeism rates. However, there exist some outliers with extremely high absenteeism rates (Figure 2).

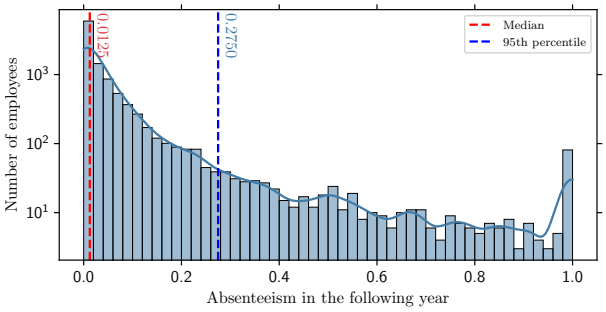

Figure 2: Log-distribution of the target variable. Most workers have very little absence, causing a right-tailed distribution with an "outlier" spike on the right.

The skewed distribution of the target variable has implications for the statistical analysis and machine learning modeling. Therefore, non-parametric statistical tests, such as the Spearman's rank correlation and Kruskal-Wallis test, were employed in EDA and data preprocessing. Additionally, the presence of outliers necessitates careful consideration during model building and evaluation.

The final dataset, comprising 10,347 instances and 42 attributes, serves as the foundation for the subsequent machine learning, where various models are trained to predict absenteeism rates.

3 Methods

The research methodology encompassed a multi-faceted approach, integrating exploratory data analysis, feature engineering, and the application of diverse machine learning models. The ultimate goal was to establish a robust predictive framework for health-related absenteeism, while also ensuring model interpretability to observe actionable insights.

3.1 Exploratory Data Analysis (EDA)

The initial phase involved a thorough EDA to understand the underlying data distribution, identify potential outliers, and uncover preliminary relationships between attributes and the target variable (absenteeism in the following year). Given the skewed nature of the target variable, visualizations like histograms and box plots were complemented by non-parametric statistical tests. The Spearman's rank correlation coefficient was employed to assess monotonic relationships between continuous attributes and the target variable, while the Kruskal-Wallis test was utilized to discern statistically significant differences across groups defined by categorical attributes.

3.2 Data augmentation/Feature Engineering

The original dataset underwent a series of transformations to enhance its suitability for machine learning. This included data cleaning, handling missing values, and the creation of new attributes based on domain knowledge and insights from the EDA. New attributes were engineered based on domain knowledge and statistical analysis. These included indicators for elevated absenteeism, receipt of bonuses or awards, high and low performance evaluations, and absenteeism rates within the employee's team and job type. External factors, such as average absenteeism rates in the employee's residential and work locations, were also incorporated. The feature engineering process was iterative, involving close collaboration with domain experts to ensure the derived attributes were meaningful and captured relevant aspects of employee behavior and organizational dynamics.

3.3 Machine Learning Models

Several well-known machine learning models were employed for absenteeism prediction, including Decision Trees, Linear Regression with L1 regularization, K-Nearest Neighbors (KNN), Support Vector Regression (SVR), Gradient Boosted Regression Trees (GBRT), and Random Forest. Hyperparameter optimization was conducted by using Optuna toolkit [1] to optimize model performance.

3.4 Model Evaluation and Selection

Model evaluation was performed using Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and coefficient of determination (R^2). The models were trained on past years' data and tested on the subsequent year, with the training set size increasing each year. The MAE provided an intuitive measure of the average prediction error, while the RMSE penalized larger errors more severely. The R2 quantified the proportion of variance in the target variable explained by the model. The models were also compared against a baseline model that simply predicted the previous year's absenteeism, to gauge the added value of the machine learning approach. A baseline model predicting the previous year's absenteeism rate was used for comparison.

3.5 Model Interpretation

SHAP (SHapley Additive exPlanations) values [4, 7] were calculated to interpret model predictions and assess attribute importance. SHAP values provide insights into the contribution of each attribute to the model's output, aiding in understanding the factors driving absenteeism. SHAP values provide a unified framework for interpreting any machine learning model, quantifying the contribution of each feature to the model's prediction for a given instance. By analyzing the SHAP values, it was possible to identify the most influential attributes and their directional impact on absenteeism.

3.6 Data Splitting

To ensure robust model evaluation and mitigate the risk of overfitting, the dataset was split into training and testing sets in a prequential manner (year after year). The models were trained on the training set and their performance was assessed on the unseen testing set for the subsequent year. This comprehensive methodological framework enabled a systematic exploration of

the factors influencing health-related absenteeism and the development of a predictive model to proactively manage this critical issue.

4 Results

The primary objective of our work was to develop machine learning models capable of predicting health-related absenteeism in the subsequent year. The models were evaluated using three key metrics: Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and the coefficient of determination (R^2). The baseline model, which simply predicted the previous year's absenteeism, served as a benchmark for comparison (Table 1).

Table 1: Model performance averaged year-over-year.

Model	RMSE	MAE	R^2
Random Forest	0.107	0.052	0.344
GBRT	0.108	0.051	0.333
Linear Regression	0.108	0.051	0.331
Regression Decision Tree	0.112	0.051	0.281
KNN	0.121	0.057	0.173
SVR	0.117	0.075	0.215
Baseline Model	0.121	0.051	0.156

As we can see, all machine learning models outperform the baseline model in terms of RMSE and R^2. This indicates their superior ability to explain the variance in the target variable (absenteeism in the following year). While the MAE remains relatively consistent across models, the improvement in RMSE and R^2suggests that the models are particularly effective in handling larger deviations in absenteeism predictions.

To establish the statistical significance of the model improvements, we conducted a paired T-test comparing the predictions of each model against the baseline model. All the selected models demonstrated statistically significant improvements ($p < 0.05$) in RMSE and R^2; this ensures that their superior performance is statistically substantiated and not due to chance.

4.1 Performance Trends and Impact of Additional Data per Employee

To gain deeper insights into model behavior, we examined their performance trends over the years. Figure 3 illustrates the evolution of MAE for each model.

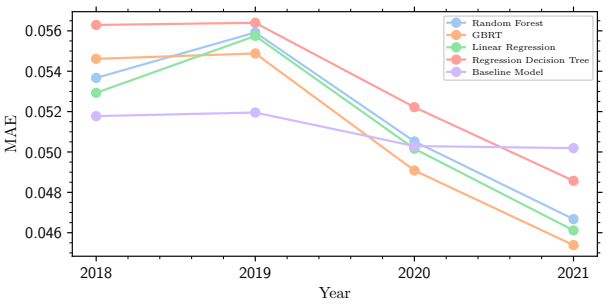

Figure 3: MAE trend over time with additional training data from past years.

Among the evaluated models, GBRT exhibited the best performance, achieving an MAE of 0.045, RMSE of 0.10, and $R^2$of 0.40 on the latest year's data. These results were statistically significantly better than the baseline model, demonstrating the effectiveness of GBRT in capturing the complex patterns underlying absenteeism.

Figure 4 reveals a general trend of MAE improvement for most models in later years, surpassing the baseline model in the final year. This suggests that the models benefit from the increasing amount of training data available in later years. RMSE and R^2charts (not shown) exhibit almost identical properties. It is clear that ML models profit tremendously from increasing amounts of data, as can be expected.

Given the observed performance gains in later years with larger training sets, we explored the impact of incorporating data from previous years. Figure 4 showcases the change in MAE for the final year when models were trained on data from the past year and the past three years, respectively.

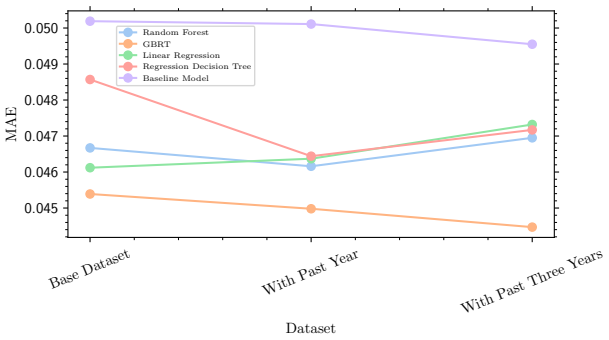

Figure 4: Impact of additional attributes from past years on MAE.

The GBRT model exhibited notable improvement with the inclusion of additional data, achieving an MAE of 0.044, RMSE of 0.093, and R^2 of 0.36. This underscores the value of historical data in enhancing the predictive capabilities of machine learning models for absenteeism and suggests that including even more historical data per employee would be beneficial.

4.2 Interpretability and Additional Insights

Analysis of SHAP values yielded the following key attributes influencing absenteeism:

- Current absenteeism rate
- Performance evaluations
- With respect to the employee's job type and location:
  - Absenteeism rate
  - Proportion of employees with elevated absenteeism
  - Proportion of employees without bonuses

Our findings suggest that absenteeism is influenced by a combination of individual factors (current absenteeism, performance evaluations) and organizational factors (job type, location, bonuses).

Additionally, a rather simple EDA visualisation of functional grouping of employees was quite surprising (Figure 5). Its interpretation can be quite speculative, possibly related to increased job satisfaction or engagement in certain groups. Another, somewhat surprising finding from EDA is that the COVID-19 pandemic did not significantly influence absenteeism rates in 2020, but it may have in 2021 (Figure 6).

Finally, t-SNE visualization of the full dataset shows that employees cannot easily be separated in clusters with similar absenteeism (Figure 7). We can identify some distinct subgroups

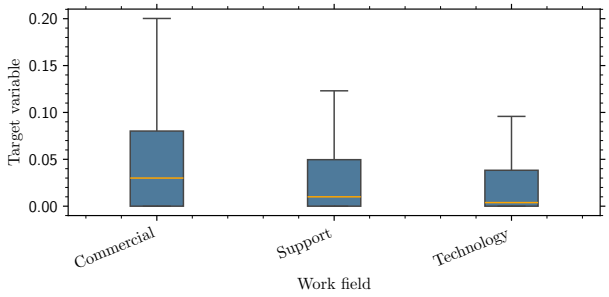

Figure 5: Target variable according to functional partitioning within the company.

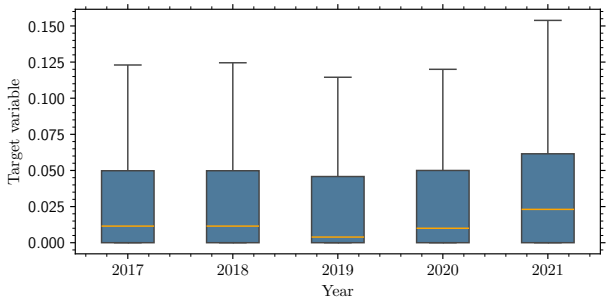

Figure 6: Target variable by year. Note the sharp increase in 2021, possibly attributable to the COVID-19 pandemic.

(like the cluster of red dots on the left), however most data points are quite intermingled. This suggests that with our current set of attributes, we shouldn't anticipate a significant improvement in predictive performance.

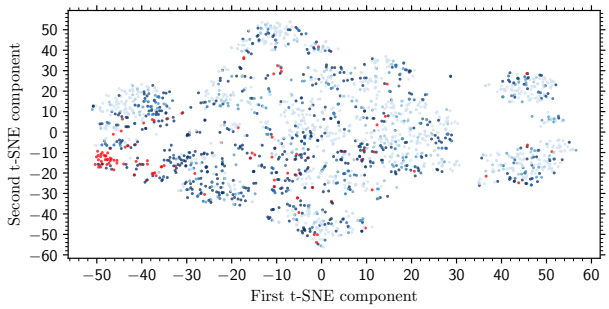

Figure 7: Data visualized in 2D space with t-SNE projection. Red dots represent examples with absenteeism in the next year above 0.25. Blue shades depict examples with absenteeism between 0 (light blue) and 0.25 (dark blue).

5 Discussion and Conclusion

Our work successfully demonstrates the application of machine learning to predict health-related absenteeism. The GBRT model's superior performance highlights its ability to capture complex data relationships, outperforming simpler models and the baseline. Also, identifying key attributes influencing absenteeism, such as current absenteeism, denied bonuses, work type and location, and performance evaluations, provides valuable insights.

The findings align with existing literature highlighting the multifactorial nature of absenteeism. The strong influence of current absenteeism on future absenteeism emphasizes its predictive power, suggesting that past behavior can be a significant indicator of future trends. The negative correlation between performance evaluations and absenteeism suggests that employees with higher evaluations tend to be less absent, potentially due to increased job satisfaction or engagement. The impact of denied bonuses on absenteeism points to the potential role of financial incentives and recognition in influencing employee attendance.

The limitations of our work include the relatively short time span and the potential influence of unmeasured external factors. Future research could address these limitations by: modeling absenteeism as a time series to capture its dynamic nature, incorporating additional data sources such as employee surveys, participation in wellness programs, and (within legal limits) health and personal circumstances data analyzing absenteeism at a finer granularity (e.g., monthly or daily), exploring the inclusion of employee health records and workplace environmental factors in predictive models, and conducting longitudinal studies to track absenteeism patterns over extended periods.

While quantitative improvements of ML model predictions are not overwhelming, the gained insights can enable targeted interventions to reduce absenteeism and promote a healthier workforce. By leveraging ML and data-driven insights, organizations can proactively manage absenteeism, thus improving productivity, financial stability, and employee well-being.

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Puzzle Generation for Ultimate Tic-Tac-Toe

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Abstract

Ultimate Tic-Tac-Toe is an interesting and popular variant of Tic-Tac-Toe that lacks available resources for improving gameplay skills. In this paper, we present a semi-automatic system for generating puzzles as a part of a larger tutorial application aimed at teaching Ultimate Tic-Tac-Toe. The puzzles are designed to enhance players' tactical and strategic understanding by presenting game scenarios where they must identify correct continuations. To ensure the quality of generated puzzles we tested the application with a group of volunteers. The results have shown that the number of solved puzzles positively impacted users' ability to reach higher strength levels but had less of an effect on lower levels.

Keywords

Ultimate Tic-Tac-Toe, puzzle generation, minimax algorithm, tutor application

1 Introduction

For centuries, people have enjoyed playing board games like chess and Go. Over time, these games have led to the development of extensive theory and the accumulation of knowledge, helping players navigate their complexity. Today, advanced artificial intelligence (AI) programs such as AlphaZero [14] surpass even the strongest human players, offering new insights into strategies. However, many lesser-known games have yet to be thoroughly explored, despite their popularity. One such game is Ultimate Tic-Tac-Toe, an advanced version of the classic Tic-Tac-Toe. This game is played on a 3x3 grid of local Tic-Tac-Toe boards, creating a global board (Figure 1a). The goal is to win three local boards in a row, while players must make their moves within specific local boards determined by their opponent's previous move. For example, if a player moves in the top-left corner of a local board, the next player must play on the top-left local board. If the designated board is full or decided, the player can choose any other available board. Despite its apparent simplicity, the game has enough spatial complexity that it cannot currently be solved using brute-force methods.

While there are several online implementations of the game, most focus on building strong AI agents; however, There is a noticeable lack of resources aimed at teaching and helping players understand the deeper strategies of the game, which could make the learning curve more manageable for new and aspiring players. Thus, we have created an application that addresses the lack of learning tools available for Ultimate Tic-Tac-Toe. This article places particular emphasis on the puzzle generation aspect of our application, which is designed to enhance players' tactical and strategic thinking.

In Section 2 we present the related work, and in Section 3 we detail the technical aspects of the developed application. In Section 4 we present the implemented agents and their approximate strength. In Section 5 we provide a description of different types of puzzles and the methodology for their construction. In Section 6 we present the evaluation and discuss the results in Section 7. Finally, in Section 8 we present the conclusions and give possible extensions and enhancements for future work.

2 Related Work

There are many implementations of the Ultimate Tic-Tac-Toe available online, mostly appearing as mobile games aimed primarily at entertainment and lacking advanced playing agents [12] [9] [10], as well as web and desktop applications developed to create the strongest possible programs [15] [7] [13]. An example of the latter is an agent based on the ideas of the AlphaZero program [14], currently considered one of the strongest players of this game [13]. During the development of this agent, significant strategies were discovered, which were also useful in developing our application. Some researchers have attempted to solve the game theoretically, but the spatial complexity proved too great to allow for a complete solution [5].

It is important to differentiate between the various versions of Ultimate Tic-Tac-Toe. One variant allows the game to continue playing on already-won local boards, which drastically changes the game's dynamics. In this variant, researchers have demonstrated an optimal strategy for the starting player, who can win in 43 moves [1]. Further research has focused on enabling a more balanced game by introducing random opening moves, which reduces the predictability of forced wins [4]. Despite these interesting findings, research on these variants is not so relevant for us, as it does not contribute to the understanding of the main game.

While there is a lack of educational material specific to our game, much can be learned from related fields, such as chess, which has been extensively researched. The paper by Gobet and Jansen [8] describes a scientific approach to learning chess, which includes methods to improve memory, perception, and problem-solving skills in players. In this context, it focuses on the acquisition and organization of knowledge, including both explicit and implicit learning of tactics and strategies. This approach facilitates a deep understanding of games and the development of more effective learning methods.

Chess also offers highly sophisticated practical solutions from which we can learn a great deal. Platforms such as `chess.com` [2] and `lichess.org` [11] offer extensive resources and tools for learning chess, especially in the areas of tactics and openings. These platforms allow players to learn through interactive lessons, solving puzzles, and studying various openings, which contribute to a deeper understanding of the game and improve playing skills.

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This approach has proven extremely effective in helping players master complex strategic and tactical concepts in chess.

On the mentioned platforms, the methods for learning tactics are designed to allow players to solve problems based on concrete game situations, which improves pattern recognition and decision-making abilities in real games. Similarly, learning openings involves demonstrating optimal opening moves and their continuations, helping players develop effective strategies at the beginning of the game.

We have applied similar methods in our Ultimate Tic-TacToe application. For example, adapting approaches for learning tactics can help users improve their recognition and solving of complex situations in the game while learning openings helps to understand key opening moves and their impact on the further course of the game. By incorporating these methods into our application, we ensured more effective learning processes and improved the overall gaming experience.

3 Application Details

In addition to puzzle-solving, the app offers a comprehensive learning experience through various other features. It includes AI opponents of different difficulty levels, game analysis, and exploration of effective opening strategies, allowing players to refine their understanding in all phases of the game. The user interface ensures smooth navigation between these modes, making the app a versatile tool for both playing and learning Ultimate Tic-Tac-Toe. By integrating these elements, the app serves as a resource for players at all levels, helping them to deepen their understanding and improve their skills.

To reach a broader audience, the application was developed for both Android and Windows, the dominant operating systems in the market [15]. It uses Flutter components to deliver a responsive and user-friendly interface. Local data storage is utilized for user settings, progress, and puzzle data, ensuring efficient performance and data management.

We employed modern technologies and mobile development practices, including state management patterns, to create an easily expandable app for future updates and enhancements. The entire project is hosted on GitHub, though it is not open-source.

Test versions of the app for Android and Windows are available on Google Drive: https://drive.google.com/drive/folders/1SnO_mN_ZVa2wXd0OGI07kLiYKQTDHuEe?usp=drive_link, while the Android production version is accessible on Google Play Store: https://play.google.com/store/apps/details?id=com.uttt_tutor.

4 AI Agents and Rating System

Playing against intelligent agents allows users to refine their skills by competing against various virtual opponents. The application includes nine different agents, each varying in difficulty and gameplay strategies. These agents are designed using Minimax and Monte Carlo Tree Search [3] algorithms, which provide different levels of complexity and depth in move analysis. The agents and their approximate strengths are shown in Table 1.

To better understand the quality of the agents and evaluate user progress, we need to establish a system for measuring their strength. Since Ultimate Tic-Tac-Toe is not widely popular, there is no established system for rating player abilities. Therefore, we decided to use the chess rating system as an approximation for our agents.

The chess rating system is used to measure the playing strength of chess players. The most commonly used system is the Elo rating [6], which predicts the likelihood of one player winning against another based on their ratings:

$$E_A = \frac{1}{1 + 10^{\frac{R_B - R_A}{400}}},$$

where E_A represents the expected score for player A, R_A is the rating of player A, and R_B is the rating of player B.

Table 1: Table of approximate agent strengths. Each agent played 100 games (50 as X and 50 as O) against the agent one level lower. The results column shows the number of points each agent earned with each symbol, as well as the total score. A win awarded 1 point, while a draw awarded 0.5 points. The last line shows the results of the strongest freely available agent against level 9. It had the same amount of time to think, and they played 30 games.

Agent	Result			Estimated Rating
	X	O	Combined	
Confused Chimp - 1	-	-	-	1
Goofy Goblin - 2	49	49	98	620
Casual Carl - 3	41.5	35.5	77	835
Average Joe - 4	37	25	62	926
Hustling Hugo - 5	39.5	34.5	74	1114
Witty Walter - 6	43	30	73	1293
Thinking Tiffany - 7	35	24	59	1361
Brainy Bob - 8	42,.5	26.5	69	1506
Bossman - 9	36.5	22.5	59	1574
UTTT AI	14.5	12.5	27	1948

5 Puzzle Description and Methodology

In this section, we describe different types of puzzles and the methodology employed to generate them for our game.

5.1 Puzzles

The puzzles in the application are divided into tactical and strategic, with each type of puzzle covering different aspects of the game and helping players improve specific skills.

Tactical puzzles are useful for understanding tactical ideas and are particularly applicable in the endgame and middlegame phases. They focus on specific situations that require precise and thoughtful moves, helping players develop the ability to think quickly and effectively. In total, we generated 1,263 tactical puzzles, distributed across five levels. The number of puzzles for each level is shown in Table 2.

Unlike tactical puzzles, strategic puzzles aim to understand the position and long-term plans. They are instrumental in the opening and middlegame, where it is crucial to recognize strategic ideas and develop plans that provide an advantage as the game continues. There are 50 strategic puzzles available, currently arranged in one level, with the possibility of expansion in the future.

5.2 Tactical Puzzle Generation

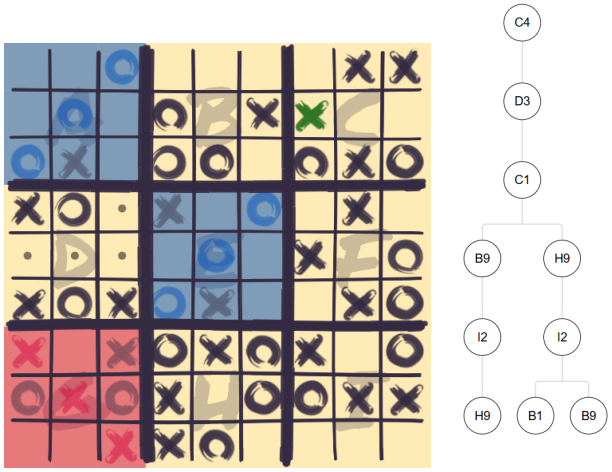
To generate tactical puzzles, we developed a specialized minimax agent that builds a tree of all possible moves leading to victory from the solver's perspective. A key step in this process is the

Table 2: Number of tactical puzzles on each level.

Level	Puzzle Depth	Quantity
1	1	273
2	3	493
3	5	231
4	7	176
5	9	90

selection of tree branches to retain only relevant and correct solutions. It is essential to preserve all of the winner's possibilities while limiting the loser's responses to those that make finding a solution as difficult as possible. Therefore, we select the continuation that allows the longest possible game for the loser while leading to the fewest continuations for the winner.

From the tree, we extract all the correct solutions for the given position. For a high-quality puzzle, it must not have too many solutions. The criterion we set is that the number of solutions must be less than the depth of the puzzle. We also decided to discard all puzzles that have multiple correct continuations for the first move. This way, we avoid trivial puzzles that would be too simple. An example of a level 3 tactical puzzle with its generated solution tree is shown in Figure 1.



(a) Level 3 tactical puzzle. **(b) Solution tree.**

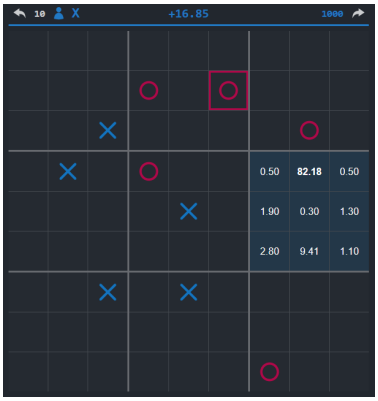
Figure 1: An example of tactical puzzle and its generated solution tree.

The generation of tactical puzzles for different difficulty levels was automated by conducting matches between agents of equal strength, with the search depth of both agents corresponding to the depth of the puzzle we wanted to find. We chose this approach to ensure that the resulting positions were interesting and balanced, as otherwise, the stronger side would usually have an overly obvious advantage at the start of the puzzle which would make it boring to solve.

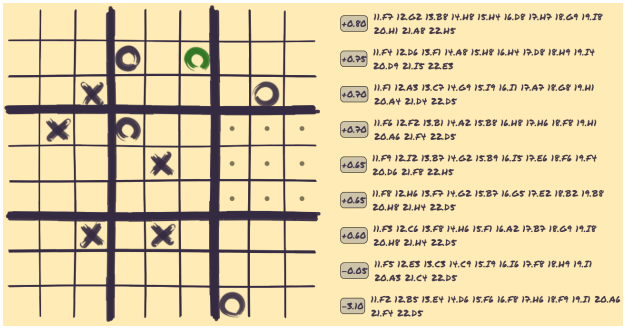
5.3 Strategic Puzzle Generation

Automating the creation of strategic puzzles is impossible without a program that could interpret the given position and simultaneously provide a human-understandable explanation. Additionally, generating strategic puzzles requires an agent with an advanced strategic understanding of the position, which our agents, using relatively simple heuristics, are incapable of. Therefore, we resorted to the most powerful freely available agent [13], which is based on the ideas of the AlphaZero program.

Thus, we generated the strategic puzzles manually. We searched for interesting and instructive positions that arose in games between the aforementioned agent and our stronger programs. We focused on moments when there was a significant deviation in the position evaluation between the two agents. When the agent with better strategic understanding detected an important change, we saved the given position, studied it more closely, and based on our understanding of the game, formulated a solution. The most common examples of such situations involved sacrificing the edge board to gain control over the central board. A basic example of this can be seen in Figure 2.



(a) User interface of the most powerful freely available agent. For the given position, it ran 1000 simulations and assessed the move F2 as the best with an 82% probability. It evaluates the position with a value of +16.85, which means it assigns approximately 58.4% win probability to player X (a value of 0 means a draw, 100 a win, and -100 a loss).



(b) Minimax agent with a search depth of 12. It marks the move F2 as the worst, as it does not recognize the long-term advantage.

Figure 2: Different interpretations of the same position, based on which we built the strategic puzzle.

6 Evaluation and Results

We conducted a quality analysis of the application with 14 volunteers. Their task was to use the app for an extended period to improve their knowledge of the game. We were interested in determining whether using the app had a positive impact on the development of their Ultimate Tic-Tac-Toe playing skills and

whether progress was dependent on motivation or the time spent learning.

To assess individual progress, participants played against the agent at the start of testing to determine their initial skill level. The application then tracked the highest level each user defeated, providing an estimate of their improvement over time. This progress, in relation to the number of puzzles solved, is illustrated in Figure 3. For a more concrete interpretation of obtained level strengths, refer to Section 4.

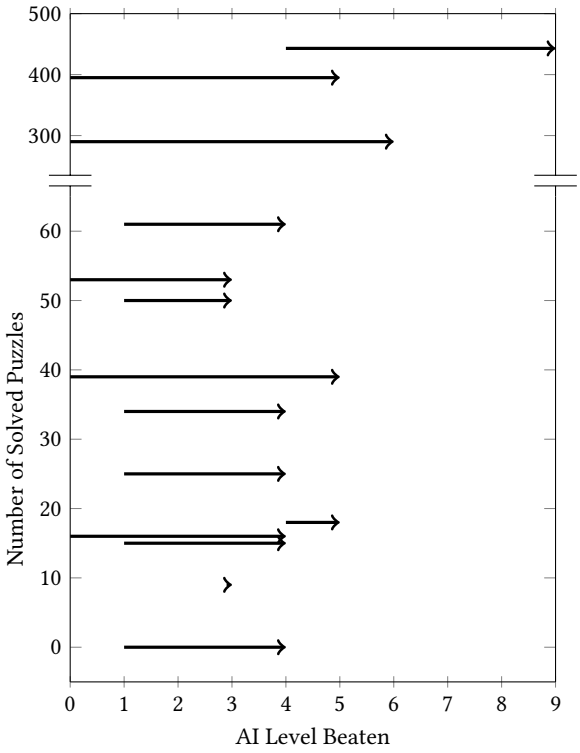


Figure 3: Progress in relation to the number of solved puzzles. Each arrow represents a human tester and indicates the change in the achieved level from the beginning to the end of the application's use.

7 Discussion

The results in Figure 3 indicate that solving more puzzles impacted users' ability to reach higher levels, but had less of an effect on lower levels. This is likely due to the fact that beginners can improve relatively quickly by simply playing the game, whereas advanced players require more effort to progress (eg. it is a lot easier to gain 100 rating points when you are rated 500 as compared to when you are rated 1500).

The reason for this is that at lower ratings, there is generally more room for rapid improvement because the skill gap between players tends to be more pronounced, and beginners can quickly benefit from fundamental knowledge and tactical awareness. As a result, achieving a higher rating initially is easier as players can fix obvious mistakes and exploit weaker opponents' errors.

However, as players reach higher levels, the competition becomes tougher, and the differences in skill become more nuanced. Players at this level are more consistent and less likely to make blunders, so improving further requires mastering advanced strategies, pattern recognition, and deeper positional understanding, making progress slower and more challenging. This reflects the diminishing returns on improvement as you climb the rating ladder.

It must also be mentioned that users were free to use any tools within the app during testing and solving more puzzles did not correlate with longer app usage. For a clearer assessment of puzzle significance, a controlled test focusing solely on puzzle-solving would be more appropriate.

8 Conclusion

In this work, we presented methods for generating puzzles for the game of Ultimate Tic-Tac-Toe. To evaluate the quality of these puzzles, we tracked how the number of solved puzzles impacted individual user progress. Our results indicate a correlation between the number of puzzles solved and the ability to reach stronger AI levels.

However, the evaluation could be refined by focusing exclusively on the puzzle-solving component, isolating it from other functionalities of the application. Additionally, the automation of tactical puzzle generation could be expanded to cover the middlegame phase, rather than being limited to endgame scenarios. Another area of improvement is providing clearer assessments of puzzle difficulty. This could be achieved by implementing a rating system that ranks puzzles based on completion rates, offering a more accurate measure of challenge for each puzzle.

Acknowledgements

The author would like to thank the family and friends who participated in testing the application.

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Ethical Consideration and Sociological Challenges in the Integration of Artificial Intelligence in Mental Health Services

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Abstract [1]
This article explores the transformative potential of artificial intelligence (AI) in the field of mental health, with a particular focus on ethical considerations and social challenges. As AI tools become increasingly sophisticated, their ability to support mental health interventions presents both opportunities and challenges. We discuss the importance of a human-centered approach to AI development and the need for comprehensive ethical guidelines to ensure patient safety and well-being. In addition, this paper explores key social trends such as the evolving dynamics of modern families, aging population, migration and considers how AI can be integrated into these contexts to improve mental health care.

Keywords:
Artificial Intelligence, Mental Health, Human-Centered Approach, Ethics, Modern Family Dynamics, Aging Populations, Migration

1 Introduction

1.1 Artificial intelligence in mental health services

Research on the application of AI in mental health care has shown some positive effects on the treatment of mental health problems [1], including early detection [2,3], providing feedback and personalized treatment plans [4], and developing of novel diagnose tools [2].

AI in mental health services is implemented through models like chatbots, digital platforms, and avatar therapy, enhancing accessibility and treatment options. Chatbots provide therapy via natural language processing [5], while digital platforms support online mostly cognitive behavioral therapeutic interventions [6]. Avatar therapy uses AI to help patients manage conditions like dementia, autism spectrum disorder, and schizophrenia [7].

1.2 The Prospect of artificial intelligence in mental health services

The future orientation underlines the importance of digital health in overcoming challenges such as limited access to services, especially in underserved regions, and outlines measures to ensure equitable access to digital health solutions across the European region [8]. The use of AI in mental health services raises questions about the role of non-human interventions, transparency in the use of algorithms and the long-term impact on the understanding of illness and the human condition [9]. There are also concerns about potential bias, gaps in ethical and legal frameworks, and the possibility of misuse [10,11].

However, there are at least two potentially positive effects of the use of AI in healthcare: Accessibility and personalization of services.

AI offers new mechanisms to reach those who might not otherwise be served. AI-supported tools can improve the early detection and diagnosis of mental disorders [12]. AI chatbots have shown promise in increasing referrals to mental health services, especially for minority groups who are blocked from accessing traditional care [13]. These technologies can provide initial assessments, psychoeducation and even treatment, expanding access to mental health support [12]. AI-driven virtual assistants and wearable devices enable continuous

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monitoring and personalized care, which could improve patient outcomes [11,14].

The integration of artificial intelligence into mental health services represents a promising avenue for the development of personalized treatment plans through the sophisticated analysis of large datasets, enabling the identification of optimal therapeutic strategies tailored to specific client profiles [15,16]. This data-driven methodology enables the dynamic adaptation of therapy to the evolving needs of the client.

2 Overcoming Sociological Challenges through the Integration of Artificial Intelligence in Mental Health Services

2.1 Modern Family Dynamics

Modern family trends show that family structures and attitudes have changed significantly in recent decades [17]. There is a growing acceptance of different family forms, including unmarried cohabitation, same-sex relationships and joint custody arrangements [18]. These changes reflect an expansion of developmental idealism and increasing support for individual freedom in family choice [17].

On the other hand, there is a growing need for mental health services for families [19]. As the most vulnerable members of the family - the children - are usually also at risk, quick and effective action in family mental health is of great importance. Many families are struggling with various psychological problems. Together with the changing family structure, this means a great burden for every family member. In addition, access to psychologists, psychiatrics and therapists is limited, leading to an acute shortage of mental health professionals worldwide.

The accessibility of services is probably the strongest argument for the integration of AI in healthcare [12]. AI-powered conversational agents can improve the accessibility of mental health services by being available online at all times and in underserved areas, being scalable, reliable, fatigue-free, and providing consistent support, being culturally sensitive to adapt, and helping with education and symptom management.

2.2 Aging Populations

AI offers promising solutions for supporting an aging population, particularly in addressing cognitive decline and mental health challenges. AI applications can monitor vital signs, health indicators, and cognition, as well as provide support for daily activities [20]. With an increasing number of elderly individuals, AI can support mental health care by providing companionship through intelligent animal-like robots (e.g., Paro, Harp seal) and assisting in monitoring and managing conditions like dementia [21,22]. AI can also help in tracking cognitive health and providing timely interventions to maintain mental well-being in older adults. These technologies have the potential to enhance independent living and quality of life for older adults and their families.

2.3 Migration

Migrants often face mental health challenges due to displacement, cultural adjustment and language barriers. AI can help migrants access mental health services by providing culturally and linguistically relevant resources and support. Chatbots and AI-driven platforms can bridge gaps in care by providing immediate help and continuity of care across different regions [23].

Recent research highlights the increasing role of digitalization and artificial intelligence (AI) in migration and mobility systems, especially in the context of the COVID-19 pandemic [24]. While these technologies offer opportunities for improving human rights and supporting international development, they also bring challenges that require careful consideration of design, development and implementation aspects. The integration of AI into migration processes requires a focus on human rights at all stages that goes beyond technical feasibility and companies' claims of inclusivity [24].

3 Ethical Consideration in the Integration of Artificial Intelligence in Mental Health Services

One of the main caveats to the use of AI in mental health is the introduction of new ethical standards to ensure user safety. The approach to integrating AI into services should therefore be human-centered [25]. Any innovation should therefore focus on people in their most

vulnerable position. It is important to assess all risks with sufficient accuracy and avoid misuse of AI as much as possible. The most important areas for ethical consideration when integrating AI into mental health services should be privacy, bias, transparency, security.

Data privacy and security are critical in digital healthcare and require robust measures to protect sensitive information and prevent unauthorized access. Protecting privacy rights and ensuring informed consent are critical to maintaining trust and ethical standards in the use of personal health data [11]. Combining multiple data streams increases the risk of unauthorized use, which exacerbates privacy issues. Ensuring informed consent and maintaining transparency, especially in emergency operations, are critical to addressing these ethical concerns and protecting the rights of participants [26].

The use of AI in mental health treatment raises ethical concerns about bias, particularly among marginalized populations who are already discriminated against and lack access to mental health care. It is uncertain whether AI-assisted psychotherapy can effectively address cultural differences and close treatment gaps in diverse populations [27]. In addition, populations that are traditionally marginalized in fields such as psychology and psychiatry are most vulnerable to algorithmic biases in AI and machine learning [27,28]. These biases limit the ability of AI to provide culturally and linguistically appropriate mental health resources, exacerbating existing inequalities. The persistence of such biases in AI systems not only risks increasing health inequalities, but also exacerbates existing social inequalities and raises critical ethical considerations [9].

The future of artificial intelligence in clinical settings is affected by a significant ethical dilemma concerning the trade-off between the performance and interpretability of machine learning models [29]. The lack of transparency in AI models makes it difficult to detect and correct biases. This underscores the need for greater transparency to ensure ethical and fair clinical decision-making.

In summary, the integration of AI into mental health services requires the establishment of strict ethical standards to protect the safety and privacy of users. A human-centered approach is essential, with a focus on dealing with potential bias, especially among marginalized groups, the risks associated with data privacy and security, and the challenges posed by the lack of transparency of AI models.

4 Conclusion

We propose to define AI as a new ethical entity in the field of mental health [30]. AI represents a novel artifact that changes interactions, concepts, epistemic fields and normative requirements. This change requires a redefinition of the role of AI, which lies on a spectrum between a tool and an agent. This shift underscores the need for new ethical standards and guidelines that recognize the unique status of AI as a distinct and influential actor in the field of mental health.

The integration of AI into services can, on the one hand, provide more efficient and faster solutions to some of the sociological challenges of today's society, but on the other hand, requires a precise and correct definition of the limits within which these models can be used. These efforts aim to bridge the gap between technology and human-centered care and ensure that AI complements, rather than replaces, the therapeutic benefits of human interaction.

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Optimization Problem Inspector: A Tool for Analysis of Industrial Optimization Problems and Their Solutions

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Abstract

This paper presents the Optimization Problem Inspector (OPI) tool for assisting researchers and practitioners in analyzing industrial optimization problems and their solutions. OPI is a highly interactive web application requiring no programming knowledge to be used. It helps the users to better understand their problem by: 1) comparing the landscape features of the analyzed problem with those of some well-understood reference problems, and 2) visualizing the values of solution variables, objectives, constraints and any other user-specified solution parameters. The features of OPI are presented using a bi-objective pressure vessel design problem as an example.

Keywords

optimization, black-box problems, sampling, problem characterization, visualization

1 Introduction

Industrial optimization problems often require simulations to evaluate solutions. For example, in electrical motor design [18, 19], assessing the efficiency and electromagnetic performance of a proposed design is done by running a simulator that analyzes the motor magnetic field and flux distribution. Such evaluations are black boxes to the user and the optimization algorithm alike, i.e., the underlying functions cannot be explicitly expressed, which makes the problem hard to understand and solve.

The established way to gain a better understanding of industrial problems is through the analysis of their solutions. Depending on the problem at hand, this can be a challenging task, as industrial problems often have a large number of variables, multiple objectives and constraints [20].

The Optimization Problem Inspector (OPI) presented in this paper is a tool conceived to ease this task for both problem experts and optimization algorithm developers. OPI provides two ways to further the understanding of an optimization problem:

(1) It computes a set of landscape features of the analyzed problem and compares them to those of well-understood reference problems.
(2) It provides visualizations of solutions through the values of their variables, objectives, constraints and any other user-specified solution parameters.

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OPI is a web application, implemented by a Python library called `optimization-problem-inspector` included in the PyPi Python package index[1]. It is highly interactive and requires no programming knowledge to be used.

Freely available contemporary software tools for multiobjective optimization, such as DESDEO [12], jMetal [7] (and jMetalPy [2]), the MOEA Framework [8], ParadisEO-MOEO [10], platEMO [17], pygmo [3], pymoo [4], and Scilab [15], provide the implementation of various optimization algorithms and test problems. While the majority of them include some visualization of solutions, the plots are mostly focused on showing algorithm results for the purpose of comparing algorithm performance and not to increase problem understanding. In addition, none of these tools compute additional problem features as OPI does. Therefore, OPI brings a unique perspective to optimization problem analysis and understanding.

Next, Section 2 presents the real-world problem that will be used to showcase the features of OPI in Section 3. The paper concludes with some remarks in Section 4.

2 Real-World Use Case

Our chosen real-world problem is a version of the well-known pressure vessel design problem, first proposed more than 30 years ago [16]. In this work, we adapt the formulation from [5] to handle the pressure vessel volume as a constraint, as well as an objective. We also remove one unnecessary constraint and use the original boundary constraints for the first two variables.

A pressure vessel is a tank, designed to store compressed gasses or liquids. It consists of a cylindrical middle part capped at both ends by hemispherical heads. The pressure vessel has four design variables (see Figure 1): the shell thickness, $x_1 = T_s$, the head thickness, $x_2 = T_h$, the inner radius, $x_3 = R$, and the length of the cylindrical section of the vessel, $x_4 = L$. The two thickness variables are integer multiples of 0.0625 inches, which correspond to the available thicknesses of rolled steel plates, while the length and the radius are continuous. The problem has three constraints, two on the search variables and one on

[1] https://pypi.org/project/optimization-problem-inspector/

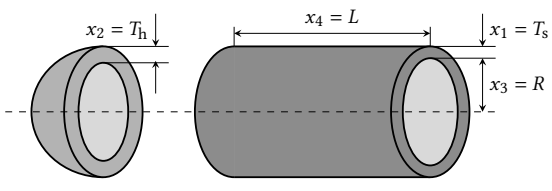

Figure 1: Pressure vessel design variables.

the volume. Its two objectives are to minimize the total costs, including the costs of the material, forming and welding, and to maximize the volume. The problem is formally defined as follows:

$$
\begin{aligned}
\min \quad & f_1(\mathbf{x}) = 0.6224 z_1 x_3 x_4 + 1.7781 z_2 x_3^2 + 3.1661 z_1^2 x_4 \\
& \quad + 19.84 z_1^2 x_3 \\
\max \quad & f_2(\mathbf{x}) = \pi x_3^2 x_4 + \frac{4}{3} \pi x_3^3 \\
\text{subject to} \quad & g_1(\mathbf{x}) = 0.0193 x_3 - z_1 \leq 0 \\
& g_2(\mathbf{x}) = 0.00954 x_3 - z_2 \leq 0 \\
& g_3(\mathbf{x}) = f_2(\mathbf{x}) \geq 1\,296\,000 \\
& x_1 \in \{18, \ldots, 32\} \\
& x_2 \in \{10, \ldots, 32\} \\
& x_3, x_4 \in [10, 200] \\
\text{where} \quad & z_1 = 0.0625 x_1 \\
& z_2 = 0.0625 x_2
\end{aligned}
$$

3 Optimization Problem Inspector Features

OPI is a web application, organized into five functional sections and a help section, providing guidance to the user. OPI expects the user to provide the problem specification and its data—evaluated problem solutions. Then, it generates and visualizes comparisons to artificial reference problems and visualizes the provided data.

Next, we will describe the main features of OPI through its five content sections: problem specification, sample generation, data, comparison to reference problems, and data visualization.

3.1 Problem Specification

In the first OPI section, the user can provide the specification of the industrial problem to be studied. The tool needs this information to properly generate the samples, described in the Section 3.2, and setup the visualisations.

The problem specification must be given in the `yaml` file format and needs to contain some basic information about problem parameters (variables, objectives, constraints) to be included in the analysis. OPI can handle one or more objectives and zero or more constraints. In addition to variables, objectives and constraints, the user can specify any number of other parameters that they want analyzed and visualized, for example, the name of the algorithm that found a solution or the time required to evaluate a solution.

For each of the parameters, the user needs to specify its name and its grouping (whether it is a variable, objective, constraint or something else). For variables, their type (continuous, integer or categorical) and the upper and lower bounds (for non-categorical types) are also required. An example `yaml` file, specifying a constrained multiobjective problem with several variables, is already provided within the tool to guide the user.

For the pressure vessel design problem, we can input four variables (first two are integer and last two are continuous), two objectives and three constraints. Alternatively, we can decide to skip the individual constraints and only use the total constraint violation instead.

3.2 Sample Generation

In OPI, a sample is a set of x-values, corresponding to the variables set in the problem specification section. In other words, a sample is a set of non-evaluated solutions.

If needed, the sample can be generated by the tool itself, based on the variable information provided in the problem specification step. However, this is not a required step in using OPI. A user that already has a set of (evaluated) solutions to work with can skip it and input the data directly (see Section 3.3).

Sample generation requires one to choose the number of desired samples, set to a default of 100, and the sample generation method. Three sample generation methods are supported: random, Sobol and Latin Hypercube, with random sampling being the default. The user may alter the settings of these sampling methods, such as the random generator seed. Selecting the button to generate and download the sample will download it in a `csv`-formatted file.

In the pressure vessel use case, OPI warns the user that not all sample generation methods are appropriate. In fact, the Sobol sampler and the Latin Hypercube Sampler are not compatible with non-continuous parameters. If used nevertheless, they may produce unexpected results.

3.3 Data

In OPI, the data is essentially a set of evaluated solutions, where each solution must contain a value for all objectives, constraints and other parameters included in the problem specification. The evaluation is conducted externally to the tool.

The data needs to be uploaded in a file in `csv` format. If any parameters from the problem specification are missing from the data, the tool will display a warning message. Any data parameters that are not included in the problem specification, are ignored without raising any warnings. When correctly input, the user will be able to view the data they have input, inspecting it in tabular format.

Inputting the data completes the setup stage of the process. The user may then begin generating visualisations to assist them in understanding their problem.

3.4 Comparison to Reference Problems

The first visualization mechanism provided by OPI visually compares the problem to a set of artificial reference problems with known properties. This is conducted by displaying the landscape features of the user-defined problem alongside the same features of each of the reference problems in a parallel coordinates plot. The plot is interactive—the user can highlight some of the problems by brushing along one of the parallel axes. In addition, the feature values can be viewed in a table and downloaded to a file in `csv` format.

The reference problems can be set by the user, however, confined within the collection labelled here as GBBOB, i.e., generalised BBOB, where BBOB stands for the well-known suite of 24 Black-Box Optimization Benchmarking problems with diverse properties [9]. OPI provides a generator of GBBOB problems that match the analyzed problem in terms of the number of variables and objectives and the presence or absence of constraints. For objectives and (optionally) the constraint, any single-objective BBOB problem instance can be used. The user can specify the desired GBBOB problems in the `yaml` format. OPI already contains five GBBOB problems to start.

A problem can be characterized by a large number of features, most hard to interpret by a human. In OPI, we included the following problem landscape features that are understandable to an expert user [1, 11, 13, 14]: `CorrObj`, `MinCV`, `FR`, `constr_obj_corr`, `H_MAX`, `UPO_N`, `PO_N` and a set of neighborhood features. `CorrObj`

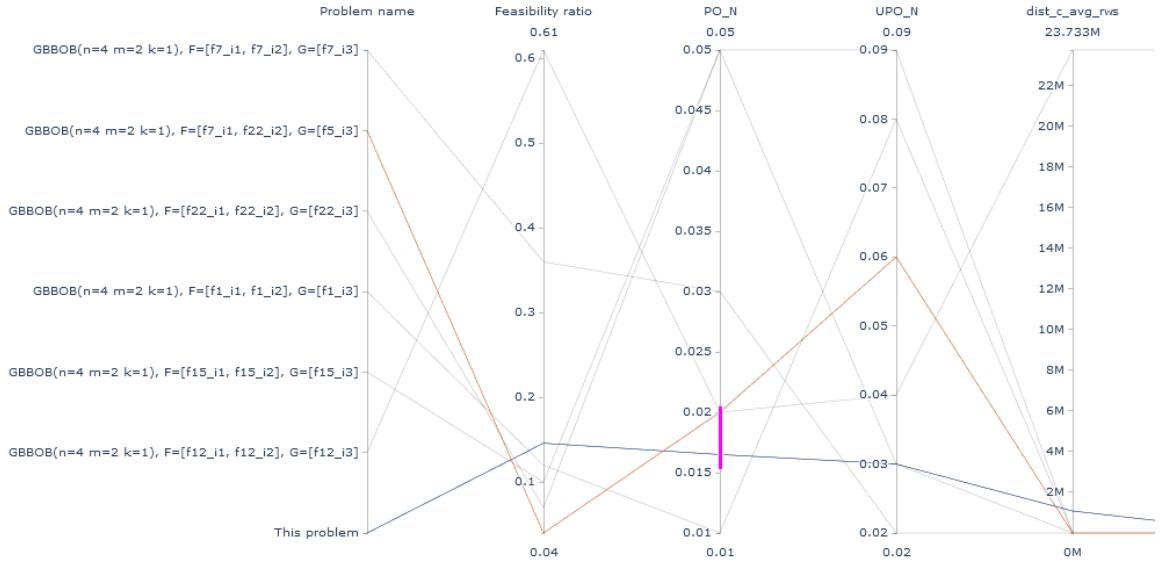

Figure 2: The initial part of the parallel coordinate plot visualizing feature values for the analyzed problem and the chosen set of artificial test problems.

is a feature that shows the correlation between the objectives. `MinCV` represents the minimum constraint violation among all solutions in the population. `FR` represents the proportion of feasible solutions in the population. `constr_obj_corr` presents the maximum correlation between the constraints and all the problem objectives. `H_MAX` is the maximum information content among all objectives. `UPO_N` is the proportion of unconstrained non-dominated solutions, while `PO_N` is the proportion of the constrained non-dominated solutions. The neighbourhood features denoted by `neighbourhood_feats` are a collection of features explaining the neighborhood of solutions, e.g., how many neighbors of a solution dominate the solution, how many neighbors are dominated by the solution, how many are incomparable to the solution, how close the neighboring solutions are, etc. OPI offers a total of 16 features, but the user can choose which to compute and visualize.

Figure 2 shows the initial part of the parallel coordinates plot (as the entire plot would not fit the paper) for the pressure vessel problem. In the comparison, we use the default five GBBOB reference problems as well as a custom created one. We notice that the pressure vessel problem is most similar to the custom GBBOB problem with the first objective equal to the step ellipsoid function f_7, the second to the multimodal peaks function f_{22}, and the linear constraint f_5. This similarity might be due to our mixed-integer problem containing plateaus in the continuous landscape space in which the features are computed, which is similar to the step ellipsoid function, and having linear constraints.

3.5 Data Visualization

In the data visualization section of the web application, the supplied data can be visualized using either a scatter plot matrix or a parallel plot. In both cases, the user can choose which problem parameters to visualize among all those listed in problem specification. Additionally, a simple data filtering that limits any variable between the desired minimum and maximum values is also supported and can be manipulated via the OPI interface in `yaml` format. The parameter used for coloring the solutions, as well as the color map, can also be specified by the user. Both visualizations support interaction and can be downloaded in `html` or `png` format.

3.5.1 Scatter Plot Matrix. The scatter plot matrix consists of n^2 plots for n chosen problem parameters as it contains 2-D scatter plots for all possible parameter pairs. In OPI, the user can apply brushing and linking to select the desired solutions in one or more of the scatter plots. These are then highlighted in all scatter plots in the matrix.

Figure 3 shows such a scatter plot for our pressure vessel problem. This visualization includes data from two sources. The first comes from a random sampling of the search space (shown in light blue) and the second from running the NSGA-II algorithm [6] on this problem for $2 \cdot 10^6$ function evaluations to achieve a good approximation of the Pareto front (shown in black). The two sources are set apart by a custom parameter that is then used for coloring the solutions. Some solutions from Figure 3 are highlighted – see the rectangle in the (x_3, x_1) scatter plot (third from the left in the top row).

These plots clearly show the linear relationship of the near-optimal solutions between x_1 and x_2 as well as x_1 and x_3. When only f_1 and f_2 are chosen, it is distinctively visible that the Pareto set approximation is piece-wise linear and disconnected.

3.5.2 Parallel Coordinates Plot. The parallel coordinates plot shows all chosen parameters as parallel coordinates and solutions as lines in the plot. Similarly as with the scatter plot matrix, interaction via brushing and linking is supported to select solutions that fit the desired values.

4 Conclusions

This work presented the features of Optimization Problem Inspector – a web application to support problem experts and algorithm designers in gaining a better understanding of industrial optimization problems. The tool provides comparisons to well-understood reference problems and interactive and highly-customizable visualizations, which can be exported in `html` and `png` formats.

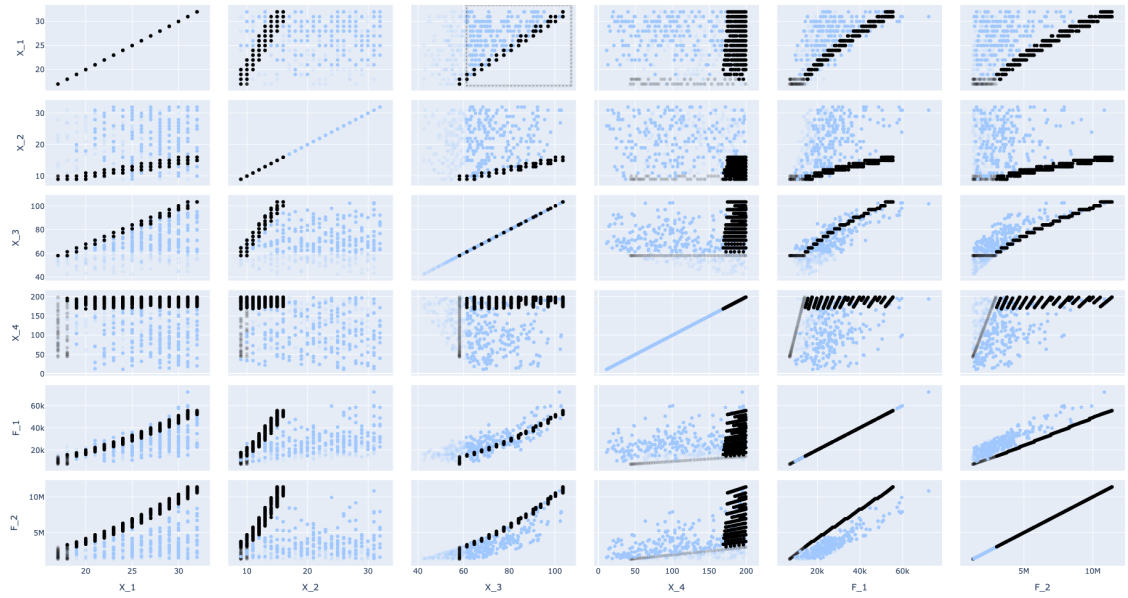

Figure 3: Random (light blue) and near-optimal (black) solutions of the pressure vessel design problem visualized in OPI with a scatter plot matrix containing variables x_1 to x_4 and objectives f_1 and f_2.

Samples can be exported and solutions imported using the standard `csv` format, which makes the data exchange between OPI and various optimization software easy to do. OPI functionality is made to be simple and at the same time flexible. Therefore, it is utilisable by non-experts and experts, alike, providing a wide range of angles from which to view the problems.

Acknowledgements

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Multi-Agent System for Autonomous Table Football: A Winning Strategy

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Abstract

This paper presents a multi-agent system (MAS) for autonomous table football, developed for the FuzbAI competition at the University of Ljubljana. Our system consists of four independent agents, each dynamically assigned specific roles—Goalkeeper, Defender, Midfielder, and Attacker—based on real-time game analysis. This role-based architecture enabled seamless coordination between offensive and defensive strategies, allowing our team to secure first place. We describe the simulation framework used, the processing of sensor data, and the control strategies that allowed the agents to execute precise actions in a dynamic environment. The results highlight the effectiveness of adaptive, role-based decision-making, demonstrating the potential of MAS in real-time, competitive settings.

Keywords

multi-agent system, autonomous table football, role-based strategy, real-time decision making, AI in robotics

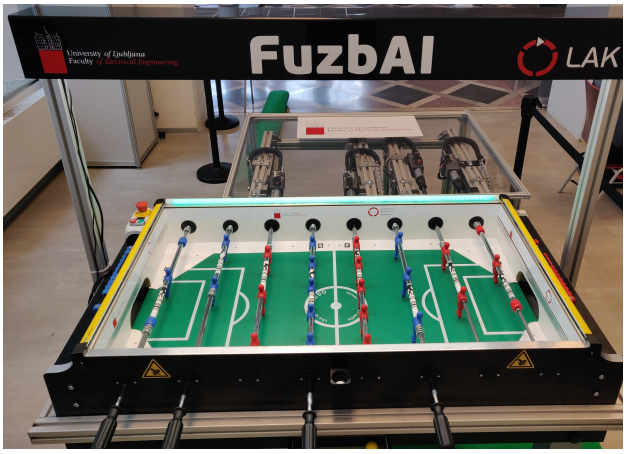

Figure 1: Table setup for the FuzbAI autonomous football competition.

1 Introduction

The FuzbAI competition, held as part of the "Dnevi Avtomatike" event at the Faculty of Electrical Engineering, University of Ljubljana, is a premier contest for students specializing in automation and artificial intelligence [11]. This event challenges participants to develop intelligent autonomous agents capable of playing table football without human intervention. The competition not only serves as a platform for demonstrating technical skills but also fosters innovation in the application of AI and machine learning techniques in real-time environments. Figure 1 illustrates the table setup used in the competition.

The FuzbAI competition is structured in a way that teams must design and implement a fully autonomous system capable of effectively competing against other AI-driven systems. Each match is a test of the participants' ability to integrate advanced algorithms and robotics, simulating the dynamics of a real football game on a miniature scale. The competitive format includes both qualification rounds and knockout stages, ensuring that only the most capable and innovative solutions advance to the final stages.

Our entry into the FuzbAI competition focused on the development of a multi-agent system (MAS), where each of our four rods functioned as an independent agent. These agents were designed to collaborate through a streamlined decision-making process, selecting roles that dictated their actions during gameplay. This strategic approach enabled our team to outperform competitors and ultimately secure first place in the competition.

This paper delves into the development and implementation of our multi-agent system. We will explore the architectural choices, the role-based decision-making strategies employed by each agent, and the overall system's performance in the context of the FuzbAI competition.

2 Competition Setup and System Description

The FuzbAI competition required all participants to develop programs capable of playing table football autonomously. To facilitate this, the competition provided a standardized simulation environment and a set of initial tools that every team used as the foundation for their development. This section describes the simulation framework, the types of data available from the system, and the means by which agents could interact with both the simulated and real game environments.

2.1 Simulation Framework

Participants were provided with a Python-based simulation framework designed to emulate a real table football match, as shown in figure 2. This simulator accurately replicated the physics of the game, including the movement of the ball and rods, and managed the interactions between the environment and the agents controlling the rods. The framework included fundamental functionalities such as ball tracking, rod positioning, and interaction rules, allowing all teams to concentrate on AI development without needing to construct the simulation infrastructure themselves.

One of the key features of the competition setup was that the interaction protocols for the simulator and the physical table were identical. The same signals and commands used to control

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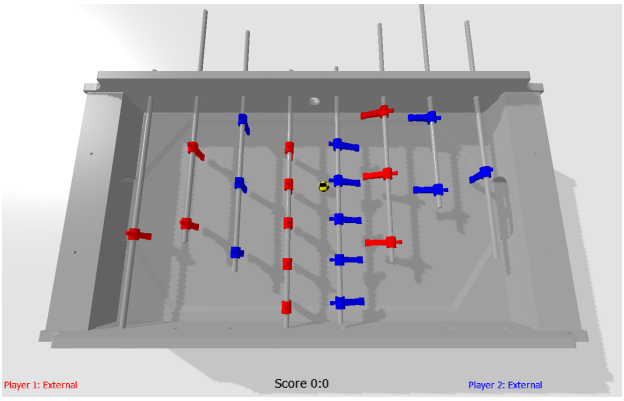

Figure 2: Simulator interface.

the actuators in the simulator were also used for the real table without any modification. This feature ensured that teams could seamlessly transition their algorithms from the simulated environment to the physical table setup, which was used in the final rounds of the competition. As a result, the simulation provided a consistent testing ground that mirrored the actual physical setup, enabling teams to develop and refine their strategies under uniform conditions.

2.2 Sensor Data

Both the simulation environment and the real table provided each team with data from two cameras, one placed on each side of the table. Each camera captured different views of the game, and teams had to decide how to combine the information from both cameras. The data provided by each camera included:

- Ball position: The coordinates of the ball on the 2D plane of the table.
- Ball speed: Velocity of the ball.
- Ball size: Area of the ball in the captured image (in pixels).
- Rod positions: Calibrated position of all rods (in the interval $[0, 1]$).
- Rod angles: Calibrated angle of all rods (in the interval $[-32, +32]$).

This camera data was streamed continuously, requiring teams to process and merge the inputs from both cameras to accurately interpret the game's state. The accuracy and frequency of the data were sufficient to enable real-time decision-making by the autonomous agents, whether interacting with the simulator or the physical table.

2.3 Actuator Outputs

To interact with the environment, each agent could send commands to the actuators that controlled the rods. The system allowed for two primary types of commands:

- Translatory movement: Moving the rod left or right across the table.
- Rotational movement: Rotating the rod to control the angle at which the players struck the ball.

Precise and timely commands were crucial for effective game control, as they enabled the agents to optimally position their figures, strike the ball accurately, and execute defensive or offensive strategies effectively.

3 Related Work

Research on multi-agent systems (MAS) and their application in robotic football has been extensively explored. This section reviews some contributions that have informed the development of autonomous systems for table football and real football.

Moos et al. (2024) [5] developed an automated football table as a research platform for reinforcement learning, highlighting the challenges of transferring learned behaviors from simulation to real-world environments and the need for robust algorithms to handle uncertainties. While reinforcement learning is a common approach in such studies, we did not achieve satisfactory results with it. Therefore, we decided to use multi-agent systems instead. Klančar et al. (2002) [4] investigated cooperative control in robot football (real football) using multi-agent systems, focusing on behavior-based control and dynamic role assignment among robots to optimize performance. Their approach emphasized effective communication for coordination in multi-agent settings. This work particularly inspired our approach to multi-agent systems, where we focused on behavior-based control and dynamic role assignment. Ribeiro et al. (2024) [6] proposed a probability-based strategy (PBS) for robotic football (real football), utilizing real-time data for centralized decision-making without relying heavily on pre-defined plays. Their approach demonstrated flexibility across different environments. Smit et al. (2023) [8] explored scaling multi-agent reinforcement learning (MARL) to a full 11v11 simulated football environment (real football), focusing on computational efficiency and the use of attention mechanisms to enhance scalability in large-scale multi-agent settings. Song et al. (2024) [9] conducted an empirical study on the Google Research Football platform (real football), introducing a population-based MARL training pipeline to quickly develop competitive AI players, highlighting the importance of scalable training frameworks. Scott et al. (2022) [7] examined end-to-end learning in RoboCup simulations (real football), optimizing both low-level skills and high-level strategies through competitive self-play, providing a comprehensive approach to multi-agent training in competitive environments.

4 MAS Approach to Autonomous Table Football Control

In this section, we describe the the methodology of our approach. We describe agent architecture, different agent roles and outline the actions they can take. Then, we discuss the conditions and priorities for role assignment during the game and evaluate the behavior of the system as a whole.

4.1 Agent Architecture

There exist several agent architectures, commonly used in MAS. Approaches, such as [4, 10, 12, 13], use role-based approach for interaction between agents and with the environment. In role-based approach, based on the concepts from role theory [1], the agents are assigned roles which affect their behavior. While the overall long-term goal of the system is typically predefined and does not change, e.g. win a table football match, the current role of an individual agent defines agent's short-term goals, which influences agent behavior, their decision-making process, and how they interact with the rest of the system. Furthermore, separation of agent functionality into independent roles can provide simplification and decoupling of individual tasks, leading to a more modular system, which can simplify and improve the extensibility of the implementation [3].

There exist several approaches to role and behavior implementation in MAS, such as merging different roles, role models and class members [2, 3, 4]. In our implementation, we simplify the architecture by allowing an agent to occupy only a single role at a time, and defining the roles in a way that allows reassigning between iterations of the algorithm without regard to the previous role or state of the agent.

Each role defines a set of possible actions an agent can take. The agents decide which action to take based on their priority and the current environment. More complex roles can be implemented in a stateful manner, meaning the decision on which action to take is dependent on previous actions as well. An agent can only be assigned a single role at a time, but can switch between roles throughout iterations regardless if the particular goal is fulfilled, when appropriate conditions arise. Additionally, every agent must have a role assigned at all times.

An action is a discrete, autonomous task that an agent can take on by making appropriate decisions and acting onto the environment, e.g. by sending commands to the actuators. This advances the agent toward the goal imposed by the current role. An agent can only execute a single action at a time. Additionally, every agent must be actively executing an action at all times.

These concepts were implemented using an Object Oriented approach, as suggested by the authors of the competition. In our implementation, each agent repeatedly executes a fast processing routine. Every iteration, the environment data is updated and role selection for the agent is performed. Then, as the agent decides on a role for that iteration, the appropriate role processing function is called, executing individual actions.

4.2 Role Description

A typical table football setup consists of four rods per player, each with a number of mounted figures. In this implementation, each rod is considered an agent, resulting in a system with four agents for which we define the following roles, typically associated with table football games.

Goalkeeper is the final line of defense, primarily responsible for intercepting the ball before it reaches the goal. Typically the left-most rod, which is nearest to the goal and has a single figure, the goalkeeper follows the ball position using two possible actions: *follow* and *misaligned follow*. The *follow* action simply tries to align the figure on the rod with the current ball position. However, if the velocity of the ball exceeds a predefined threshold, the agent instead attempts to estimate the ball trajectory based on its velocity vector. This estimation is simplified by assuming that the ball maintains a straight-line path. The figure is therefore positioned at the intersection of the rod and the estimated trajectory in an attempt to intercept a fast-moving ball.

The *misaligned follow* action is an augmented variant of the former action, designed to increase the overall defense surface of the defending agents. A common scenario in table football occurs when an attacker attempts to bypass the defenses by slightly pushing the ball parallel to the rod and striking it immediately after. Even though a human player might react fast enough to block such an attack, actuator response times are often insufficient. A defense strategy against such attacks is is to misalign the goalkeeper and defender figures, increasing the defense surface. Here, this is implemented by the *misaligned follow* action, and is activated whenever the ball is relatively slow, in the possession of the opponent and another agent in front of the Goalkeeper is currently in a Defender role. This decreases the chances of the opponent scoring even if the actuators fail to respond fast enough to block this style of attack. Here, communication between the two agents is performed implicitly, as each agent perceives the roles of other agents as a part of the overall environmental state.

Defender is an agent tasked with blocking opponent attacks by intercepting the ball when it is in the opponent's possession or moving towards the goal. This role utilizes a single *follow* action, similar to the Goalkeeper's *follow* action. Whenever the Defender role is active, the agent tracks the position and velocity of the ball, trying to match either its current coordinate or the estimated intersection with the trajectory of the ball. The agent identifies the figure closest to the intersection and attempts to move the rod using minimal amount of movement. This approach allows for faster adjustments during the game, improving defensive efficiency.

Midfielder is a an agent role with the primary task of raising the figures to allow passing the ball from behind the current agent. This role, although simple, is essential in order to avoid accidentally breaking a friendly attack by an Attacker agent behind the current rod.

Attacker is an agent with the task of kicking the ball towards the opponent goal in an attempt to score a point. Unlike other roles, the Attacker role is implemented in a stateful manner. Actions can only happen in a specified order, when the corresponding conditions are met. The role implements *follow*, *kick* and *prevent back-kick* actions.

Whenever the agent is assigned this role, the *follow* action is executed first. During the *follow* action, the agent slightly raises the figures in order to prepare for a kick. The figure closest to the ball is selected and rod offset is adjusted in order to align the figure with the ball. Whenever the agent determines that the alignment with the ball is sufficient, the agent moves onto the next state, the *kick* action. Here, the rod is rotated in order to strike the ball. During this state, it is still necessary to track the position of the ball, as the ball can move significantly within a few iterations of the algorithm. As the rod completes the forward rotation, the agent monitors the position of the ball and assesses if the figure successfully hit the ball. In that case, the next action is set back to *follow*, and the agent is usually assigned a new role according to the environment. However, if the figure missed the ball during the kick, the agent moves onto the *prevent back-kick* action. This final action is meant to prevent an accidental kick in the opposite of the intended direction. The rod is translated sideways and slowly rotated into a neutral position, in order to circumvent the ball. While executing this action, role switching for the current agent is disabled as well.

During execution, the agent aligns the rod position with the ball; however, a perfectly aligned figure results in a straight shot, which is easily defended by maintaining alignment with the ball. A more effective strategy involves kicking at an angle to aim for the goal or create a rebound off the wall, which is harder to defend. This role achieves this by slightly misaligning the figure before and during the kick. The agent computes the angle between the ball's current position and the selected target, with the figure's required misalignment set proportionally to this angle and adjusted by a tunable parameter for fine-tuning. This attack strategy significantly increases the performance of the Attacker role.

4.3 Role Assignment

Individual roles are assigned to agents according to defined assignment conditions and rules. Some approaches use an objective function in order to select a role, often taking role priority into account [4]. In this approach, we instead define a simple set of conditions which, along with role priority, decide on the most appropriate role for a particular agent based on the current state of the environment.

If in a particular instant, more roles fulfill the assignment conditions for a particular agent, the role with higher priority is selected. In this implementation, the highest priority belongs to the Attacker role, followed by the Goalkeeper, Defender and finally the Midfielder with the lowest priority. This ordering is based on the strictness of assignment conditions for each role, and the importance of that particular role. For example, the Attacker role has the strictest selection conditions among all roles, and therefore is assigned the highest priority, while the Midfielder role has a very broad assignment condition and is not as important compared to an Attack agent.

We define the role selection conditions as follows. The Attacker role is selected whenever the ball speed drops below a specified threshold, and the ball is within kicking clearance of the rod. The Goalkeeper role is selected if that particular agent belongs to the left-most rod, closest to the player's goal. The Defender role is selected whenever the ball is in front of the rod. Lastly, the Midfielder role is selected whenever the ball is behind the rod, as the role's only task is to raise the figures to allow the ball to pass forward.

This set of conditions combined with the defined role priority, allow the agents to switch between roles effectively and covers the main functionality required to play the game. Role priority ensures that the agent works toward a correct goal based on the circumstances. For example, any rod, even the Goalkeeper, should attempt to kick the ball if it is close and slow enough, while only the left-most rod should attempt to be the goalkeeper.

4.4 Behavior of the System as a Whole

The system's primary offensive strategy is for the Attacker agents to advance the ball as far forward as possible, ultimately aiming for the goal, while Midfielder agents ensure that they do not obstruct forward passes. During opponent attacks, the systems primary defensive strategy is for the Defender and Goalkeeper roles to intercept the ball. In certain situations, they collaborate to expand the defense surface, compensating for the limitations posed by actuator response times. Once the opponent's attack ends, agents detect the change in the environment and the roles are reassigned to shift the game towards offensive play.

The system's game strategy can be adjusted by modifying parameters such as role priority, assignment rules, or individual actions. For instance, a more defensive strategy can be achieved by tightening the conditions for assigning the Attacker role.

Overall, the implemented algorithm performs well, with the combination of discrete roles resulting in a competent gameplay. However, delays and noise present in measurements, and delays due to actuator response times, sometimes cause the system to miss, e.g. during attacks. The *prevent back-kick* action of the Attacker role proves essential in such situations, performing careful repositioning. Another surprisingly successful strategy is aiming at the goal or the wall during the *attack* action. Even if the ball does not follow the intended trajectory due to measurement noise and system delays, it still considerably increases the attack success rate. Additionally, even though there are no explicit, intentional passes between agents, the strategy of simply passing the ball as far forward as possible is enough for a successful gameplay.

The system overall is sensitive to changes in parameters and requires precise tuning. The simulator, although effective, does not perfectly simulate the physical table, and additional parameter tuning is required when transitioning from the simulator to real-world application.

5 Conclusion

This paper presented a multi-agent system (MAS) for autonomous table football, developed for the FuzbAI competition. Our role-based design allowed each rod to act as an independent agent, dynamically adapting to the game state. This approach enabled effective coordination between offense and defense, contributing to our system's first-place win.

The results demonstrate the effectiveness of a modular, adaptive architecture in dynamic environments, highlighting the importance of robust decision-making and quick role-switching. Future work could include machine learning to predict opponent behavior and optimize strategies, as well as expanding the system to more complex environments. Overall, our MAS showed strong performance in a competitive setting, offering valuable insights for future developments in autonomous systems.

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Towards a Decision Support System for Project Planning: Multi-Criteria Evaluation of Past Projects Success

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Abstract

Project planning typically refers to the project management step in which project assets, timelines, budgets, milestones, subcontractors, etc., are determined before the new project starts. In this paper, we address infrastructure design projects in the context of a specific company (Elea iC) and explore the idea of using data about past-finished projects to help project managers and project leaders in project planning. A crucial requirement in this context is the ability to evaluate/assess the success of finished/new projects. This paper proposes a solution using a multi-criteria model to evaluate finished projects. This way, we add project success information to the finished projects database, which we shall use in the decision support system being designed to extract knowledge for the new project plan.

Keywords

Project success evaluation, multi-criteria model, decision support systems, data analysis, data mining, project management, project leading tools.

1 Introduction

Infrastructure, such as tunnels, bridges, schools, houses, sewage systems, roads, etc., and its design discipline play a vital role in society. Thus, infrastructure design must have properly and thoroughly defined requirements, objectives, scope and constraints concerning many expert fields such as civil engineering, architecture, geology, geotechnics, environmental engineering, urban planning, and other expert fields [1], [2], [3]. The term design is connected to the process that ends with technical documentation, technical approvals, models, and other deliverables prepared at the end of the design process. Each such process is referred to as the project [4]. The projects are expected to have clearly defined:

- *Goals* defining the project's desired result, e.g., a building permit for a bridge, static analysis of a retaining wall, architectural design for a subway station, geotechnical exploration for a tunnel, etc. [4].
- *Objectives* that support project goals include concrete and measurable project characteristics such as deliverables, milestones, and other steps and strategies to achieve the goals [7].
- *Scope and requirements* concerning project boundaries, e.g., the need for experts, potential subcontractors, technical equipment and other requirements to finish the project.
- *Constraints and limitations* concerning project deadlines, costs, etc. [8].

Besides that, each project should finish with the client's and stakeholders' satisfaction [8].

To achieve the above for the new project, project planning is vital at the beginning of each new project [6], [8]. It is the project management and project leaders' task to recognize and include all these in the project plan so that the work and processes lead to successful project completion.

This study aims to support this process in the context of Elea iC company, an interdisciplinary provider of engineering services and projects in Slovenia [5]. We wanted to include the knowledge obtained from past–finished projects in the project planning process for the new projects. The company collected this data from 2001. The assumptions are as follows:

1. The finished projects in the database offer valuable information for the new project planning phase.
2. The project workflows established in the company and requirements remained similar over the years.

The main challenge related to this question is the new project success assessment and its consideration in light of the available finished project data [7]. Unfortunately, the actual finished projects database does not contain much information about the finished projects' success. To bridge this, we had to construct a project success evaluation model, evaluate finished projects in the database and add this information to the database. The expected result of those steps is a database suitable for applying data-analysis and knowledge extraction methods, such as hierarchical clustering and machine learning [20].

This paper describes the finished project success evaluation component (hereafter called FPSE), which is part of the future decision support system (DSS, [12], [13], [14]) for project planning (hereafter called E-DSS). First, we present the general architecture of the E-DSS, explaining the role and integration of FPSE in its context. In section 3, we present the database of finished projects and its preparation for supporting the configuration of new projects. The evaluation model used and the experimental evaluation of FPSE are presented in sections 4 and 5, respectively. Section 6 concludes the paper.

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2 E-DSS Architecture

E-DSS is a DSS under construction to support the project management and project leaders in the Elea iC company (hereafter called "the user") in configuring the new project plan parameters when a new project starts.

The user is expected to define the E-DSS input as shown in Figure 1: the new project objectives, requirements, desires, and expectations. Practically, this means that the user collects all the available new project data by:

- Extracting the new project data from the new project assignment and contracts containing relevant information for the project planning.
- Checking the company and potential subcontractors' state of the resources and assets needed to complete the new project.

Examples of those data include projected monetary value, project scope and goals, project start and finish date, the expert fields needed for project completion, etc.

The E-DSS output (Figure 1) consists of the new project plan configuration together with the corresponding success scores (+S). The configuration comprises the data such as the number of employees involved, the number of subcontractors, work distribution, work duration, the number of pauses, etc. Project success scores are assessed assuming this configuration settings.

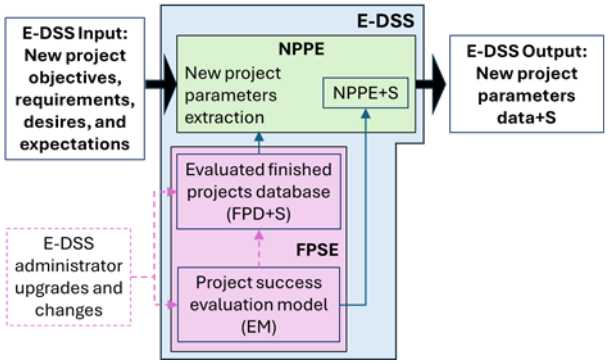

Figure 1: E-DSS architecture

Accordingly, E-DSS is composed of the following components (Figure 1):

- **NPPE** (New Project Parameters Extraction) is the component that extracts the potential new project configuration parameters and corresponding data to support the decision-making. NPPE is currently under construction and is aimed to operate interactively with the user and support: searching for similar projects in FPD+S according to a predefined range, searching the projects by desired success score, project segmentation, and project group identification—unsupervised descriptive analytics and parameter prediction by supervised machine learning methods. The component NPPE+S inside NPPE evaluates the success of the potential new project's configuration parameters obtained. The evaluation is made by EM, which is part of FPSE.
- **FPSE** (Finished Project Success Evaluation) consists of:
  - **EM** (Project success Evaluation Model) for evaluating the new project configuration (described in section 4).
  - **FPD+S** is the database of finished projects with project success evaluations (section 3).

Figure 1 also shows the element **E-DSS administrator** used to upgrade FPSE periodically by upgrading the database of the finished projects or making changes in EM according to the system's operational requirements and expected results.

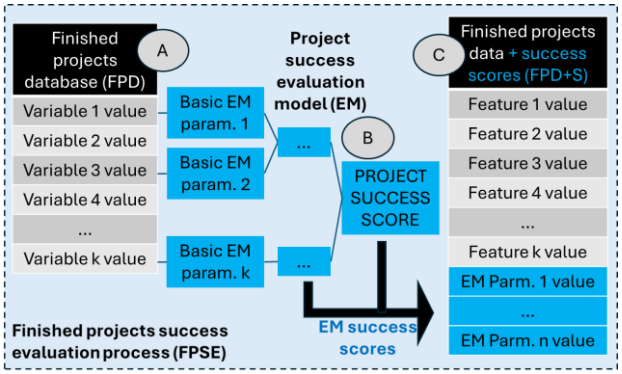

Figure 2: FPD+S development workflow

This paper focuses on the development of FPSE. The workflow is shown in Figure 2, consisting of the following steps:

Step A. Finished projects database preparation (FPD), as described in section 3.

Step B. Project success evaluation model (EM), as described in section 4.

Step C. Finished projects database with EM success scores (FPD+S): The result of the FPSE is the upgraded database of the finished projects with the finished projects' success scores (FPD+S).

3 Data Description

E-DSS is a data-driven system that operates on data from past-finished projects. This data was collected in Elea iC company from the year 2001 to 2023. At the beginning of the data collection, the number of the observed variables was relatively small, but it has grown substantially over the years. At the time of this study, the database contained data on 4704 finished projects, described by 39 numeric variables; 6 of them were date/time/year variables, and 2 categorical variables.

Data preparation (Step A, Figure 2) was carried out as follows:

1. Data cleaning: replacing "Nan" and deleting erroneous data;
2. Outlier's removal using the Interquartile range approach [18];
3. Data imputation: replacing the missing values using a descriptive statistic (e.g. mean, median, or most frequent) along each column or using a constant value [19]. We employed the mean strategy.
4. Sensitive data and information removal. For this reason, all numeric data was scaled to a range between 0 and 1.

We ended up with the database FPD containing data on 3132 finished projects described by 27 numeric variables. The variables describe the main project management characteristics, such as project financial results, workload distribution, number of employees, subcontractors, etc. Table 1 shows the list of all variables together with their basic statistics.

This way, the finished project database (FPD) was prepared for the FPSE component. FPD is the main resource for Exploratory Data Analysis for observing the data and its

properties, such as variable correlations, variable information gain, etc. These operations are invoked interactively by the user in the context of NPPE and are not discussed further in this paper.

Table 1: Basic statistics of the variables after data cleaning, outliers' removal, and data scaling

	min	max	median	mean
Project_Value	0.0	1.0	0.4215	0.2476
Number_of_Hours	0.0	1.0	0.0017	0.0123
Number_of_Employees_on_Project	0.0	1.0	0.0452	0.0420
Emploees_Workhours_Load	0.0	1.0	0.0119	0.0114
Costs_of_Subcontractors	0.0	1.0	0.0000	0.0069
Number_of_Subcontractors	0.0	1.0	0.0000	0.0150
Travelling_km	0.0	1.0	0.0000	0.0044
Project_Income	0.0	1.0	0.0018	0.0368
Project_Duration	0.0	1.0	0.2024	0.2414
Work_Period_Duration	0.0	1.0	0.0271	0.0770
Pauses_Duration	0.0	1.0	0.0000	0.0558
Number_of_Pauses	0.0	1.0	0.0000	0.0473
Proj_Work_Concentration	0.0	1.0	0.4985	0.5780
Number_of_Work_Months	0.0	1.0	0.0282	0.0740
Work_dist_Mean	0.0	1.0	0.0084	0.0190
Work_dist_Std	0.0	1.0	0.0283	0.0364
Work_dist_Min	0.0	1.0	0.0019	0.0076
Work_dist_25%	0.0	1.0	0.0041	0.0110
Work_dist_50%	0.0	1.0	0.0067	0.0161
Work_dist_75%	0.0	1.0	0.0096	0.0227
Work_dist_Max	0.0	1.0	0.0089	0.0253
Work_dist_Kurtosis	0.0	1.0	0.2051	0.2047
Work_dist_Skewness	0.0	1.0	0.4807	0.4799
Year	0.0	1.0	0.4167	0.4852
Pauses_Time_Share	0.0	1.0	0.0000	0.2096
Hour_Income	0.0	1.0	0.4547	0.2923
Time_Reserve	0.0	1.0	0.8128	0.6891

4 Evaluation of Projects' Success

The project success evaluation model (EM), developed in Step B (Figure 2), is aimed at:

- The evaluation of the projects in FPD resulting in the FPD+S (Figure 2).
- The evaluation of potential new projects suggested through interaction between the user and NPPE+S (Figure 1).

Project success evaluation involves multiple criteria that have to be aggregated into a single evaluation score. Different criteria might be of different importance and affect the score differently, i.e., with different weights. For this purpose, we chose MAUT (Multi-Attribute Utility Theory) [11], a multi-criteria modelling approach that facilitates both hierarchical structuring of criteria and using weights for the aggregation of scores.

Considering the above requirements, available FPD data and other multi-criteria approaches to project evaluation ([15], [16], [17]), we developed the EM as presented in Figure 3.

EM consists of three components [10]: input parameters, evaluation parameters and aggregation functions.

Input parameters are variables in the leaf nodes of the model:

- *Project Work Concentration*: explains the distribution of the work on the project. If the value is closer to 0 or 1, the majority of the work is done at the beginning or at the end of the project, respectively.
- *Time Reserve*: explains if the project work ended earlier than defined in the contract.
- *Number of Pauses*: the number of times the work on the project stopped.
- *Pauses Time Share*: the ratio between the months the employees did not work and the total number of months.
- *Hour Income*: the ratio between project value and the number of work hours necessary to finish the project.

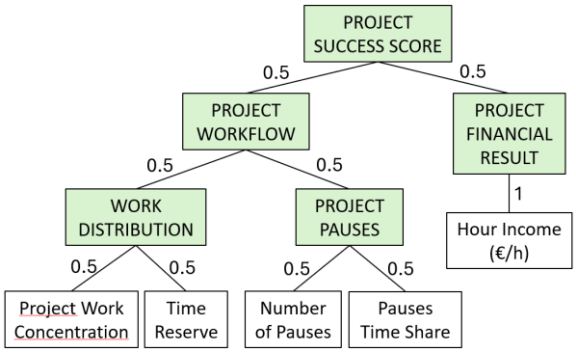

Figure 3: Multi-criteria model for the projects' success evaluation

Evaluation parameters represent outputs of the model*:*

- *WORK DISTRIBUTION*: assesses the characteristics of the work distribution in the project duration.
- *PROJECT PAUSES*: assesses the work pauses.
- *PROJECT WORKFLOW*: combines evaluation parameters WORK DISTRIBUTION and PROJECT PAUSES
- PROJECT FINANCIAL RESULT: assesses the project's success from the financial point of view.
- *PROJECT SUCCESS SCORE*: overall success score, determined by aggregation of all subordinate parameters.

Aggregation functions map subordinate EM parameters to the corresponding parent parameters. Employed is the weighted average function, using weights shown in Figure 3. Currently, weights are chosen to make all parameters equally important.

5 Experimental Evaluation of FPSE

Figure 4 shows an example of evaluating a project from FPD. Input parameters' values (terminal nodes) were obtained from the data base, while evaluation parameters' values (green nodes) were calculated by EM. The example project shows good workflow score (0.75), but has a poor financial score (0.29), both leading to an average success score (0.52) of the project. Several other projects of different types were evaluated in this way, confirming the appropriateness of EM structure and conformance with requirements of potential users. In this way, the quality of EM was assessed on a sample of past projects. Further assessment is planned in the next stages while configuring new projects, where EM's results can be confronted with opinions of project leaders actively involved in the process.

EM already enables evaluation of multiple finished projects. In Step C (Figure 2), FPD was extended by adding five variables corresponding the five Evaluation parameters of EM. All projects in FPD were evaluated by EM, resulting in FPD+S.

Basic statistics of FPD+S is presented by the distribution of the variables in Figure 5. The variables marked with red colour on the x-axis are E-DSS input parameters, the green uppercase variables are those corresponding to success scores, and the blue variables are potential new project parameters. The distribution of the final project evaluation, PROJECT_SUCCESS_SCORE,

(average = 0.52, min = 0.15, max = 0.94) indicates that it well covers the range of possible outcomes and enables the discrimination and sorting of projects.

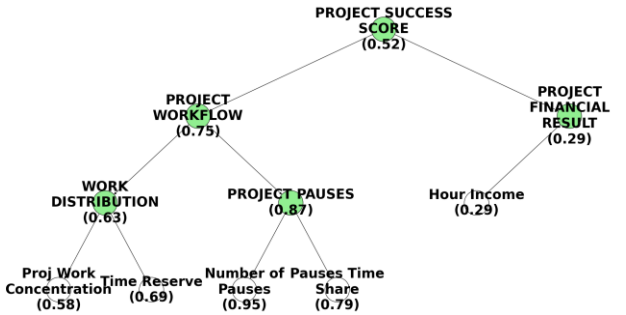

Figure 4: Example of evaluating a project using EM

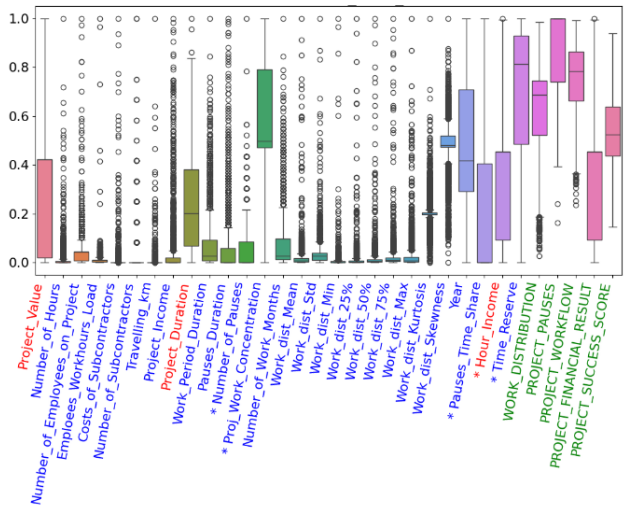

Figure 5: Distribution of the FPD+S features, including EM project success assessments

6 Conclusions

E-DSS is a DSS under construction, aimed at supporting the project management and project leaders' process in the new infrastructure project planning phase. We presented the design and development of the FPSE component, consisting of a multi-criteria project success evaluation model EM and a data base of projects, extended with success evaluation scores FPD+S.

EM has been developed using the MAUT approach and has turned out to be "fit-for-purpose". It employs the data that is available in the projects' database. It meaningfully describes aspects of the project's success and offers practical and functional model for the evaluation of multiple projects in the database.

FPSE is a key decision-support resource for E-DSS. E-DSS will allow the user to interactively search for similar past projects, to filter them according to the success score and simulate the effects of alternative project configurations, ultimately proposing the best one. Approaches based on unsupervised descriptive analytics (clustering) and supervised machine learning methods for prediction of E-DSS output parameters are foreseen for this purpose. Actually, we have already tested hierarchical clustering and decision tree classification methods on FPD+S, and first results are encouraging. We obtained meaningful clusters of past projects and created decision trees for prediction of individual output parameters that may lead to high new project success scores.

Future work will primarily continue by further data analysis and data mining of FPD+S, attempting to design effective algorithms for interactive exploration of past projects and suggesting as good as possible configurations of new projects. On this basis, we shall make a detailed functional specification of the NPPE+S component and design/implement the E-DSS.

Despite that E-DSS considered here is tailor-made for the specific business environment and is bound to the specific data base, the approach seems general enough to be applied to similar environments, projects and processes [9]. This work is a showcase of substantial efforts needed to prepare a corporate database for decision-support, which is often neglected in the literature. The main contribution is a combination of data processing with MAUT-based multi-criteria decision modelling.

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Minimizing Costs and Risks in Demand Response Optimization: Insights from Initial Experiments

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Abstract

This paper presents a method for changing the energy use of consumers participating in Demand Response (DR) programs, focusing on peak balancing to improve grid stability. Multiple objectives including costs and risks are considered, and a weighted sum is used to transform them into a single objective. This results in an optimization problem that can be optimally solved. To calculate the costs, the load consumption baseline needs to be established. Since this is challenging and can be exploited, we conduct initial experiments to test whether our method to adjust the baseline can be easily manipulated. We explore an original scenario and three of its variants to examine the effects of various parameters on the optimization outcome. Our results indicate that 1) an excessive emphasis on risk results in no energy change, 2) enforcing a net zero energy change minimizes energy use while still securing the rebate, and 3) without an adjustment period, the consumer is less inclined to increase the load just before the demand period. In future work, we will reformulate some objectives to avoid exploitation and better reflect the real-world needs of DR.

Keywords

multiobjective optimization, mixed-integer linear programming, demand response, baseline consumption, electrical grid

1 Introduction

Peaks in energy demand can strain the electrical grid, leading to inefficiencies and potential failures. A widely used strategy for balancing these peaks is Demand Response (DR), in which the Distribution System Operator (DSO) forecasts future peaks and requests from consumers to adjust their energy use to reduce them. In the peak time rebate DR program [2], consumers receive a rebate if they reduce their load in the demand period. On the other hand, if they commit to respond to the demand, but fail to do so, they can be penalized. It is therefore of utmost importance to accurately assess whether and how much a consumer reduced their load to meet the demand.

The load reduction of a consumer is computed as the difference between its baseline (the amount of energy the customer would have consumed without a demand request) and its actual use [2]. The importance of establishing a baseline and the various ways of calculating it are presented in [5]. Common methods for calculating baselines include simple historical data averages, exponential moving averages and short-term load forecasting techniques. However, baselines can be exploited, e.g., when consumers artificially increase consumption before an event to inflate their baseline and maximize the awarded rebate.

Through the SEEDS project[1], we are developing a methodology for providing energy flexibility services to prosumers – participants in energy markets capable of both producing and consuming energy – in order to enhance grid stability. Machine learning is used to predict the baseline energy usage of prosumers and their flexibility, while mixed-integer linear programming (MILP) is used to optimize the operation of prosumers within their flexibility. Our approach will be tested in the Slovenian pilot, in collaboration with Petrol d.d. and Elektro Celje d.d.

Our work integrates prosumer flexibility into DR optimization, focusing on minimizing costs and risks while limiting energy fluctuations. While the goal is to eventually use this approach on real-world data from the pilot, this paper reports on some initial experiments verifying whether the current problem formulation results in solutions with desired properties. In particular, we wish to test if our adjusted consumer baseline approach can be easily exploited.

Research on prosumer flexibility, optimization techniques, and demand response optimization includes a wide range of approaches [8]. In [3], Balázs et al. quantify residential prosumer flexibility using engineering models and real-world data. Their work provides valuable insight into prosumer behavior and energy management. Capone et al. [4] optimize district energy systems by balancing costs and carbon emissions with genetic algorithms and linear programming, showing significant emission reductions at a modest cost increase. Magalhães and Antunes [7] compare thermal load models in demand response strategies using MILP, finding that discrete control formulations improve computational efficiency. Thus, our methodology is in line with related work while the actual optimization problem (its variables, objectives and constraints) differs from existing ones as it is adapted to our specific use case.

This paper is further organized as follows. In Section 2, we provide a brief overview of the optimization problem, followed by its detailed definition in terms of its variables, constraints and objectives. The optimization approach is explained in Section 3, where we discuss the scalarization technique used to transform our multi-objective problem into a single-objective MILP form and the method used to solve it. The experiments and their results are given in Section 4. Finally, conclusions and further work ideas are described in Section 5.

2 Optimization Problem

The problem formulation in this work assumes a peak time rebate DR program in which the DSO and the consumer have a contract stipulating the following conditions: 1) the consumer can chose whether to respond to a demand request, 2) if the consumer

[1] https://project-seeds.eu/

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participates in DR, it receives a rebate proportional to the reduced load, 3) if the consumer participates in DR but does not reduce the load by at least 75 % of the required amount, it is penalized, 4) the load reduction is estimated using an adjusted consumer baseline, which takes into account the forecast consumer energy usage as well as its actual consumption before the demand period.

The optimization task is to set the energy consumption of all loads of a consumer participating in DR taking into account their flexibility so that consumer costs, risks and energy fluctuations are minimized. This ensures efficient grid operation while maintaining economic feasibility for the consumer.

To formally define our optimization problem, we first introduce its variables, followed by the constraints and the objective functions we aim to optimize. Finally, we provide an overview of the weighted sum approach, which serves as the scalarization technique to transform all objective values into a single one.

2.1 Variables

A solution is specified by the energy amounts $E_{c,i} \in \mathbb{R}$ for each consumer load $c \in C$ and time interval $i \in \{1, \ldots, n\}$. They correspond to the change of consumption from the forecast one. These are the only variables of this optimization problem.

From these energy amounts and the forecast timetable of energy usage, the resulting energy consumption E_i in time interval $i \in \{1, \ldots, n\}$ is computed as

$$E_i = E_i^{\mathrm{F}} + \sum_{c \in C} E_{c,i}.$$

2.2 Constraints

The energy amounts of a solution need to adhere to two kinds of constraints. The first type are the interval energy constraints:

$$E_{c,i}^{\min} \leq E_{c,i} \leq E_{c,i}^{\max},$$

for each consumer load $c \in C$ and time interval $i \in \{1, \ldots, n\}$. The second are the total energy constraints:

$$E_c^{T,\min} \leq \sum_{i=1}^{n} E_{c,i} \leq E_c^{T,\max},$$

for each consumer load $c \in C$.

2.3 Objective Functions

The three objectives to be minimized in this scenario are the costs, risks and energy fluctuations.

The first optimization objective f_1 consists of all costs associated with the solution and equals

$$f_1 = f^{\mathrm{E}} - f^{\mathrm{R}} + f^{\mathrm{P}},$$

where f^{E} represents the energy costs, f^{R} is the rebate for the recognized load reduction and f^{P} is the penalty that is charged in case the recognized load reduction does not meet the requirements.

The energy costs f^{E} equal the sum of energy costs over all time intervals $i \in \{1, \ldots, n\}$,

$$f^{\mathrm{E}} = \sum_{i=1}^{n} p_i \, E_i,$$

where p_i is the interval energy price.

The solution gains a rebate it the load is reduced in the demand period $\{t^{\mathrm{S}}, \ldots, t^{\mathrm{E}}\}$. Note that the recognized load reduction E_t^{R}, $t \in \{t^{\mathrm{S}}, \ldots, t^{\mathrm{E}}\}$, is computed from the adjusted timetable energy E_t^{A} instead of the forecast one E_t^{F}, where the adjustment is determined by the energy amounts in the adjustment period – the n^{A} intervals before the start of the demand period t^{S}. More formally, the adjusted timetable is computed as

$$E_t^{\mathrm{A}} = \begin{cases} E_t^{\mathrm{F}} - \dfrac{1}{n^{\mathrm{A}}} \displaystyle\sum_{j=t^{\mathrm{S}}-n^{\mathrm{A}}}^{t^{\mathrm{S}}-1} \left(E_j^{\mathrm{F}} - E_j\right), & \text{if } n^{\mathrm{A}} > 0; \\ E_t^{\mathrm{F}}, & \text{otherwise} \end{cases}$$

for all intervals $t \in \{t^{\mathrm{S}}, \ldots, t^{\mathrm{E}}\}$ in the demand period. Then, the recognized load reduction E_t^{R} at demand time interval $t \in \{t^{\mathrm{S}}, \ldots, t^{\mathrm{E}}\}$ is determined as

$$E_t^{\mathrm{R}} = E_t - E_t^{\mathrm{A}},$$

while the total recognized load reduction E^{R} is computed as

$$E^{\mathrm{R}} = \sum_{t=t^{\mathrm{S}}}^{t^{\mathrm{E}}} E_t^{\mathrm{R}}.$$

A rebate is awarded if E^{R} is negative (the consumption has been reduced). If the total recognized load reduction exceeds the total demanded energy reduction E^{T}, the rebate is capped, i.e.,

$$f^{\mathrm{R}} = \begin{cases} p^{\mathrm{B}} \min\left(\left|E^{\mathrm{R}}\right|, \left|E^{\mathrm{T}}\right|\right), & \text{if } E^{\mathrm{R}} < 0 \\ 0, & \text{otherwise} \end{cases}.$$

Finally, a penalty is added to the total costs if the demand has not been met, that is, the ratio between the recognized and demanded energy reduction, E^{D}, in any of the demand time intervals $t \in \{t^{\mathrm{S}}, \ldots, t^{\mathrm{E}}\}$ is lower than 75 %,

$$f^{\mathrm{P}} = \begin{cases} p^{\mathrm{P}} \left|E^{\mathrm{T}}\right|, & \text{if } \dfrac{E_t^{\mathrm{R}}}{E^{\mathrm{D}}} < 75\,\% \text{ for one or more } t \in \{t^{\mathrm{S}}, \ldots, t^{\mathrm{E}}\} \\ 0, & \text{otherwise} \end{cases}.$$

The second optimization objective f_2 represents risks. In order to penalize any changes to the timetable when the risks are high, the objective function is defined as

$$f_2 = \sum_{i=1}^{n} r_i \sum_{c \in C} \left|E_{c,i}\right|,$$

where r_i represents the risk at time interval i.

To penalize unnecessary energy fluctuations, the third objective f_3 averages the consecutive changes in energy amounts for all consumer loads, i.e.,

$$f_3 = \frac{1}{(n-1)|C|} \sum_{i=2}^{n} \sum_{c \in C} \left|E_{c,i} - E_{c,i-1}\right|.$$

2.4 Weighted Sum Approach

Since the optimal solutions to this problem appear to reside in the convex region of the objective space, we use a weighted sum approach to transform all objective values into a single one. The single objective function to be minimized thus equals

$$f = w_1 f_1 + w_2 f_2 + w_3 f_3$$

under the condition $w_1 + w_2 = 1$. The weight w_3 can be set independently of w_1 and w_2 and serves as a measure of limiting the energy fluctuations.

3 Optimization Approach

3.1 Setting Weights in the Weighted Sum

To obtain diverse solutions with the weighted sum approach, a good strategy for setting the weights is needed. While we plan to use a more sophisticated approach for this purpose in future work, these initial experiments were made by choosing equidistant values of w_1 from the interval $[0, 1]$ and defining w_2 as $1 - w_1$. In order to limit energy fluctuations, we set w_3 to 10^{-3}. Smaller weights proved insufficient in limiting the fluctuations while larger weights interfered with the first two objectives, which are more important than the third.

3.2 Linearization

Since all of the objective functions specified in Section 2.3 are either non-linear or contain non-linear parts, specific techniques are required to linearize these objectives and ensure the problem fits the MILP form. In particular, it is necessary to linearize the absolute value of a real variable, the product of a binary variable and a real variable, the minimum of two variables, along with other non-linear function conditions. We use standard approaches to achieve linearization for all these cases [9].

3.3 Tool and Solver

We use the OR-Tools Python library[2] to implement and solve the single-objective MILP problem. The library is a comprehensive tool for solving optimization problems, including linear programming, integer programming, and combinatorial optimization. Specifically, we use the SCIP (Solving Constraint Integer Programs) solver [1] integrated within OR-Tools[3] for solving MILP problem instances.

To solve a MILP problem using OR-Tools and the integrated SCIP solver, the following steps are performed: import the linear solver wrapper, declare the SCIP solver, define the variables with their respective bounds, set the constraints and the objective function and lastly, analyze and display the solution.

4 Experiments

We first conduct experiments using a basic scenario with a single consumer load. Then, we variate some parameters of this scenario to see how they affect the resulting solutions.

4.1 Experimental Setup

The basic scenario has the following parameters:

- Time is represented as 28 15-minute intervals.
- The demand period starts at $i = 13$ and ends at $i = 16$.
- The total required reduction E^{T} equals -8 kWh and the required reduction E^{D} at each interval equals -2 kWh.
- The adjustment period has a duration of four intervals.
- The load change needs to be within $[-3\,\mathrm{kWh}, 3\,\mathrm{kWh}]$ for each interval $i = 5, 6, \ldots, 24$ and is fixed to 0 kWh for the remaining intervals.
- The forecast timetable energy E_i^{F} is constant and equals 12 kWh for all time intervals.
- The total energy constraint is unbounded.
- The risk equals 0.50 for all time intervals.
- All prices are constant: $p_i = 0.25$ EUR, $p^{\mathrm{R}} = 0.50$ EUR and $p^{\mathrm{P}} = 1.00$ EUR.

[2] https://developers.google.com/optimization

[3] https://github.com/google/or-tools/blob/stable/ortools/linear_solver/samples/mip_var_array.py

The three scenario variants differ from the basic as follows. The first scenario variant has no demand. In the second and third scenario variant, the total energy change is set to 0 kWh ensuring the reduction in energy consumption in some intervals is matched with its increase in others. Additionally, the third scenario variant has no adjustment period, i.e, $n_{\mathrm{A}} = 0$.

4.2 Results and Discussion

We discuss here the results of our original scenario and its three variants. They are depicted also in plots in Figures 1 to 4, which show with a black line how the consumer load changes from its planned timetable. Consumer load flexibility at each time interval is shown in gray (there is no flexibility in the first four and last four intervals). The demand period is denoted in red and the adjustment period in blue. In most cases (unless the risk has a large weight), the consumer reduces the load in the demand period enough to meet the required demand and earn the entire available rebate while not incurring any penalty. The amount of this reduction and the energy change outside of this period differ for the various scenario variants.

4.2.1 Original Scenario. When the risk has a large weight, the load does not change outside of the demand period (see the top plot in Figure 1). However, when the impact of risk is minimal (bottom plot in Figure 1), the load is reduced everywhere except during the adjustment period. This strategy artificially increases the perceived load reduction to maximize the rebate, as dictated by the rebate calculation formula.

4.2.2 Scenario Variant #1: No Demand. If the optimization is called without a demand, the result depends on the weighting of the first two objectives. As long as the impact of risk is significant (top plot in Figure 2), the load does not change. Otherwise, the load is reduced to the maximum extent in each interval (bottom plot in Figure 2). This approach minimizes the function f_E, therefore reducing costs. This means that the consumer behavior can change when optimized even if no demand is present.

4.2.3 Scenario Variant #2: Zero Total Energy Change. Due to the zero energy constraint, the consumer makes adjustments solely within the demand and adjustment periods (see Figure 3). During the adjustment period, the user offsets the consumption from the demand period, thereby achieving a maximal rebate. To adhere to the requirement of minimizing risks and fluctuations in other intervals, no additional changes are made, as such actions would increase the objective value.

4.2.4 Scenario Variant #3: Zero Total Energy Change and No Adjustment Period. When the baseline is not adjusted, the load is increased in intervals outside of the demand period, regardless whether they occur before or after it. The specific intervals when this happens depend on the solver and are random as they lead to the same objective function value. An example of such a case in depicted in Figure 4.

The last two variants additionally confirm that the usage of the adjustment period enables exploitation – the entire rebate can be gained with a smaller load reduction in the demand period if the load is increased in the adjustment period.

5 Conclusions

This paper focuses on demand response optimization and the growing role of prosumers in energy systems. A standard MILP framework is used to set the consumer load energies within

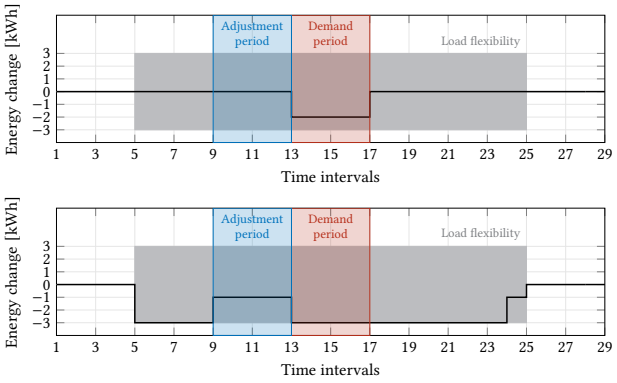

Figure 1: Results for the original scenario with $w_1 = 0.6$ and $w_2 = 0.4$ (top) and $w_1 = 0.8$ and $w_2 = 0.2$ (bottom).

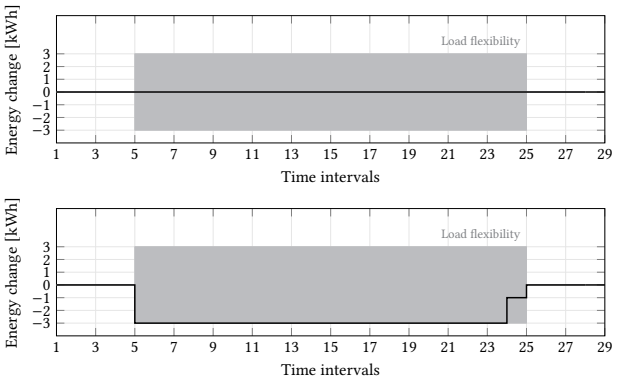

Figure 2: Results for the variant without demand with $w_1 = 0.5$ and $w_2 = 0.5$ (top) and $w_1 = 0.7$ and $w_2 = 0.3$ (bottom).

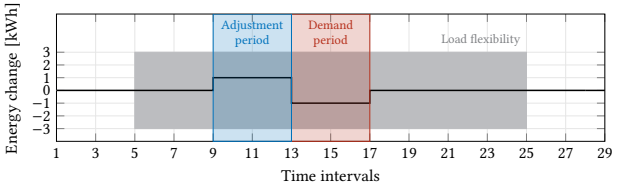

Figure 3: Results for the variant with zero total energy change with $w_1 = 0.6$ and $w_2 = 0.4$.

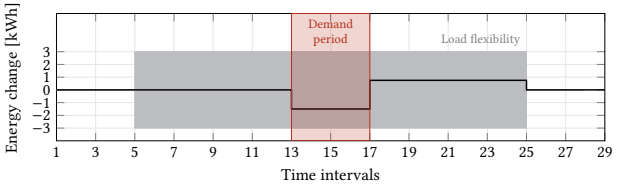

Figure 4: Results for the variant with zero total energy change and no adjustment period with $w_1 = 0.6$ and $w_2 = 0.4$.

their flexibility so that the costs, risks and energy fluctuations are all minimized. Since the objectives are scalarized with the weighted sum approach, correctly setting their weights is crucial for generating a set of diverse solutions representing various trade-offs between costs and risks.

By creating three scenario variants, we were able to explore the effect of some parameters on the optimization outcome. We observe that:

- Regardless of the variant, the optimal load schedule does not deviate from the forecast one if the importance of risk is too high, i.e., if the weight w_2 is too large. This critical value of w_2 depends on the scenario variant.
- If the consumer is obliged to a zero sum in load increase and reduction, the optimal solution uses the minimal necessary resources to earn a rebate while avoiding excessive energy changes.
- When the adjustment period is unspecified, the prosumer is less likely to increase the load just before the demand period.

Moving forward, we need to refine the objectives. The current method to assess the baseline consumption is susceptible to exploitation and should be amended. We could calculate the consumer baseline from similar consumers that do not participate in DR as suggested in [6]. We will also need to revise the penalty calculation to account for the imminent change of tariffs in the Slovenian energy market. We additionally plan to improve the calculation of risks to ensure more robust optimization and real-world applicability. Finally, we intend to develop a better strategy for setting the weights, targeting values with the most significant impact rather than evenly distributing them.

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Predicting Hydrogen Adsorption Energies on Platinum Nanoparticles and Surfaces with Machine Learning

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Abstract

The growing interest in hydrogen gas as a fuel drives research into environmentally friendly hydrogen production methods. One viable approach of obtaining hydrogen is the electrocatalysis of water, which includes the hydrogen evolution reaction (HER) as one of the half-reactions. In the search of highly active catalysts for the HER, machine learning can be effectively utilized to develop models for calculating hydrogen adsorption energy, a key descriptor of catalytic activity. In this study, we learned models for predicting hydrogen adsorption energy on platinum. We used various machine-learning (ML) techniques on two datasets, one for extended surfaces and the other for nanoparticles. The respective results reveal that ML models for extended surfaces are more accurate than those for nanoparticles, and that the features describing the local environment are the most significant for the predictions. For surfaces, the coordination number is the most relevant feature, while the d-band center is the most important for nanoparticles. The ML models developed in this study lack sufficient accuracy to provide reliable results, highlighting the need for further investigation with additional features or larger datasets.

Keywords

platinum, hydrogen, DFT calculations, decision trees, feature ranking

1 Introduction

A lot of scientific and societal interest is devoted to hydrogen fuel, which can generate electrical power by producing water as a byproduct. One environmentally friendly method of producing hydrogen is through the electrocatalysis of water, where hydrogen and oxygen gases are formed. This process involves two reactions: oxygen and hydrogen evolution reactions. Considerable effort is being directed towards improving catalysts for both reactions and understanding the fundamental processes involved [21, 13]. In this contribution, we will focus on the hydrogen evolution reaction (HER), for which platinum is known to be a highly active catalyst due to its near-optimal hydrogen adsorption free energy [15, 21]. However, the high cost of platinum motivates ongoing research of alternative materials.

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The mechanism of HER includes adsorbed hydrogen atom (H*) as an intermediate. Consequently, the adsorption energy of hydrogen is often used as a descriptor of the catalytic activity of the material [15, 21]. The most straightforward approach to obtain the adsorption energies is with density-functional theory (DFT) calculations. However, as the size of the system and the number of different adsorption sites increase, a full DFT analysis becomes computationally unfeasible. To address this challenge, machine-learning methods can be employed to predict hydrogen adsorption energies based on DFT results, enabling the investigation of more complex systems [10]. For example, bimetallic nanoparticles were investigated by Jäger et al. [8] and Zhang et al. investigated amorphous systems [20].

This contribution focuses on the use of machine learning for predicting hydrogen adsorption energies on platinum using electronic and geometric descriptors. Two separate datasets were constructed, one for surfaces and the other for nanoparticles. By employing supervised learning and attribute ranking, we built ML models, assessed their accuracy and analyzed whether the two datasets exhibit similar correlations. The idea of the contribution is illustrated in Figure 1.

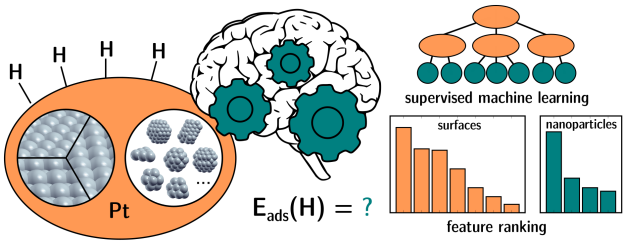

Figure 1: Supervised machine learning and feature ranking was performed for hydrogen adsorption energy on platinum catalysts modeled as surfaces and nanoparticles.

2 Materials and Methods

2.1 DFT Calculations and Datasets

We utilized DFT calculations to calculate hydrogen adsorption energies (a target variable for ML) and electronic descriptors for ML. We also utilized geometric descriptors. Two datasets were constructed, one for platinum nanoparticles and the other for platinum surfaces.

DFT calculations were performed with the Perdew-Burke-Ernzerhof (PBE) approximation [17], a plane-wave basis set, and PAW pseudopotentials [3]. Energy cutoffs were set to 50 and 575 Ry for wavefunctions and electron density,

respectively. Methfessel-Paxton smearing [12] of 0.02 eV was employed.

Pt(111), Pt(100), and Pt(110) surface slab models were constructed with the calculated lattice parameter of bulk Pt (3.97 Å). The models of Pt(111) and Pt(100) surfaces consist of 4 atomic layers, with the bottom layer fixed to bulk positions, while Pt(110) has 6 atomic layers with the bottom two layers fixed. To achieve a greater variety of adsorption sites, Pt(111) and Pt(100) were also modeled with a missing-row defect. All surface models are shown in Figure 2. Calculations accounted for the dipole correction and periodic images of slabs were separated by at least 15 Å of vacuum. Different sizes of surface supercells were used, and the k-point grid for (1×1) surface unit cells of Pt(111), Pt(100), and Pt(110) were 12×12×1, 11×11×1, and 11×8×1, respectively. For larger supercells, the number of k-points was adapted accordingly.

Calculations with nanoparticles were performed with the gamma k-point and Martyna-Tuckerman correction for isolated systems [11]. Nanoparticles were modeled with different shapes and sizes, consisting of 3 and up to 116 atoms. Their periodic images were separated by at least 15 Å of vacuum. All calculations were preformed with the Quantum ESPRESSO package [5].

The hydrogen adsorption energy was calculated as:

$$E_{\mathrm{ads}} = E_{\mathrm{H}*} - E_{*} - \frac{1}{2}E_{\mathrm{H_2}} \tag{1}$$

where $E_{\mathrm{H}*}$ is the calculated energy of optimized adsorption system, E_* is the energy of the standalone platinum system, and $E_{\mathrm{H_2}}$ is the energy of the hydrogen molecule. All performed calculations included only one adsorbed H atom per supercell or nanoparticle.

As an electronic descriptor, we used the d-band center, which is considered to be a good indicator of metal reactivity [6]. It was obtained through DFT calculations using the following equation:

$$\varepsilon_{\mathrm{d}} = \frac{\int_{-\infty}^{\infty} n_{\mathrm{d}}(E)EdE}{\int_{-\infty}^{\infty} n_{\mathrm{d}}(E)dE} \tag{2}$$

where E is the energy and n_{d} is the projected density of states on d-orbitals of the atoms forming the adsorption site.

For the geometric descriptors, we determined the average coordination number of Pt atoms forming the adsorption site, as well as the generalized coordination number (GCN) of the adsorption site [2], calculated as:

$$\mathrm{GCN}(i) = \sum_{j=1}^{N_i} \frac{\mathrm{CN}(j)}{\mathrm{CN}_{\mathrm{max}}} \tag{3}$$

where i denotes an atom or a group of atoms forming the adsorption site, N_i is the number of first nearest neighbors of i, which are denoted with j. $\mathrm{CN}(j)$ is the coordination number of atom j and $\mathrm{CN}_{\mathrm{max}}$ is the maximal coordination of a given site found in the bulk material.

In addition, the type of adsorption site was used as a descriptor. For extended surfaces, the coverage of H atoms, the surface area per H atom and surface type were also used for learning. For nanoparticles, some descriptors relevant to the size of nanoparticles were also utilized, in particular: the number of all atoms (N_{all}) in the nanoparticle, the number of surface atoms (N_{surf}), the maximal (r_{max}) and minimal (r_{min}) distances from the center of the nanoparticle to the surface atoms and the distance from the center of the nanoparticle to the adsorption site (r_{ads}). The datasets for surfaces and nanoparticles contained 46 and 85 data points, respectively.

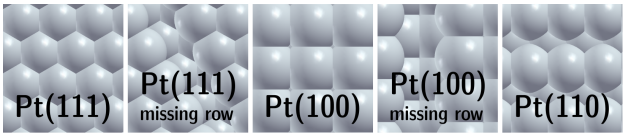

Figure 2: Models of extended surfaces used to calculate hydrogen adsorption energies.

2.2 Machine-Learning Methods

The prepared datasets were analyzed using the Weka software package [4]. The target value in both datasets is the hydrogen adsorption energy, making this a regression task. Supervised machine learning was employed to develop models for predicting the target value, which were evaluated by 10-fold cross-validation.

One of the used methods is linear regression, that computes the linear relationship between the target value and the descriptors. The relevant descriptors included in the equation were selected according to the M5 method [18]. This method iteratively removes descriptors with the smallest effect on the model until the error of the model no longer decreases.

We also used the random forest method [7, 1] with 100 trees of unlimited depth. With this method, multiple decision trees were constructed by selecting relevant features from a random subset of $\mathrm{int}(\log_2(m)+1)$ features, where m is the total number of features. The final values are the averages of the predictions from the individual trees.

To obtain an explainable ML model, we also built regression trees using the M5' method [18, 19]. In this method, trees are built by splitting the training sets according to attributes that maximize the standard deviation reduction. After the trees are constructed, they are pruned to avoid overfitting and smoothed to address discontinuities between the leaves. For our datasets, we used unpruned trees to prevent the formation of trees that are too small and give poor predictions. We also restricted tree branching to a minimum of 6 instances per leaf node for surfaces and 20 for nanoparticles to avoid overfitting the data and to ensure trees of sufficient size.

We also performed variable importance estimation and ranking for our selected descriptors with all data points used as a test set. To evaluate the importance of the descriptors with respect to hydrogen adsorption energy, we employed two methods: ReliefF [9] and correlation [16]. The ReliefF method is more sensitive to feature interactions and works by calculating the distances between training instances and identifying the 'nearest hit' and 'nearest miss'. It then adjusts the weights of the differing descriptors between the target and nearest instances. The correlation method evaluates the Pearson correlation coefficient [16]

between the features and the target variable, without accounting for interactions between features. It gives scores ranging from −1 to 1, with 1 being the highest correlation score, a score of −1 indicates anti-correlation, and 0 indicates no correlation.

3 Results and Discussion

3.1 Machine-Learning Models

Supervised machine learning was performed using linear regression, random forest, and M5' regression tree. The obtained Pearson's correlation coefficients and root mean squared errors (RMSE) between true and predicted values are shown in Table 1.

We can observe that not all ML models provide better RMSE values compared to those calculated with a simple arithmetic average, referred to as the default predictor. For surfaces, linear regression and random forest perform the best and yield similar results. The regression tree model performs the worst and has higher RMSE compared to the default predictor. For nanoparticles, all methods yield errors close to those of the default predictor and correlation coefficients bellow 0.5.

The obtained results indicate that with the selected descriptors, the hydrogen adsorption energies are more accurately predicted on surfaces, which are simpler as compared to nanoparticles. Surfaces have high symmetry and only a handful of different adsorption sites, while nanoparticles have different shapes and sizes, consist of different facets, and each nanoparticle has numerous different adsorption sites. This gives a huge variety of adsorption sites that can make the prediction of adsorption energies harder.

Considering the best models, the obtained adsorption energies have an error of ±0.13 eV for surfaces and ±0.22 eV for nanoparticles. Due to the exponential dependence of reaction rate and adsorption energy, even a small error in adsorption energy hugely affects the reaction rate. Hence, the models, particularly for nanoparticles, do not provide sufficiently accurate results for any practical use.

The selected ML models also provide insights into the relations between the considered features and the target variable. The linear regression model for nanoparticles includes only the d-band center and a factor for the hollow adsorption site, whereas the equation for surfaces is more complex. It includes adsorption site, surface type, and both coordination numbers. This indicates that for nanoparticles, the d-band center is the most relevant factor, while for surfaces, geometric factors exhibit greater predictive value.

Table 1: Pearson's correlation coefficients (CC) and root mean squared errors (RMSE) in eV units for all three used ML methods. For comparison, RMSE of the default predictor is also given.

	surfaces		Nanoparticles	
	CC	RMSE	CC	RMSE
linear regression	0.71	0.13	0.38	0.22
random forest	0.69	0.13	0.34	0.22
M5' decision tree	0.49	0.19	0.34	0.22
default predictor	/	0.18	/	0.23

The regression-tree models shown in Figure 3 have lower accuracy and, consequently, are less reliable.

The ML models could be improved by expanding the dataset or by calculating additional descriptors. For surfaces, more data can be obtained through calculations on a wider variety of surface types and by accounting for different surface defects. However, expanding the dataset for nanoparticles is limited by their size, since DFT calculations for larger particles are computationally too demanding. Therefore, a larger number of different smaller particles can be tested instead. Using more sophisticated descriptors such as atom-centered symmetry functions, smooth overlap of atomic positions and many body tensor representation could also improve the results, but would require different sampling of adsorption structures. The use of transfer learning from pre-trained models based on chemical structures could also lead to significant improvements.

3.2 Feature Ranking

Feature ranking was performed for both surfaces and nanoparticles, with the results presented in Figure 4. The ReliefF and correlation importance criteria provide different rankings of features. For surfaces, the coordination number is identified as the most relevant descriptor, followed by the generalized coordination number. In contrast, for nanoparticles, the d-band center is the most important descriptor. Features describing the size of different nanoparticles show lower relevance for predictions. The most relevant features in both data sets describe the local environment of the adsorption site, indicating the local nature of adsorption.

The importance of the d-band center is already well-documented in the literature [14], as it correlates with the reactivity of metals. As seen from the graphs, the d-band center is not so strongly correlated with the hydrogen binding energy on surfaces. This can be attributed to the fact that on a perfectly flat surface, all surface atoms have the same d-band center. In contrast, on nanoparticles, the d-band center varies for each adsorption site because the atoms are not equivalent. Therefore, the d-band center is expected to be more relevant for nanoparticles. For the ranking based on correlation, the calculated factors for the

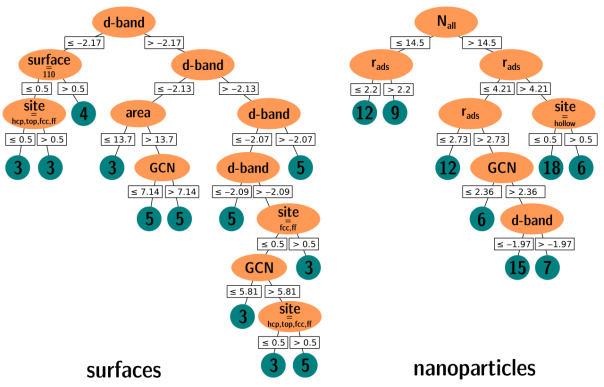

Figure 3: Schematic representation the obtained random-tree models for ideal surfaces and nanoparticles. Nodes are denoted with orange and the resulting classes are represented with turquoise circles and include the number of data points in the class.

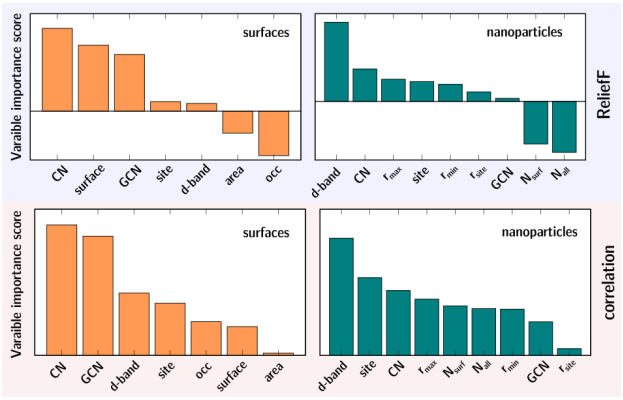

Figure 4: Variable importance scores calculated by the ReliefF and correlation criteria. Importance scores for correlation criteria are given as absolute values.

d-band center are negative. This indicates that a lower d-band center corresponds to a higher adsorption energy and consequently a less reactive site, which is physically intuitive.

It is also interesting to note that the surface type descriptor is not very relevant according to correlation, yet it becomes the second most important feature when other descriptor are considered. This can be attributed to the fact that this descriptor has the same value for all adsorption sites on the same surface. However, when combined with other descriptors, it can give additional information, as similar adsorption sites on different surfaces can yield considerably different adsorption energies.

4 Conclusion

We applied different ML techniques to predict the adsorption energy of hydrogen on platinum surfaces and nanoparticles using simple geometric and electronic descriptors. Models for predicting adsorption energy on surfaces performed better, with the linear regression and random forest methods showing the highest correlation coefficient and accuracy. In contrast, predictions for nanoparticles yielded lower correlation coefficients and accuracy similar to the one calculated by a default predictor. Therefore, the models presented in this contribution do not provide accurate estimation of hydrogen adsorption energies. Utilizing more sophisticated descriptors and larger training data sets could enhance the performance of these models.

Differences between datasets are also evident in feature ranking. For surfaces, coordination numbers are the most relevant descriptors, while for nanoparticles, the d-band center shows the highest relevance. All these relevant descriptors are related to the local environment of the adsorption site, indicating that adsorption is a local phenomenon.

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SmartCHANGE Risk Prediction Tool: Demonstrating Risk Assessment for Children and Youth

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Abstract

Non-communicable diseases (NCDs) have become a significant public health challenge in developed countries, driven by common risk factors such as obesity, low physical activity, and unhealthy lifestyle choices. Early childhood and adolescence are crucial for establishing healthy behaviours, and early intervention can play a crucial role in preventing or delaying the onset of NCDs later in life. However, current tools for identifying high-risk individuals are primarily designed for adults, which results in missed early detection opportunities in younger populations. The SmartCHANGE project (https://smart-change.eu/) seeks to bridge this gap by developing reliable AI tools that assess risk factors in children and adolescents as accurately as possible while promoting optimized risk reduction strategies.

In developing the risk assessment tool, we addressed the challenge of merging diverse datasets, predicting missing data to create longitudinal datasets, implementing existing validated models for diabetes (QxMD) and cardiovascular disease (SCORE2), and ultimately creating a simple online application to demonstrate the functionality of the developed risk tool.

Keywords

risk tool, dataset merge, neural networks, online application

1 Introduction

In developed countries, non-communicable chronic diseases (NCDs) have emerged as the foremost public health challenge over recent decades. According to the World Health Organization (WHO), NCDs account for more than 70% of mortality in the European region [18]. Common risk factors for NCD include obesity, poor physical fitness, and unhealthy lifestyle habits such as inadequate physical activity, sedentary behaviour, poor nutrition, insufficient sleep, smoking, and excessive alcohol consumption. Embracing a healthy lifestyle can improve physical, social, and mental well-being, especially among youth, while mitigating the risks of NCD-related morbidity and mortality [15], [14], [5].

Traditionally, clinical prevention strategies for NCDs have been directed at adults, as the risk factors typically become evident in adulthood. However, recent evidence suggests that focusing interventions on children and adolescents can be a more effective strategy for reducing NCD risk through behaviour modification [13]. While NCDs may not appear in childhood or adolescence, early signs can alreadexistnt. Tackling risk factors and promoting healthy habits during these stages can prevent or delay NCDs later in life [12]. Childhood and youth are also crucial periods for establishing healthy lifestyle habits. Since risk factors for NCDs often persist from childhood into adulthood [9], early risk assessment and reduction of risk factors can potentially lower the incidence of NCD. Lastly, NCDs in youth are a significant global health challenge, with nearly one in five adolescents worldwide being overweight or obese [1].

Identifying high-risk individuals for future health problems is essential for targeted preventive interventions. Existing tools focus mainly on adults [6], for instance predicting 10-year risk of developing cardiovascular disseased [17] or diabetes [8], missing the opportunity to identify high-risk individuals during childhood and adolescence, a critical period for forming lifestyle habits. However, recognition of health risks is not a trivial task. For instance, only 35% of doctors in the UK are aware of the recommendations for physical activity, and only 13% can specify the recommended weekly duration. Moreover, more than 80% of parents of inactive children incorrectly believe that their children are sufficiently active [4]. Developing risk prediction tools for children and youth would significantly improve NCD prevention and promote cost-effective strategies.

This paper presents the development of an initial demo application of a risk assessment tool designed for children and adolescents in the SmartCHANGE project [3] - merging datasets, predicting missing data to build longitudinal datasets, and implementing existing validated models for diabetes (QxMD) and cardiovascular disease (SCORE2) and finally, the application development.

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Table 1: Overview of Selected Datasets

Dataset Name	SLOfit	LGS	YFS	AFINA-TE
Country of Origin	SI	BE	FI	PT
Age Range	5 - 20	5 - 25	0 - 60	5 - 25
Longitudinal Study	Yes	Yes	Yes	No
# of Participants	280,165	17,991	3,596	1,632
# of Measurements	3,121,399	31,127	32,364	1,632
# of Variables	13	80	24	59
% of Missing Values	2.55%	16.25%	39.49%	33.53%

2 Methodology

2.1 Datasets

To estimate the risk of non-communicable diseases in children, ideally, one would need a dataset that tracks risk factors from a young age (when the prediction is made) to an older age (when these diseases typically emerge). Such comprehensive longitudinal datasets would allow for accurate predictions of an individual's likelihood of developing a disease later in life based on their early risk factors. However, such datasets are currently unavailable, so we must rely on a collection of partial and often heterogeneous datasets.

In our study, we have chosen 16 types of variables that are used by risk models SCORE2 [17] and QxMD [8]. The datasets we were using are described in Table 1. The SLOfit program is a school fitness monitoring initiative in Slovenia [11]. The Leuven Growth Study (LGS)[2, 16] is a longitudinal study initiated in 1969 that evaluates physical fitness. The Cardiovascular Risk in Young Finns Study (YFS)[10], started in the late 1970s, focuses on early cardiovascular disease risk factors. The AFINA-TE dataset [7] is part of an intervention program in Portugal designed to enhance physical fitness, activity, and nutritional knowledge among children and adolescents.

2.2 Data Imputation Through Datasets

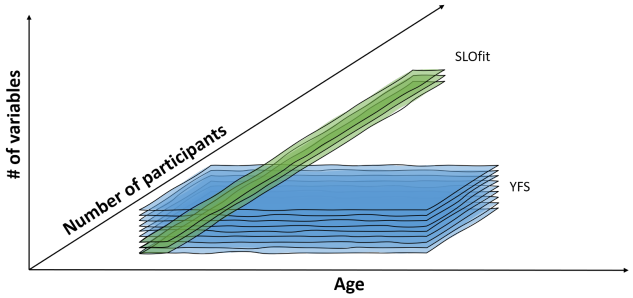
The first step involved imputing missing values within each dataset (see Figure 1 for representation). To guide this process, we calculated the coverage for each variable. Initially, we used only fully observed variables—such as height, weight, and sex—as features in models to impute missing values for other variables. The variables were imputed based on their coverage using machine learning on existing features. After this initial imputation sweep, we had a complete, though potentially imperfect, dataset. In the second sweep, we treated all columns as complete, incorporating the newly imputed values from the first sweep. This allowed us to train models with a more comprehensive dataset, improving the accuracy of the imputation.

2.3 Longitudinal Data Imputation

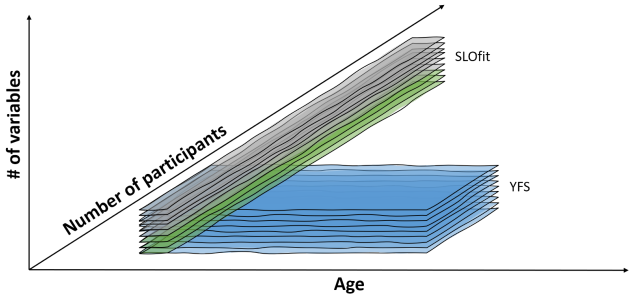
In the second step, we employed a similar approach but focused on merging the datasets to fill the new merged dataset longitudinally (see Figure 2 for representation). To maximize their overlap, we treated certain variables as equivalent—such as vertical jump from the LGS dataset and standing long jump from the SLOfit dataset.

Since the raw values of these variables differ, we standardized them by converting them to z-scores, which were calculated as follows:

$$z_score = \frac{variable - mean}{standard_deviation}.$$



(a) Example of the datasets pre-imputation.



(b) Example of the datasets post-imputation.

Figure 1: The YFS dataset (blue) covers a broad range of variables across a wide age span but includes a relatively small number of participants. In contrast, the SLOfit dataset (green) has many participants but includes fewer variables over a shorter age span. In the first step, we imputed the missing variables across the datasets (grey).

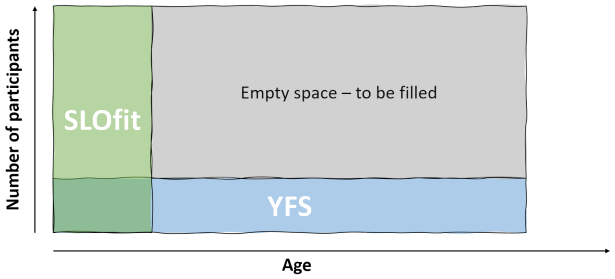


Figure 2: Longitudinal filling of the datasets.

For instance, a vertical jump one standard deviation above the mean in the LGS dataset was considered equivalent to a standing long jump one standard deviation above the mean in the SLOfit dataset. After matching and standardizing the columns across datasets, we merged the individual datasets into a single, comprehensive dataset and repeated the imputation process.

With a merged dataset free of missing values, we built models to predict attribute values at age 55—the oldest age supported by our data—using values from age 14. Due to the lack of data covering the entire age range from 14 to 55, we approached this in two stages: predicting from age 14 to 18 and then from 18 to

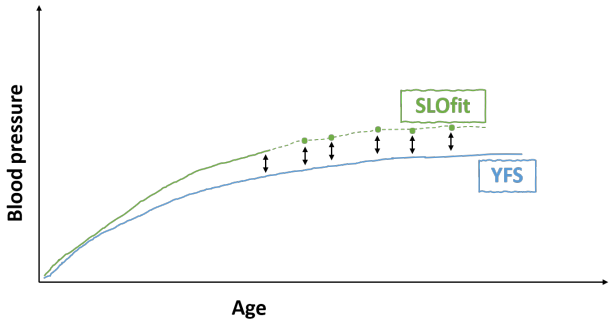


Figure 3: Population-based approach using z-scores.

55. The models used were simple neural networks with a single hidden layer.

This individual forecasting approach required available data for the same person from the start to the end age. However, since we had more data available for different people of various ages, we also explored a population-based approach to forecast the typical evolution of each variable. While this method is less personalized, it is also less prone to anomalies caused by atypical individuals. In the population-based approach, we again used z-scores, assuming that each person's z-score remains constant. For example, if someone's blood pressure is one standard deviation below the mean at age 14, it is assumed to stay one standard deviation below the mean at age 55 (see Figure 3).

2.4 Risk Models

The SCORE2 and QxMD models were used in the application to assess cardiovascular disease and type 2 diabetes risk. These models were chosen for their validity, robustness and effectiveness in predicting these chronic conditions. By incorporating both, healthcare practitioners can comprehensively evaluate cardiometabolic risk factors, aiding in well-informed patient management and intervention decisions.

The SCORE2 model, developed by the European Society of Cardiology, estimates the risk of cardiovascular events over ten years. It calculates the risk score by incorporating variables such as age, sex, smoking status, blood pressure, and lipid profile. Additionally, SCORE2 considers regional variations in risk factors, providing more accurate predictions tailored to specific populations [17].

The QxMD Diabetes Risk Calculator, a comprehensive clinical decision support tool, is employed to evaluate the risk of developing type 2 diabetes mellitus. This model integrates risk factors, including age, BMI, family history, physical activity level, and dietary habits, to estimate an individual's diabetes risk [8].

3 Evaluation

Table 2 presents the cross-validated evaluation results of our forecasting models. As anticipated, the errors in the first stage of individual forecasting are shallow due to the relatively short period. The emistakesin the second stage are higher but still considered acceptable, with the notable exceptions of weight and smoking. We hypothesize that the high variability during puberty, which many adolescents experience around age 14, complicates accurate weight forecasting. In population forecasting, the errors are generally more significant, which aligns with the less personalized nature of this method. However, weight is forecasted

	Ind. 18	Ind. 55	Pop.
Height [cm]	3.11	3.47	1.62
Weight [kg]	4.79	13.60	10.58
SBP [mmHg]	1.46	2.39	10.91
Total cholesterol [mmol/L]	0.05	0.10	0.64
HDL [mmol/L]	0.02	0.08	0.21
LDL [mmol/L]	0.05	0.17	0.51
Smoking [1-9]	1.01	1.72	2.26

Table 2: Mean absolute error for individual forecasting to ages 18 and 55, and for population forecasting.

with greater accuracy in this approach. In the future, we may explore combining both methods or select the more accurate one depending on the variable.

4 Demo Application

To show the general idea of the project, we constructed a demo application implemented with Python in the Dash framework. In the app, a user can specify the inputs (some inputs, such as steroid use, were fixed to make the app more concise) to the models, which in turn yielded two plots which showed how the cardiovascular and diabetes risk evolved from the currently selected age up to an age of an older adult, at age 55. In a different plot, we also showed how a risk factor chosen changes over time.

4.1 Risk Prediction using Demo Application

The developed demo application interface offers a dynamic tool for visualizing health risks based on various user-input parameters used in risk models (Figure 4). By allowing users to adjust these parameters, the dashboard generates real-time projections of two key risk metrics: a 10-year cardiovascular risk score and a 10-year risk of developing diabetes. These risks are shown in two line graphs, illustrating how these conditions' probability evolves with age. Additionally, the dashboard includes a feature that tracks the progression of a selected health parameter (BMI, systolic blood pressure, total cholesterol, HDL) over time, providing insight into how this factor might change as the individual ages. The developed tool intuitively explains how lifestyle and physiological factors contribute to long-term health risks, offering valuable insights for clinical decision-making and personal health management.

4.2 Further Development of the Application

The current version of the demo application is developed based on the data and models currently available. However, there remains an open question regarding the specific needs and preferences of the medical experts who will ultimately use the final application. To address this, we plan to present the current version to these experts and, based on their feedback, refine and enhance the application in subsequent iterations.

5 Conclusion

The SmartCHANGE project represents a significant step toward improving the early detection and prevention of non-communicable diseases (NCDs) in children and youth. While the tool presented in this paper is a demo version demonstrating some basic functionalities, our future work will focus on developing a more comprehensive web application for medical professionals and a mobile application for families. We also plan to enhance the tool

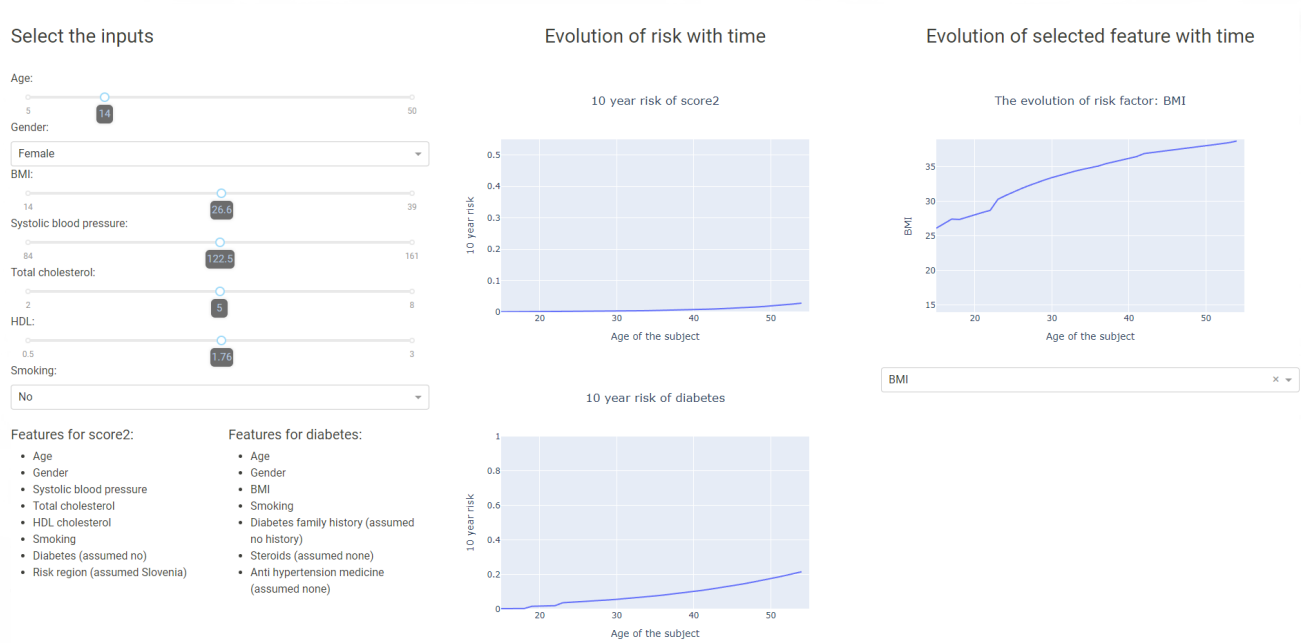


Figure 4: The figure is a dashboard interface that allows users to input various health-related parameters and observe the evolution of associated risks over time.

by replacing the current SCORE2 and QxMD risk models with more advanced models—Test2Prevent for diabetes and Healthy Heart Score for cardiovascular disease—incorporating features related to diet and physical activity. Additionally, the application will be updated to meet medical experts' needs based on their feedback.

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Predicting Mental States During VR Sessions Using Sensor Data and Machine Learning

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Abstract

Empathy is a multifaceted concept with both cognitive and emotional components that plays a crucial role in social interactions, prosocial behavior, and mental health. In our study, empathy and general arousal were induced via VR, with physiological signals measured and ground truth collected through questionnaires. Data from over 100 participants were collected and analyzed using multiple machine learning models and classification algorithms to predict empathy based on physiological responses. We explored different data balancing techniques and labeled data in multiple ways to enhance model performance. Our results show that they are effective in detecting general arousal, empathy, and differentiating between non-empathic and empathic arousal, but the models encountered difficulties with precise emotion detection. The dataset extracted at 5-second intervals and models using Random Forest and Extreme Gradient Boosting showed the best performance. Future work will focus on refining emotion detection through advanced modeling techniques and investigating gender differences in empathy.

Keywords

VR, mental states, machine learning, sensor data

1 Introduction

Empathy is a multifaceted concept explored across various fields, including psychology, neuroscience, and sociology. Though no universal definition exists, empathy is generally understood to include both cognitive (understanding another's perspective) and emotional (experiencing another's feelings) components [8]. Our research defines empathy as the ability to model others' emotional states and respond sensitively while recognizing the self-other distinction [14].

There is no "golden standard" for measuring empathy [10], with methods varying from self-report questionnaires to psychophysiological measures like heart rate and skin conductance. Each method has its pros and cons, often leading to a combination of approaches for a comprehensive assessment. Psychophysiological measures offer objective data but face challenges due to individual variability and non-empathetic factors. Our study addresses these issues by using machine learning to directly measure empathy from physiological signals, offering a novel approach.

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VR creates an immersive environment that enhances empathy by allowing users to experience different perspectives and engage emotionally. VR is effective for empathy training and is referred to as 'the ultimate empathy machine' [1, 11] for various reasons: 1) Immersive Experience: Provides a strong sense of presence, helping users adopt new viewpoints [15]. 2) Perspective-Taking and Emotional Engagement: Simulates realistic scenarios to provoke emotional responses and understanding [19]. 3) Empathy Training: Effective in healthcare, education, and diversity training by challenging preconceptions and deepening emotional insights [16]. 4) Ethical Considerations: Ensures respectful use of VR, balancing immersive experiences with participants' well-being [2].

The objective of this study was to examine how participants' empathy correlates with changes in their physiological metrics, measured using sensors such as inertial measurement unit (IMU), photoplethysmograph (PPG), and electromyography (EMG). Participants were immersed in 360° VR videos featuring actors displaying various emotions (sadness, happiness, anger, and anxiety) and reported their empathetic experiences via brief questionnaires. Using data from these sensors and questionnaires, machine learning models were developed to predict empathy scores based on physiological responses during the VR sessions [9].

2 Materials and Data Collection Process

2.1 Materials and Setup for Empathy Elicitation in VR

To elicit empathy, we immersed participants in a 360° and 3D virtual environment, as VR has proven more effective than methods like 2D videos, workshops, or text-based exercises [8, 13, 17, 20]. We used videos featuring actors expressing four emotions—happiness, sadness, anger, and anxiousness—without additional content to avoid confounding factors [2]. Recognizing the impact of understanding emotional context, an audio narrative version was also created, followed by a corresponding video (50-120 seconds). To ensure gender balance, we recorded videos with two male and two female actors. Five versions were developed: four with narratives (two male, two female) and one non-narrative, where all emotions are portrayed by all actors without accompanying narratives. The non-narrative version allows gradual transitions between emotions, making it suitable for participants of all linguistic backgrounds.

Additionally, a 2-minute forest video ("The Amsterdam Forest in Springtime") was included at the start to establish a relaxed baseline and a roller coaster video ("Official 360 POV - Yukon Striker - Canada's Wonderland") at the end to control for non-empathic arousal. Both videos were sourced from YouTube.

Participants completed trait empathy questionnaires (QCAE) [14] and, after each emotion-specific video, provided feedback

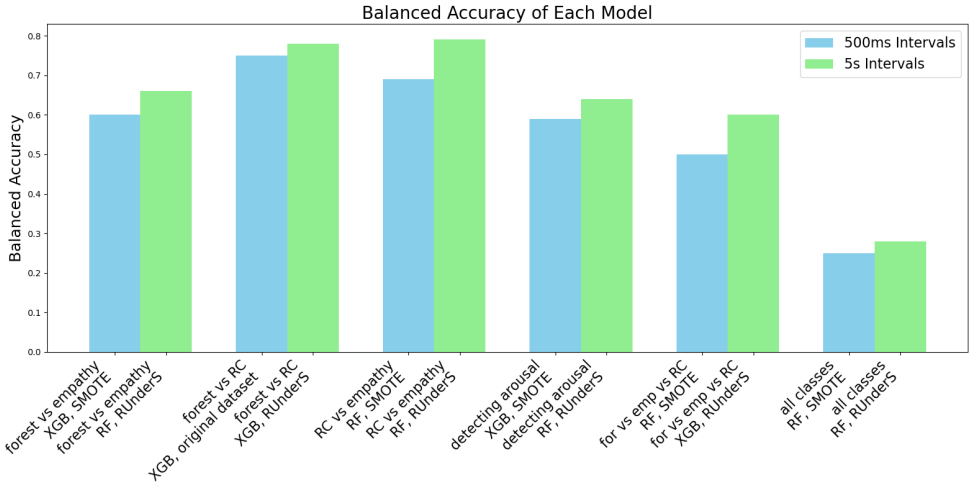

Figure 1: The best accuracies for each group of models, developed using datasets extracted at two different frequencies and various data balancing techniques, presented for all the labeling schemes

on their empathic state (State Empathy Scale) [18], arousal and valence levels (SAM) [3], and personal distress (IRI) [5]. Each VR session lasted around 20 minutes to minimize VR sickness, with participants viewing one of five versions.

Sensor data were collected using the emteqPRO system attached to the Pico Neo 3 Pro Eye VR headset, including EMG for facial muscle activation, PPG for heart rate, and IMU for head motion tracking. The device uses an internal clock as well [12].

2.2 Dataset Description

In this research, we used convenience sampling to recruit participants from the general public without a specific selection pattern. Participants were invited from various sources, including Jožef Stefan Institute employees, university students, and the general public. Invitations were sent verbally or in writing. Data collection concluded with 105 participants, averaging 22.43 ± 5.31 years (range 19–45), with 75.24% identifying as female. Participants had diverse educational and professional backgrounds. Additionally, ethical clearance for this study was obtained from the Research Ethics Committee at the Faculty of Arts, University of Maribor, Slovenia (No. 038-11-146/2023/13FFUM). Furthermore, written informed consent was obtained from the actors prior to recording.

The EmteqPRO system not only provides raw sensor data but also generates derived variables through the Emteq Emotion AI Engine, which utilizes data-fusion and machine learning to analyze multimodal sensor data and assess the user's emotional state. This system provides a file with 29 derived features, called affective insights for each recording: 7 features for heart-rate variability (HRV) and 3 for breathing rate; 2 features for facial expressions; 4 features for arousal and 4 for valence; 1 feature for facial activation; and 1 feature for facial valence. Additionally, head activity is tracked, reflecting the percentage of the session with head movement. Dry EMG electrodes on facial muscles such as the zygomatic, corrugator, frontalis, and orbicularis provide four more features, each representing muscle activation as a percentage of maximum activation observed during calibration. The data also includes the time elapsed since the start of the recording and the row index.

3 Methodology

3.1 Preprocessing

Since all the features or insights are numeric, except for the feature "Expression/Type," which has three values—smile, frown, and neutral—we applied one-hot encoding, a technique used in data preprocessing where categorical (non-numeric) variables are transformed into a numerical format. Each unique value in the original non-numeric feature is transformed into a separate binary (0 or 1) feature.

Next, because missing values represent less than 1% of the total data for each participant, they were filled in using the average of each feature's values. Scaling the values in the descriptive features between 0 and 1 was the final step in the preprocessing process.

3.2 Feature Engineering

Since features were provided at intervals ranging from 1 second to 500 milliseconds, we divided the data into two windows: one of 5 seconds and one of 500 milliseconds. For each window, we computed features from the 22 insights across the seven modules, as well as from the features for head activity and facial muscle electrodes, deriving a total of 108 new features, including minimum, maximum, average, and standard deviation for each original feature or insight. Additionally, the features for head activity and facial muscle electrodes were used to define 'Expression/Type,' and the time and row index were used as provided. However, the row index was disregarded further in the study.

We labeled the dataset in six different ways: 1) as a binary classification aiming to detect empathic arousal, comparing empathic parts with the forest part of the video, while excluding the non-empathic content of the roller coaster video; 2) as a binary classification using the forest and roller coaster, aiming to detect non-empathic arousal; 3) again, as a binary classification, but including only empathic parts and the roller coaster, aiming to distinguish between empathic and non-empathic arousal, and examining the differences in physiological responses between empathic content and non-empathic arousal-inducing content, such as the roller coaster video; 4) aiming to detect arousal in

general, regardless of whether it is empathic or non-empathic, by splitting the entire dataset into two classes: the forest and everything else, including empathic parts and the roller coaster; 5) into three classes: treating the chunks of the roller coaster and forest as separate classes and grouping all the empathic parts into one class, without differentiating between the different emotions. The goal is to distinguish among no-arousal, empathic arousal, and non-empathic arousal; 6) with the average of participants' answers to the state empathy questions for each part of the video, with each part of the empathic content considered a separate chunk. Additionally, there are two other classes: the forest and the roller coaster. The aim is to detect the level of empathy participants experience during the session. We also included each participant's ID, intending to later use it for model evaluation with the 'leave-one-subject-out' technique.

4 Experiments and Results

4.1 Experimental setup

To build models for predicting a participant's state empathy during the VR session, we used six different classification algorithms: Gaussian Naive Bayes, Stochastic Gradient Descent Classifier, K-Nearest Neighbors Classifier, Decision Tree Classifier, Random Forest Classifier, and Extreme Gradient Boosting Classifier. The balanced accuracy score was used as an evaluation metric to assess the classification models for predicting participants' state empathy. This metric evaluates the overall balanced accuracy of the model by calculating the average of recall obtained on each class. Additionally, we used a confusion matrices to evaluate the performance of the classification models by comparing the actual and predicted labels.

For model evaluation, we used a Leave-One-Subject-Out cross-validation setup, where each subject is a unique participant identified by their ID.

Because the labeling schemes 2, 3, 5, and 6 are not balanced (with the 80% of the majority class), we conducted four experiments for each developed model: 1) applying the Synthetic Minority Over-sampling Technique (SMOTE) to create synthetic samples for the minority class to balance the dataset; 2) using the RandomUnderSampler (RUnderS) method to randomly select samples from the majority class, thereby reducing their count and balancing the dataset; 3) using SMOTETomek, a combination of SMOTE for oversampling and Tomek links for undersampling, which targets both the minority and majority classes; and 4) using the dataset as it is, without any undersampling or oversampling.

4.2 Results

Including models developed by six different classification algorithms on two distinct datasets—with two different window sizes—and utilizing four different data balancing techniques: undersampling, oversampling, combination techniques, and the dataset in its original form, along with six different labeling schemes, we obtained 288 unique confusion matrices and corresponding accuracies for each combination.

We ran a correlation matrix, which revealed that the highest correlation with the state empathy feature was found with the derived maximum and minimum values from the mean heart rate, the derived maximum and minimum values from the arousal class feature, and the average of the arousal class — the insight, which can be -1 (low), 0 (medium), or 1 (high). The derived standard deviation, maximum, and minimum values from the activation—expressed as a percentage of the maximum activation of particular muscles from the calibration session, especially the zygomaticus and orbicularis muscles—were also highly correlated.

Regarding the labeling schemes, we can conclude the following: 1) We can detect empathic arousal with confusion matrices that show a relatively good distribution of correct predictions across both classes and high accuracies for most of the developed models; 2) We can detect non-empathic arousal, with almost every developed model achieving a balanced accuracy higher than 60%, reaching up to 78%, and a reasonable balance between classes, indicating satisfactory classification performance; 3) We can even distinguish between empathic and non-empathic arousal with balanced accuracy of 79%; 4) We can detect arousal in general, again with high accuracies and balanced classes; 5) We can distinguish to some extent among no-arousal, empathic arousal, and non-empathic arousal; 6) However, it is currently very challenging to detect the precise level of empathy participants are feeling during the session using these methods, and to determine whether they are empathizing by mirroring emotions or experiencing something different while observing specific emotions. The best we can detect in this regard is up to 28% balanced accuracy, with confusion matrices showing a relatively balanced performance across multiple classes, with a good number of correct classifications, particularly in the more frequent classes.

Regarding the two window sizes, both models showed similar class balance and balanced accuracy scores. However, the dataset extracted at 5-second intervals performed slightly better. Using this dataset, false positives and false negatives were reduced more effectively. This led to more reliable classification performance, especially in terms of precision and recall, despite the smaller scale. Thus, the models developed using the 5-second interval dataset generally performed better, showing more effective classification and fewer errors. The simpler confusion matrix and potentially better handling of fewer classes suggest that it performs better in practical terms (Figure 2, Figure 1).

Regarding the data balancing techniques, the undersampling technique never produced the best results. For the dataset extracted at 500 ms intervals, using the SMOTE oversampling technique and SMOTETomek yielded the best results. For the dataset extracted at 5-second intervals, using the entire dataset yielded the best results, although models developed using SMOTETomek yielded slightly lower results in each combination of different labeling schemes.

Regarding the classification algorithms, Gaussian Naive Bayes performed the worst in terms of balanced confusion matrices, while Random Forest Classifier and Extreme Gradient Boosting performed the best across all combinations, with Random Forest Classifier showing slightly better results for most combinations (Figure 2, Figure 1).

4.3 Conclusion

In this study, we define the entire plan for developing materials, methods, and environments to evoke and measure the level of empathy. We started by defining the videos and the session, creating or selecting questionnaires for later use as ground truth, writing the narratives, recording the VR videos, and then editing and preparing them for use. Additionally, we collected a dataset from over 100 participants, which we filtered, preprocessed, and prepared for feature engineering and analysis.

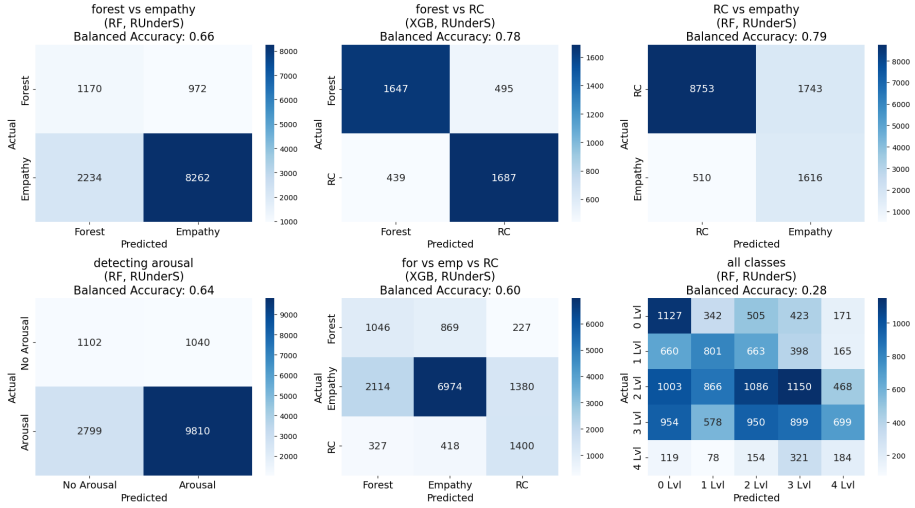

Figure 2: The best confusion matrices for each group of models, developed using dataset extracted at a 5s window size and various data balancing techniques, shown for all labeling schemes

We conducted and analysed four groups of experiments, totaling 288 combinations, where we developed models using two different window sizes, six classification algorithms, and three resampling techniques, with six different labeling schemes aimed at detecting various aspects of the dataset chunks: four empathetic parts, forest, and roller coaster.

The main conclusion is that we can detect arousal in general, non-empathic arousal, empathy, and differentiate between non-empathic and empathic arousal, as well as between relaxed states and arousal. However, we face difficulties in detecting and distinguishing between the precise levels of empathy during VR sessions using these methods and approaches.

Our next steps involve refining the detection of empathy levels during VR sessions by applying detailed data filtering and transforming it into a stationary format. Furthermore, we will develop models such as Autoregressive, Moving Average, and Extended Recurrent Moving Average, and use clustering techniques like DBSCAN and HDBSCAN. Additionally, we will extract more features from the raw data or use end-to-end neural networks. We plan to analyze gender differences in empathy with a t-test [7], and explore the impact of narrative context and emotions on empathic responses using ANOVA and MANOVA [4, 6].

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Biomarker Prediction in Colorectal Cancer Using Multiple Instance Learning

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Abstract

Microsatellite instability (MSI) is a crucial biomarker in colorectal cancer, guiding personalised treatment strategies. The focus of our paper is on evaluating how different state-of-the-art pretrained artificial intelligence models perform in extracting features on molecular and cellular oncology (MCO) study dataset to predict biomarkers. In this study, we present an advanced approach for MSI prediction using multiple instance learning on whole slide images. Our process begins with comprehensive preprocessing of WSIs, followed by tessellation, which breaks down large images into manageable tiles. State-of-the-art feature extraction techniques are utilised on these selected tiles, employing pretrained models to capture rich, discriminative features. Various aggregation methods are applied to combine these features, leading to the prediction of MSI status across the entire slide. We assess the performance of different pretrained models within this framework, demonstrating their effectiveness in accurately predicting MSI, with results showing an AUROC of 0.91 on the MCO dataset. Our findings underscore the potential of multiple instance learning-based approaches in enhancing biomarker prediction in colorectal cancer, contributing to more targeted and effective treatment strategies.

Keywords

multiple instance learning, whole slide images, colorectal cancer, biomarker prediction

1 Introduction

MSI is a crucial biomarker in colorectal cancer (CRC) that indicates defects in the DNA mismatch repair system, leading to a high mutation rate within tumor cells. MSI status has significant clinical implications, influencing treatment decisions, particularly the use of immunotherapy, and providing prognostic information. Traditionally, MSI is determined through laboratory tests such as PCR-based assays or immunohistochemistry (IHC) on tumor tissue samples, which require invasive biopsy procedures. However, these methods can be time-consuming, costly, and dependent on the availability of sufficient tissue samples.

Deep learning methods have emerged as a promising non-invasive alternative for MSI prediction by analysing whole slide images (WSIs) of histopathological samples. These models can detect patterns linked to MSI, eliminating the need for genetic testing. WSIs provide a comprehensive view of tumor histology, offering a faster, less invasive, and more accessible means of diagnosis.

Integrating deep learning into clinical practice can improve early MSI detection, personalise treatment, and reduce invasive procedures. WSI-based methods streamline diagnostics and enhance cancer care with accessible predictive analytics.

To manage these challenges, WSIs are often divided into smaller regions or patches. A common method to address these issues is Multiple Instance Learning (MIL) [3, 8]. Due to the vast size of WSIs, computational resources can be easily overwhelmed, making MIL an essential approach. MIL is a machine learning technique that operates on sets or "bags" of instances, where the label is assigned to the entire bag rather than individual instances. This is particularly advantageous in WSI analysis, where labels such as MSI status apply to the entire slide, which is composed of numerous smaller regions or patches.

In this context, [4] demonstrates state-of-the-art (SOTA) results in predicting MSI in colorectal cancer. Their workflow utilizes the Swin-T model on small datasets to predict MSI. First, a pretrained tissue classification model is employed to filter out non-tissue patches, followed by fine-tuning a pretrained model to classify the remaining patches. Both intra-cohort and external validation are performed. When trained on the MCO dataset (N=1065), the model achieved a mean AUROC of 0.92 ± 0.05 for MSI prediction. Similarly, [11] employs a transformer-based approach for large-scale multi-cohort evaluation, involving over 13,000 patients for biomarker prediction, achieving a negative predictive value of over 0.99 for MSI prediction. When trained and tested only on a single cohort (MCO), the model achieved an AUROC of 0.85. While [4] achieved promising results on the MCO dataset using an additional tissue classifier, we obtained comparable performance without the need for tissue classification. On the other hand, [11] used a multicentric cohort, which demands additional computational resources. In comparison to their results on the MCO dataset, we achieved a 6% improvement using a smaller dataset.

In this study, we leverage MIL to process WSIs for the prediction of MSI in CRC. By testing SOTA models on the MCO dataset, we aim to assess their performance in MSI prediction using MIL. This approach not only highlights the potential of MIL in processing complex, unannotated WSIs but also contributes

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to the broader goal of improving biomarker prediction in CRC, ultimately supporting more personalized and effective treatment strategies.

The paper is organised as follows: Section 2 outlines the methods used in the pipeline, Section 3 provides a description of the data, Section 4 presents the results, and Section 5 discusses the findings and potential directions for future work.

2 Methods

This section outlines the pipeline for MSI prediction, as illustrated in Figure 1. The process begins with the preprocessing of WSIs, including tessellation into smaller patches. Next, SOTA pretrained models are employed to extract features from these patches. These models, trained on large and diverse datasets, capture rich and discriminative features crucial for accurate MSI prediction. Finally, aggregation techniques are applied to combine the information from the patches, enabling precise MSI status prediction for the entire slide. Each subsection provides a concise explanation of these individual processes.

2.1 Preprocessing

WSIs are first tessellated into smaller, more manageable patches to facilitate further processing. This step involves dividing the large images into smaller regions using the tiatoolbox presented in [9]. Non-informative tissue patches are removed to ensure the analysis focuses solely on relevant tissue areas.

Specifically, patches that are out of bounds—where only a portion contains actual image data and the remainder consists of padding—are discarded. Patches that consist entirely of tissue are retained for subsequent analysis. This preprocessing step ensures that only informative and relevant patches are used for feature extraction and MSI prediction.

2.2 Feature Extraction Methods

Since only WSI-level annotations are available, several pretrained feature extraction models - UNI [1], ProvGigaPath [13], Phikon [2] and CTransPath [12] - are applied to patches, removing the need for detailed patch-level labeling. These SOTA models, trained on large datasets, can capture complex and discriminative features essential for accurate biomarker prediction. The extracted feature embeddings are then used as input for the aggregation and classification stages, laying the foundation for precise MSI status prediction. For technical details about these models, see Table 1.

2.3 Aggregation Methods

After feature extraction, we apply aggregation techniques to combine patch-level features into a slide-level representation. Traditional pooling methods like max-pooling and mean-pooling provide straightforward approaches.

However, these methods are limited by their lack of trainability. In recent years, attention-based pooling or ABMIL became a popular technique that adresses this issue [6]. ABMIL assigns a weight α_i to each patch's feature vector, reflecting its importance:

$$F = \sum_{i \in P} \alpha_i f_i$$

The attention scores α_i are computed as:

$$\alpha_i = \frac{\exp(w^\top \tanh(V f_i))}{\sum_{k \in P} \exp(w^\top \tanh(V f_k))}$$

where w and V are trainable parameters.

This approach allows the model to dynamically focus on the most relevant patches, leading to more accurate MSI predictions.

Another technique similiar to attention is DSMIL [7] or a dual stream aggregator, consisting of two branches, employing both an instance classifier and a bag classifier. Let $h_i \in \mathbb{R}^{L \times 1}$ be a feature embedding, and $B = \{h_0, ..., h_n\}$ a bag of embeddings. The first stream uses an instance classifier, followed by a max-pooling operation to obtain a score $c_m(B)$ and the critical embedding h_m. The second stream aggregates the embeddings into a single bag embedding which is then passed through a bag classifier:

$$c_b(B) = W_b \sum_{i}^{n-1} U(h_i, h_m) v_i$$

Where W_b is a weight vector for classification, v_i an information vector and U is a distance measurement between an arbitrary embedding and the critical embedding:

$$U(h_i, h_m) = \frac{\exp(\langle q_i, q_m \rangle)}{\sum_{k=0}^{n=1} \exp(\langle q_k, q_m \rangle)}$$

where is a query vector. Both q_i and v_i are calculated by:

$$q_i = W_q h_i, \quad v_i = W_v h_i, \quad i = 0, ..., n-1$$

where W_q and W_v are weight matrices. The final prediction is given by:

$$c(B) = \frac{1}{2}(c_m(B) + c_b(B))$$

The last approach for feature aggregation reviewed in this paper is TransMIL, as proposed in [10], a Transformer based aggregation method, which unlike the afore-mentioned methods, takes into account spatial information as well. By treating a bag of embeddings as a sequence of tokens, TransMIL uses a novel TPT module made up of two Transformer layers and a position encoding layer, where Transformer layers are designed for aggregating morphological information and Pyramid Position Encoding Generator (PPEG) which encodes spatial information, followed by a multi-layer perceptron (MLP) which classifies the bag.

2.4 MSI Classification

The aggregation step produces a single feature vector F, which encapsulates the most informative characteristics of the entire slide. This aggregated feature vector F is then passed through one or more fully connected (dense) layers. These layers apply learned weights and biases to the features to transform them into a form that is more suitable for classification. The output of the fully connected layer is often passed through an activation function, such as a sigmoid or softmax, depending on whether the classification task is binary (microsatellite instability MSI vs. microsatellite stability MSS) or multi-class. For MSI prediction, a sigmoid function is typically used, outputting a probability value between 0 and 1. The final output of the model is a single probability value indicating the likelihood of the slide being MSI. A threshold (e.g., 0.5) is applied to this probability to make a binary decision.

3 Data

For this paper the MCO study [5] was used for training and testing. The MCO study collection contains 1,500 digitized whole slide images (WSIs) of colorectal cancer tissues. Conducted by the Molecular and Cellular Oncology (MCO) Study group from 1994 to 2010, this study systematically gathered tissue samples

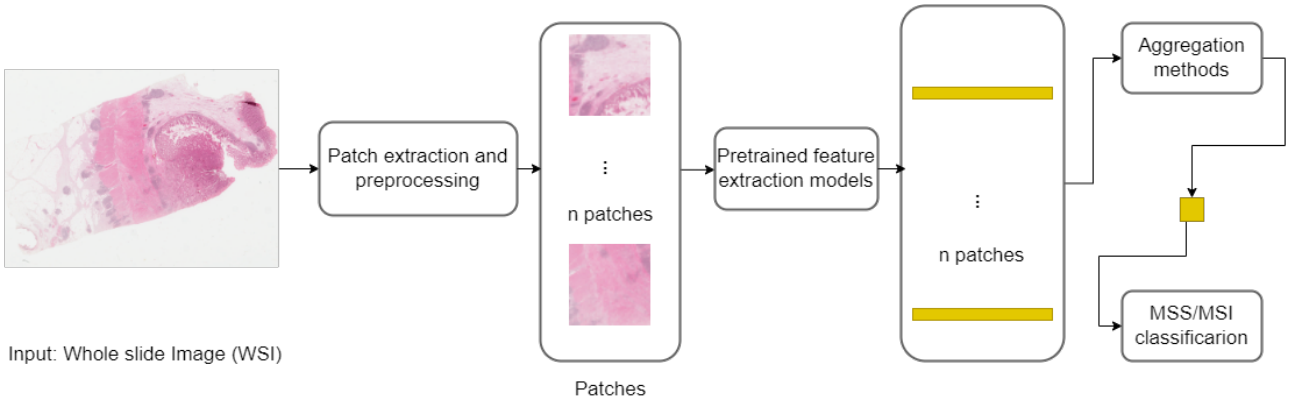


Figure 1: General architecture: multiple-instance learning approach.

feature extractor	architecture	dataset	embedding size
UNI [1]	ViT-large, DINOv2, 16 heads	Mass-100k: in-house histopathology slides from MGH and BWH, and external slides from the GTEx consortium containing >100M images, derived from >100,000 WSIs across 20 major tissue types	1024
ProvGigaPath [13]	ViT-large, DINOv2, 24 heads	Prov-Path: dataset from Providence, a large US health network comprising 28 cancer centres, consisting of 1,3B images from 171,189 WSIs	1536
Phikon [2]	ViT-large, iBOT combining MIM and CL	PanCancer40M: dataset from TCGA, covering 13 anatomic sites and 16 cancer subtypes, consisting of 43,4M images from 6,093 WSIs	768
CTransPath [12]	CNN with multi-scale Swin Transformer	dataset from TCGA and PAIP, consisting of 15M images from 32,220 WSIs	768

Table 1: Technical details about the pretrained feature extraction models.

and clinical data from over 1,500 patients who underwent colorectal cancer surgery. Each slide, representing a typical tumor section, is stained with Hematoxylin and eosin and scanned at a 40x objective, achieving a resolution of 0.25 mpp comparable to an optical microscope (~100,000 dpi). The total data size is approximately 3 Terabytes, and the collection is available on the Intersect Australia RDSI Node.

4 Results

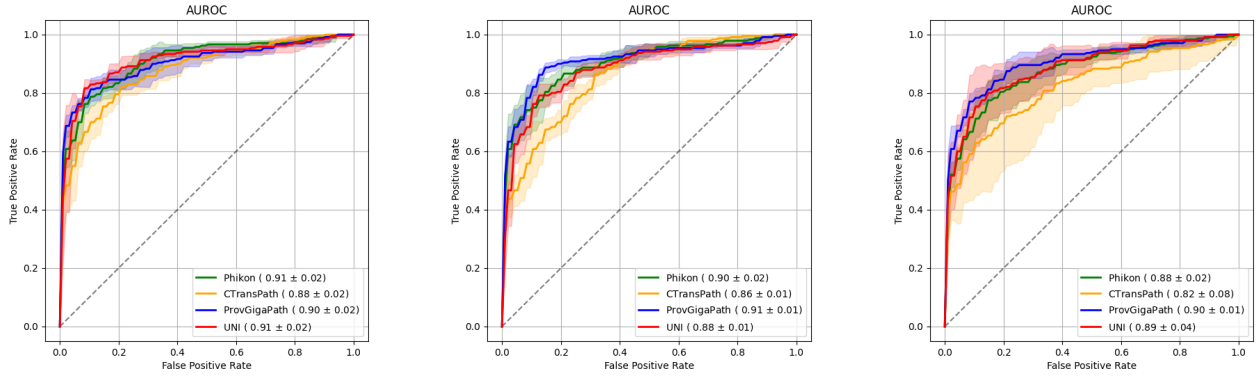
The dataset used in this study comprised 996 whole slide images (WSIs), with 242 labeled as MSI and 754 as MSS. To evaluate the performance of various aggregation methods, models were trained using 5-fold cross-validation, which ensured robust training and validation. To create a balanced testing set of 96 samples, 20% of positive (MSI) samples and an equal number of negative (MSS) samples were randomly excluded. The remaining data was split into five equally balanced parts for cross-validation, with each fold consisting of 180 samples in the validation set and 720 samples in the training set.

WSIs were then preprocessed into bags, each containing approximately 2,000 to 4,000 patches. Each patch was then converted into feature embeddings using four different feature extraction methods: Phikon, CTransPath, ProvGigaPath, and UNI. Specifically, CTransPath and Phikon produced embeddings with 768 features, UNI with 1024 features, and ProvGigaPath with 1536 features.

Three feature aggregation methods—ABMIL, DSMIL, and TransMIL—were applied to the extracted features to generate a single representative feature for each WSI. Following aggregation, a simple neural network with a sigmoid activation function and a threshold of 0.5 was used to classify MSI and MSS.

Each aggregation model was then trained for each feature extraction method on each fold, with training being conducted over 50 epochs using the AdamW optimiser and the 1-cycle learning rate scheduler to adjust the learning rate as models approached convergence. Binary cross-entropy (BCE) was used as the loss function. After each epoch, model performance was evaluated on the validation set using the AUROC metric to select the best checkpoint, as most models tended to overfit toward the end of training. The selected checkpoints were then tested to calculate the mean AUROC across all folds.

Results are presented in Figure 2a. The best performance was achieved using the DSMIL aggregation method with the ProvGigaPath feature extractor, yielding an AUROC of 0.91 ± 0.01. The ABMIL method performed best with the Phikon and UNI extractors, achieving AUROCs of 0.91 ± 0.02. Finally, the TransMIL method combined with ProvGigaPath resulted in an AUROC of 0.90 ± 0.01. Additionally, statistical analysis was performed, specifically, the Wilcoxon signed-rank test, which yielded an average p-value of 0.446, showing a relatively insignificant difference in performance of different feature extraction methods, as expected.



(a) ABMIL **(b) DSMIL** **(c) TransMIL**

Figure 2: Predictive performance of 5-fold cross-validation of different feature extractors and aggregation methods. AUROC plots for prediction of MSI/MSS status. The true positive rate represents sensitivity and the false negative rate represents 1-specificity. The shaded areas represent the standard deviation (SD). The value of the lower right each plot represents mean AUROC ± SD.

5 Discussion and Conclusion

n this study, we explored the potential of MIL combined with SOTA pretrained models for predicting MSI in colorectal cancer. Our results indicate that the approach is highly effective, achieving an AUROC of 0.913 on the MCO dataset. This is a notable achievement, particularly when compared to previous studies, such as [4] and[11], which reported AUROCs of 0.92 and 0.85, respectively, on the same dataset. Our results not only validate the effectiveness of our approach but also suggest that the careful selection and combination of feature extraction and aggregation methods can yield improvements in predictive accuracy.

The positive and negative rates observed in our results reflect the model's ability to correctly classify MSI and MSS cases. A high true positive rate (sensitivity) indicates the model's proficiency in identifying MSI-positive cases, which is crucial for ensuring that patients who could benefit from MSI-targeted therapies are accurately identified. Conversely, a high true negative rate (specificity) shows the model's effectiveness in correctly classifying MSS cases, thereby minimising false positives. To further enhance the accuracy and reliability of MSI prediction, several avenues for future work are planned.

Utilisation of the Entire Dataset: We plan to leverage the full dataset to improve the robustness of our model. Training on a larger dataset may help in capturing more nuanced patterns and variations, leading to even more accurate predictions.

Fine-Tuning of Pretrained Models: While we used pretrained models without fine-tuning in this study, fine-tuning these models specifically for the task of MSI prediction could further improve their performance. Tailoring the models to our specific data distribution and task requirements may yield significant gains in accuracy.

Incorporation of a Tissue Classifier: Since MSI is typically found in tumor tissue, we plan to integrate a tissue classifier to automatically remove non-tumor tissue from the analysis. This step should enhance the model's focus on relevant tissue regions, potentially improving MSI prediction accuracy and speed up the whole process.

Development of Advanced Aggregation Methods: We also plan to explore more sophisticated aggregation techniques that can better capture the complex relationships between patches within a WSI. Advanced methods may help in refining the prediction process, leading to further improvements in model performance.

Overall, our study demonstrates the potential of MIL-based approaches in enhancing biomarker prediction in colorectal cancer, paving the way for more personalized and effective treatment strategies.

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Feature-Based Emotion Classification Using Eye-Tracking Data

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Abstract

The field of emotion recognition from eye-tracking data is well-established and offers near-real-time insights into human affective states. It is less obtrusive than some other modalities, such as electroencephalogram (EEG), electrocardiogram (ECG) and galvanic skin response (GSR), which are often used in emotion recognition tasks. This study examined the practical feasibility of emotion recognition using an eye-tracker with a lower frequency than that typically employed in similar research. Using ocular features, we explored the efficacy of classical machine learning (ML) models in classifying four emotions (anger, disgust, sadness, and tenderness) as well as neutral and "undefined" emotions. The features included gaze direction, pupil size, saccadic movements, fixations, and blink data. The data from the "emotional State Estimation based on Eye-tracking database" was preprocessed and segmented into various time windows, with 22 features extracted for model training. Feature importance analysis revealed that pupil size and fixation duration were most important for emotion classification. The efficacy of different window lengths (1 to 10 seconds) was evaluated using Leave-One-Subject-Out (LOSO) and 10-fold cross-validation (CV). The results demonstrated that accuracies of up to 0.76 could be achieved with 10-fold CV when differentiating between positive, negative, and neutral emotions. The analysis of model performance across different window lengths revealed that longer time windows generally resulted in improved model performance. When the data was split using a marginally personalised 10-fold CV within video, the Random Forest Classifier (RF) achieved an accuracy of 0.60 in differentiating between the six aforementioned emotions. Some challenges remain, particularly in regard to data granularity, model generalization across subjects and the impact of downsampling on feature dynamics.

Keywords

eye-tracking, emotion recognition, machine learning

1 Introduction

Emotion recognition is a vibrant area of research, leveraging diverse data sources such as images [11], audio [16], and also, ocular features like pupil dilation, gaze direction, blinks, and saccadic movements [3, 8, 12]. Such eye-related features provide valuable insights into emotional states, offering a less-invasive and real-time approach to understanding human affective responses. Most studies that tried to predict emotions from these eye-related features relied not only on eye-tracking data but also on EEG [8, 12]. We hypothesized that eye-tracking data is a valuable modality for multi-modal emotion recognition on its own, with potential applications in real-world scenarios like office work, driving, and psychological assessments, as well as in estimating well-being. Our motivation was to explore eye-tracker-based predictive models as an essential component in such practical applications.

The primary objective of our study was to validate existing findings on the performance of classical ML models for emotion classification from eye-tracking data, using the models – Support Vector Machine (SVM) and k-Nearest Neighbors (KNN) – and features already explored in the literature [9, 15] as well as exploring classifiers not so frequently used in this field – such as RF and XGBoost (XGB). Additionally, we aimed to explore the potential of emotion recognition at lower sampling frequencies available in most non-professional eye trackers. For the early feasibility study, we used an existing dataset, which collected data using a wearable eye-tracker but findings could possibly be extended to high-quality unobtrusive contact-free trackers. Our research also focused on understanding the impact of individual features and window lengths on model performance.

2 Related Work

In literature, various physiological signals have been employed for emotion recognition, with a particular focus on modalities such as EEG, GSR, and eye-tracking systems [1, 6, 9]. Researchers have explored both uni- and multi-modal approaches, finding that the integration of multiple modalities can significantly enhance emotion recognition accuracy. Lu et al. achieved 0.78 accuracy with eye-related features recorded with eye-tracking glasses – which are not contact-free but record at relatively low frequencies of 60 Hz or 120 Hz. They predicted positive, negative and neutral classes with SVM. Interestingly, they observed a 0.10 increase in accuracy when combining eye-related and EEG features [12]. Similarly, Guo et al. observed a more substantial gain, with accuracy improving by 0.20 when integrating EEG, eye-tracking, and eye images, as opposed to using only eye-tracking data [7].

The features derived from eye-tracking have been widely used in ML algorithms to detect emotional states [2, 7, 12, 15]. However, most studies have traditionally categorized emotions into broad groups like positive, negative, and neutral [12, 14]. Pupil size, in particular, has emerged as a valuable indicator for distinguishing between positive and negative emotions [2, 7, 12] . Recent efforts have begun to refine these broad categories, identifying more specific emotions like happiness, sadness, fear, anger, etc. [2, 7, 15]. Although current methods can effectively identify certain emotions such as sadness and fear, further research is needed to reliably differentiate between others like disgust, joy, and surprise [2].

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3 Methodology

3.1 Data

In our research, we used the "emotional State Estimation based on Eye-tracking database" (eSEEd) [13]. The eSEEd comprises data from 48 participants, each of whom watched 10 carefully selected videos intended to evoke specific emotional responses. After viewing each video, participants ranked their emotions – anger, disgust, sadness, and tenderness – on a scale from 0 to 10. Tenderness, however, is not regarded as one of the basic emotions, but it has been widely utilized in emotion research in recent years [13]. Since the participants had ranked all four emotions for every video, a labelling problem emerged when multiple emotions shared the highest score, in our case, leading to "undefined" labels. In our study, emotions were mapped by applying a set of extraction rules in the following order: if the highest-ranked emotion is below four, the response is labelled as neutral; if multiple emotions share the highest rank, the label is undefined; otherwise, the emotion with the highest rank is chosen. The boundary of four was chosen because the original study on eSEEd constructed this rule and we adapted it from there [13]. Although the initial study design aimed for an even distribution of emotions, neutral responses dominate, representing about one-fourth of the labels (depending on window length).

3.1.1 Data Preprocessing. We have preprocessed the data to make it more suitable for our future research and to reduce its size. We wanted to study the performance of data with a relatively low frequency rate of 60 Hz, which is used by relatively affordable mid-tier eye-trackers, like Tobii Pro Spark. Firstly, the features that were uninformative or could be misleading (e.g. raw tracker signal and timestamps) were removed, and the following set of features was preserved: 2D screen coordinates of gaze points (for standard deviation (std) of screen gaze coordinates), 3D coordinates of gaze points (exclusively for saccade calculations), pupil sizes (a and b of the pupil ellipse), and eye IDs (each eye has its own pupil size features). Secondly, rows containing any NaN values were removed, as there were no large consecutive blocks of such rows and downsampling of the data was planned. Finally, we further downsampled the data to 60 Hz, matching the sampling frequency of a mid-tier eye-tracker. However, we acknowledge that downsampling might lead to the loss of high-frequency information, which could be important for capturing subtle dynamics in gaze behaviour and pupil responses. This is particularly relevant considering that recent studies, such as those by Collins et al. [3] and the SEED project [4, 17], have utilized data collected at much higher frequencies to preserve these subtle dynamics. Therefore, while downsampling makes the data more meaningful to our research and more computationally manageable, it is important to keep in mind the reduced temporal resolution when discussing the results.

Following the preprocessing, window segmentation was applied to the data. This step is essential for analyzing temporal patterns within the data, as it allows for the capture of trends and behaviours over specific time intervals. By segmenting the data into windows, we can improve the robustness of feature extraction and model training, enabling the detection of meaningful patterns that might be obscured in raw, unsegmented data. Additionally, with window segmentation, the number of training instances increases which is commonly better for learning more robust ML models and conducting rigorous evaluation. Hence, multiple window lengths were examined, namely: 1, 3, 5 and 10 s. We used 50% sliding window overlap. From each window, we computed 22 features, belonging to the following groups:

(1) gaze coordinates on screen: std of x and y coordinates
(2) pupil ellipse sizes of a and b for each eye: mean, std
(3) blinks: number; mean and std of duration (all 0 if no blinks)
(4) saccades: number; mean speed; mean, std, total duration
(5) fixations: number; mean, std, total duration

Saccade and, implicitly, fixation calculations were done using existing code based on the algorithm proposed by Engbert et al. [5, 10]. The algorithm calculates the velocity and acceleration of eye movements by using a velocity threshold identification method to detect saccades based on continuous 3D gaze data. In our study we define fixation (interval) as an absence of a saccade (interval), thus one fixation is declared between every two saccades (and before the first and after the last one).

As mentioned previously, our data was imbalanced in terms of class distribution, namely the distributions for anger, disgust, sadness, neutral, tenderness and undefined were 8.7%, 13.6%, 17.5%, 25.7%, 15.8% and 18.7%, respectively. Notably, for the 1 s window length, the number of windows was 67,181, whilst for the 10 s window, the number of instances decreased to 6,507.

3.2 Experiments

We initially examined feature correlation matrices to identify potential correlations between features, as well as between feature and class. Then, we compared the following classifiers from the Scikit-learn library: Random Forest (RF), Support Vector Machines (SVM), k-Nearest Neighbors (kNN), and XGBoost (XGB) from the XGBoost library, as well as an ensemble method majority vote of the aforementioned classifiers. We compared all results against a baseline majority classifier. Each model was trained and tested using its default hyperparameters. To evaluate the models' performance, we implemented multiple CV techniques.

The first CV technique was Leave-One-Subject-Out (LOSO). Secondly, we implemented a marginally personalised 10-fold CV "within video." In this approach, a standard 10-fold CV was performed where 90% of temporally sequential windows were used for training and 10% for testing. The splits were done separately for each video within every subject. All the training data from every video was combined to train a single model, and all the test data was combined to evaluate the model, ensuring that the model was exposed to data from all subjects and videos. We named the experiment "marginally" personalised because most training data does not come from any single subject and is thus not very personalised. Finally, we explored a completely personalised 10-fold CV "within subject." Here, training and testing were done only on data of one subject. In all three CV methods, the instances were never shuffled to preserve temporal and subject sequential information and to minimize overfitting.

We attempted to merge certain classes in a way to group negative emotions – anger, disgust, and sadness – under the category "negative," while labelling tenderness as "positive." The label for neutral remained unchanged, while the undefined label was changed to "negative" because it always resulted from multiple negative emotions scoring equally. Lastly, the feature importances were analysed for different combinations of data splits and models in order to identify potential consistently important features.

4 Results

The results described in the following subsections are summarised in Table 1.

4.1 Feature Correlations

The first important observation from correlation matrices was that no output class is closely correlated to any other singular feature. Secondly, we noticed some strong correlations, for example, a 1.0 correlation between a number of fixations and a number of saccades, because one simply equals the other increased by one. More importantly, we noticed little-to-no correlation between features that proved to be most important in some best-performing models, meaning each of these features brought some novel information to the model. The only exceptions of important features being correlated are the features representing the mean size of a pupil i.e., ellipse a and b axes, which are expected to be correlated. They were correlated more than 0.8. However, we decided not to remove any features because we assessed the feature count of 22 to be well-balanced in relation to the number of instances.

4.2 Leave-One-Subject-Out

With the goal of training a robust general model for our dataset, we first applied the LOSO CV technique. The best performance was achieved by RF on 10 s windows, yielding an accuracy of 0.28 ± 0.13 and an F1-score of 0.28 ± 0.16. It outperformed the majority classifier by 0.03 in accuracy and 0.13 in F1-score. In a subsequent experiment, the negative emotions were grouped. This adjustment led to an overall increase in performance. However, with such grouping the majority classifier score also increased to 0.59 accuracy, which is the same as the best-performing model.

Further analysis revealed that high accuracy mainly implied the subject predominantly reported "neutral" feelings and low accuracy implied little-to-no "neutral" labels. However, not every subject with a high "neutral" count achieved outstanding results and not every subject with a wide range of emotions yielded poor results. A comparison was made between the number of windows in the left-out subject to their performance and no correlation was found. 10 s window length performed better than the shorter windows with lengths 1-5 s. We also tested longer (60 s) windows and the resulting accuracies were higher than those from 10 s windows, but we evaluated that the number of instances was insufficient for the results to be representative.

4.3 Marginally Personalised 10-fold Cross-Validation Within Video

Given that the LOSO yielded relatively poor results, the next step was to explore 10-fold CV. Experiments showed an average accuracy of 0.60 ± 0.07 and an F1-score of 0.60 ± 0.08, produced with RF on 10 s windows, the best-performing model. This should be compared to the results given by the majority classifier – average accuracy of 0.21 ± 0.01 and F1-score of 0.07 ± 0.01. With negative emotions grouped, the accuracy and F1-score raised to 0.76 ± 0.04 and 0.73 ± 0.04, respectively, for the best-performing XGB on 10 s windows. The majority class classifier yielded an accuracy of 0.66 ± 0.02 and an F1-score of 0.52 ± 0.02.

4.4 Personalised 10-fold Cross-Validation

Even though 10-fold CV within video resulted in much better performance compared to LOSO, we wanted to see the performance of completely personalised models. All the models performed similarly well, with the absolute best being RF on 10 s windows which outperformed the majority classifier by 0.05 and 0.13 for accuracy and F1-score, respectively. When grouping the negative emotions, we observe an absolute improvement in models' performance, but a relative decline toward the majority classifier benchmark. The best model, in this case, did not surpass the majority classifier in terms of accuracy, with the majority classifier achieving 0.67 ± 0.16 accuracy and 0.61 ± 0.16 F1-score, while SVM, the best-performing model, scored an accuracy of 0.64 ± 0.13 and an F1-score of 0.63 ± 0.12.

4.5 Feature Importances

Following the completion of model training, we analyzed the feature importances of the best-performing models. For RF this was calculated based on the Mean Decrease in Impurity, summing the impurity reduction each feature contributes across all trees; and for XGB, feature importances were calculated using the "weight" metric, which counts the number of times each feature is used to split the data across all trees. For SVM we did not calculate feature importances. In the completely personalised 10-fold experiments, feature importances varied significantly across different subjects and even between different runs within the same subject, specifically with RF, as the random state was not fixed. In contrast, feature importance was notably consistent in experiments where models were trained on data from multiple subjects, such as in the LOSO and the 10-fold within video, even with a variable random state of the RF model.

The most important features of best-performing models were those related to average pupil sizes, followed by fixation duration. These results partially align with those of Collins et al., who found features relating to pupil diameter and saccades statistically significant [3].

5 Conclusion

Our research explored emotion classification using eye-tracking data with classical ML models and hand-crafted features. The data was downsampled to a lower-than-standard frequency i.e., to 60 Hz, which was more realistic for consumer contact-free eye-tracker data. This made the problem harder, making it not directly comparable with other studies working on eSEEd, but valuable from a practical perspective.

Window segmentation significantly impacted model performance, with the best results constantly obtained using the largest window length. This suggests that longer observation periods capture more comprehensive information, making smaller windows less effective for emotion classification. We hypothesize that this does not transfer to realistic scenarios, as users might experience emotions in short bursts while being neutral for the majority of the time. In specifically designed cases where emotion is consistently induced for longer periods of time (like our dataset), this is more expected.

The LOSO validation strategy, which tests model generalization across different subjects, yielded poor results. The variability in performance across subjects indicates the challenge of capturing general relationships between eye features and emotions. While both 10-fold CV approaches showed an increase in performance, their generalizability is limited. Completely personalised 10-fold showed worse results than the marginally personalised one presumably because of the low number of videos per emotion within an individual subject.

Table 1: Best-performing models and their corresponding results along the results of the Majority Class Classifier for the same parameters. Window lengths are 10 s.

Settings	**Model Acc**	Model F1	Majority Class Acc	Majority Class F1
LOSO, RF	**0.28 ± 0.13**	0.28 ± 0.16	0.25 ± 0.25	0.15 ± 0.26
LOSO, SVM, negative emotions grouped	**0.59 ± 0.19**	0.46 ± 0.18	0.59 ± 0.19	0.46 ± 0.18
10-fold within video, RF	**0.60 ± 0.07**	0.60 ± 0.08	0.21 ± 0.01	0.07 ± 0.01
10-fold within video, XGB, negative emotions grouped	**0.76 ± 0.04**	0.73 ± 0.04	0.66 ± 0.02	0.52 ± 0.02
10-fold within subject, RF	**0.38 ± 0.20**	0.42 ± 0.19	0.33 ± 0.26	0.29 ± 0.26
10-fold within subject, SVM, negative emotions grouped	**0.64 ± 0.13**	0.63 ± 0.12	0.67 ± 0.16	0.61 ± 0.16

An important issue with the eSEEd data is that all participants watched the same 10 emotion-evoking videos in the exact same order. This uniformity raises concerns that, given the small number of videos (two intended[1] per emotion), the models might learn to associate features unrelated to emotions, such as video dynamics or illumination. We circumvented the problem with video dynamics by dropping the mean gaze coordinate features and not using them in our experiments.

Despite these challenges, our experiments offer valuable insights into the feasibility of emotion recognition from low-frequency eye-tracker data, providing a foundation for future work. We opted for classical models initially due to their explainability, lower computational complexity, and efficiency, which are in our opinion essential for understanding the data before transitioning to more complex deep learning models.

In future work, several enhancements could be explored to improve the robustness and accuracy of emotion classification models using eye-tracking data. One approach could involve analyzing distinct fixation areas as an additional feature, potentially offering deeper insights into visual attention patterns. Moreover, considering that each emotion is (in some cases) represented by two videos, a valuable experiment would be to train models on one video and test on the other. This could help assess the model's ability to generalize across different stimuli within the same emotional category.

Further analysis could focus on demographic factors by examining the LOSO results for potential correlations between model predictions and participant characteristics such as gender, age, and education. This might reveal underlying biases or trends that affect model performance. Additionally, rather than downsampling and removing rows with missing data, future work could explore retaining or imputing these rows.

Furthermore, exploring the training of neural networks on raw, non-downsampled data from multiple modalities is another promising direction, as other studies already observed promising results with such approaches. Moreover, we should address the issue of overlapping emotions which could involve developing a multiclass output model, reflecting a real-world scenario where multiple emotions can be present simultaneously. This approach could also help reduce the number of undefined labels, increasing the amount of useful data.

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[1]The average percentage of the videos for which the participants had reported the target emotion (also known as the "hit rate") was 71.8% [13].

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PREDGOVOR

Dobrodošli na konferenci Kognitivna znanost. Na letošnji konferenci bodo avtorice in avtorji raziskovali mnoge plati človeške kognicije in predstavili tako svoje empirične ugotovitve kot tudi teoretska raziskovanja. Poleg prispevkov s področja teme letošnje konference, "Preseganje vrzeli v raziskovanju in razumevanju uma", bomo potovali skozi različna področja kognitivne znanosti - od psihologije in nevroznanosti do filozofije in umetne inteligence, ter ob tem spoznavali raznolike tematike vključujoč uporabo VR tehnologij pri raziskovanju kognicije, uporabo inteligentnih tehnologij pomoči pri demenci, uporabo dregljajev za spreminjanje vedenja, vpliv umetne inteligence na demokracijo, izzive vzorčenja izkustva in manj poznane vidike doživljanja kot so ozadnja občutja.

Konferenca se bo zaključila z okroglo mizo, na kateri bomo razmišljali o izzivih, ki jih prinašajo vrzeli v raziskovanju in razumevanju v kognitivni znanosti: med drugim o združevanju prvo- in tretje-osebnih pristopov k raziskovanju človeškega uma, o povezovanju različnih nivojev opazovanja (na primer mikro-nivoja nevrološke aktivnosti z makro-nivojem vedenja in družbenih sistemov) ter o izzivih povezovanja različnih disciplinarnih pristopov.

Upamo, da bo letošnja konferenca predstavljala prostor radovednega povezovanja in izmenjave kreativnih idej. Skupaj bomo premagovali disciplinarne in metodološke ovire, združili mlade in izkušene znanstvenike ter znanstvenice, ki si delijo strast do raziskovanja skrivnosti kognicije.

Dobrodošli!

Anka Slana Ozimič
Borut Trpin
Toma Strle
Olga Markič

FOREWORD

Welcome to the Cognitive Science Conference. At this year's conference, authors will explore the many facets of human cognition and present both their empirical findings and theoretical research. In addition to contributions on the topic of this year's conference, Bridging the Gaps in Research and Understanding the Mind, we will explore a diverse range of fields of cognitive science – from psychology and neuroscience to philosophy and artificial intelligence – while also learning about various topics, including the use of VR technologies in research, the use of intelligent assistive technologies for dementia, the use of nudges to change behavior, the impact of artificial intelligence on democracy, the challenges of sampling experience, and explore the less known aspects of experience, such as background feelings.

The conference will conclude with a roundtable discussion, where we will reflect on the challenges posed by gaps in research and understanding of mind in cognitive science: among others, we will think about the integration of first- and third-person approaches to studying the human mind, the relation and possible links between different levels of observation (for example, the micro-level of neurological activity and the macro-level of behavior and social systems), and the challenges of connecting different disciplinary approaches.

We hope that this year's conference will be a space for networking and sharing insightful ideas. Together we will overcome disciplinary and methodological barriers, bringing together young and experienced scientists who share a passion for exploring the mysteries of cognition.

Welcome!

Anka Slana Ozimič
Borut Trpin
Toma Strle
Olga Markič

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The Ontological Shock: What Psychedelics can Teach us about the Nature of the Mind

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ABSTRACT

The following article provides a brief overview of the significance and potential challenges of profound psychedelic experiences that prompt individuals to question the nature of reality, often referred to as "ontological shocks." These experiences are believed to induce changes in the structure of consciousness, leading to subsequent shifts in worldviews, behaviors, relationships, and mental health. While they can result in long-lasting positive changes, they are not always pleasant. Due to the complex alterations these experiences produce, they offer a unique opportunity to explore gaps in our understanding of the human mind and the nature of the reality it perceives, enacts, or constructs. The article aims to raise awareness of these issues by shedding light on various aspects of the discourse surrounding this topic.

KEYWORDS

psychedelics, ontological shock, mind, consciousness

1 INTRODUCTION

Psychedelics are psychoactive substances that can lead to altered states of consciousness, experienced as a change in perception and cognitive processes. Classic psychedelics, such as psilocybin, mescaline, LSD and DMT, primarily act through the stimulation of the serotonin 5HT-2A receptor. Due to somewhat similar psychological effects, substances such as MDMA and ketamine are also sometimes considered as psychedelics even though they target different neurological structures [1].

In recent years, there has been a growing interest in research on the potential use of psychedelic substances for mental health treatment. There are many studies that support this claim [e. g. 2, 3, 4], but there is also evidence that psychedelics can lead to longer lasting adverse effects [e. g. 1, 5].

Some of the challenges that may emerge after a psychedelic experience stem from profound shifts in one's worldview [6], metaphysical beliefs [7], and an overall ontological shock [8], in which the individual begins to re-evaluate the nature of their reality. Commonly, people also experience a shift in their spiritual orientation [9], due to experiences that have been labeled as “spiritual emergencies” [10]. These include transpersonal experiences, out-of-body experiences, hallucinations of religious nature etc. [10].

In this paper, we will tackle the problem of the “ontological shock” that can arise due to psychedelic experiences, how individuals cope with them and what implications they have on our understanding of the mind.

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2 ONTOLOGICAL SHOCK FOLLOWING THE USE OF PSYCHEDELICS

As interest in researching psychedelics for their potential therapeutic effects increases, there is a growing need to understand the mechanisms that enable these changes to occur. Changes in metaphysical beliefs are thought to be one of the driving mechanisms of change that enable the transformational process to occur [8]. However, changes in metaphysical beliefs don’t come easily, as they normally induce the so-called ontological shock about the nature and reality of existence [8]. This means that people start to question the nature of (their) reality and subsequently come to adopt an altered belief system, commonly constituting beliefs such as animism, life after death, the existence of alternative realities etc. [7].

On one hand, psychedelic experiences are often reported to be among the most meaningful and significant experiences, leading to positive long-term changes [11]. On the other hand, many individuals report prolonged difficulties after a profound psychedelic experience, struggling with ontological challenges as they question their own reality and existence [8]. This presents ethical challenges in both formal and informal practices for integrating psychedelic experiences, while also raising broader questions about the nature of reality itself.

2.1 Coping with the ontological shock

Psychedelic experiences that possess mystical qualities—characterized by feelings of ineffability, significance, and the perceived “trueness” of the experience—are more likely to result in an ontological shock and lead to a transformed belief system [12]. These experiences can offer profound insights into the "oneness" of reality and foster a sense of "ontological comfort," bringing a greater sense of purpose and meaning to life. However, they can also present challenges, as individuals may struggle to integrate these insights into their everyday lives. This raises the question of how best to support people in making sense of these new ontological truth claims [12].

Challenging psychedelic experiences can lead to various ontological difficulties, such as questioning one's identity,

grieving the loss of a past self, experiencing persistent encounters with (spiritual) entities, psychotic episodes, spiritual grandiosity, feelings of meaninglessness and emptiness, isolation and despair [8], derealization, delusional beliefs, and experiences of possession [9]. These prolonged challenges can impact individuals in different ways, resulting in difficulties with everyday interactions, attentional problems, disruptions at work [8], challenges in managing emotions, and perceptual difficulties [9].

Research on the adverse effects of psychedelics [e.g. 13, 14, 15, 16] and the challenges that arise following the so-called ontological shocks these experiences can induce [e.g. 1, 8, 9] highlights the importance of developing therapeutic practices and guidance rooted in empathic resonance and the concept of psychedelic apprenticeship [6]. While there are many existing therapeutic and shamanic frameworks aimed at making sense of psychedelic experiences [6], it is crucial to recognize that these experiences often lead to heightened suggestibility [17], which must be considered when helping individuals navigate their shifting worldviews. People have reported various strategies that helped them cope with extended difficulties, such as meditation, embodied contemplation, self-education through reading and journaling, and physical exercise. In terms of support from others, individuals expressed a need to feel seen, heard, understood, believed, and to have their experiences accepted and validated [1, 8]. This suggests a responsibility for practitioners working with and guiding people through psychedelic experiences to help them find meaning in their experiences without imposing any specific ontological truth claims [12].

Extensive research on challenging psychedelic experiences, including work by Stanislav Grof's clinical team, has identified common existential challenges that individuals often face following these experiences, primarily centered around fears of dying, going insane, or losing control [18]. According to Grof's team, psychedelic experiences can activate deep existential concerns that only subside once the individual has successfully processed them. It is suggested that people may encounter a sense of the groundlessness of being [18], which can be understood as an underlying "principle" of cognition. This brings us to the next point of this paper: the implications these experiences might have for the scientific understanding of the mind.

3 POSSIBLE IMPLICATIONS ON UNDERSTANDING THE MIND

3.1 Understanding psychedelic experiences

The underlying mechanisms that facilitate changes after the use of psychedelics have yet to be fully understood. However, several hypotheses have been proposed to explain how these cognitive shifts might occur. One prominent hypothesis is based on the framework of predictive processing [19]. This framework conceptualizes the mind as a "prediction machine" that continuously balances information by integrating prior knowledge about the world with incoming sensory data from the environment [19].

Within this framework, the "Relaxed Beliefs Under Psychedelics" (REBUS) model suggests that psychedelics increase the brain's level of entropy—or uncertainty—while reducing reliance on prior beliefs, thereby allowing more room for new sensory information [20]. This process can lead to the dissolution of previously rigid mental models and established worldviews. The resulting experience of an ontological shock may represent a direct encounter with the fundamental uncertainty of reality [8]. This concept, referred to as "groundlessness," attempts to explain how individuals continuously construct a world of meaning that is inherently without a fixed foundation and perpetually in flux [21].

It is important to note that psychedelics can also reinforce existing beliefs, potentially enhancing established worldviews, mental models, and expectations [22]. To address this complexity, the "Altered Beliefs Under Psychedelics" (ALBUS) model proposes that the effects of psychedelics on prior beliefs depend on factors such as the dose consumed and the individual's pre-existing state of mind [22]. This model aims to explain how psychedelics can both diminish and strengthen prior beliefs, bridging gaps between different proposed mechanisms of how psychedelics influence reality and well-being [22].

Additionally, other models offer explanations for the mechanisms of action of psychedelics. The "Cortical-Subcortical Communication Theory" (CSCT) suggests that psychedelics reduce thalamo-cortical filtering of internal and external stimuli, allowing new, unfiltered sensory information to emerge [23]. The "Cortical-Claustrum Communication" (CCC) model posits that psychedelics decouple cortical areas from the claustrum, leading to reduced cognitive control [24]. Furthermore, psychedelics are thought to open a critical period for social learning, potentially fostering new social behaviors and reducing tendencies toward isolation [25].

These various theories attempt to explain how psychedelics can facilitate the creation of new cognitive models of the world and reality. However, the field of psychedelic research continues to grapple with understanding the precise mechanisms of these substances, with ongoing testing of competing theories and hypotheses. For a comprehensive evaluation of these theories, see [26].

There is also an ongoing debate about the role of subjective experiences in the transformative effects of psychedelics. Some researchers take on a reductionist approach, focusing solely on the brain mechanisms involved [27, 28]. This is problematic, as it opens the question of how to understand the profound ontological shocks and the integration of the psychedelic experience in everyday lives of individuals. It is also problematic, as evidence suggests that psychedelic experiences with rich subjective effects, such as mystical-type experiences, can lead to the most significant transformations [29, 30]. If transformative effects were purely mechanistic, without considering subjective experiences, it becomes challenging to explain the struggles and positive changes individuals report in their daily lives after using psychedelics.

Subjective experiences cannot be easily dismissed [31, 32, 33, 34], and they are crucial for understanding how people's ontological reality gets altered. Investigating these subjective aspects could help address some of the unresolved questions about the mind. Studying the invariants and stable states of the "changing mind" following psychedelic use may bring us closer to unlocking the nature of the mind. This research could have implications for not only understanding and treating mental health issues but also for exploring concepts like consciousness [22, 36, 37] and the self [22, 33, 35, 38]. Additionally, it could

impact the reductionist debate [32], consciousness theories, and discussions about the "easy" and "hard" problems of consciousness [22, 36, 37].

3.2 Possible contribution to understanding the mind

In previous sections, we provided a short overview of what psychedelics are and sketched some possible implications they can have in the everyday lives of people, as well as our broader impact they may have on our understanding of the mind. In the last section we want to finish with diving a bit deeper into some possible implications that ontological shocks can have on understanding the mind.

Let us stop for a moment on how we understand the concept of the “mind”. This is an important question as the theories of psychedelic mechanisms all have their own postulates, the prevalent implicit view being that the mind is a product of neuronal activity (which applies for previously presented theories – the REBUS [20], CSCT [23] and CCT model [24]). This is a reductionist view of the mind that equals the mind with the brain [39]. Another possible view is that the mind is an information-processing system that manipulates and transforms information, which is a computational view [40]. In the previous years, another understanding on the mind has slowly been evolving in cognitive science – that the mind is embodied, embedded, extended and enacted, which we call the 4E cognition. This view understands the mind as a complex interplay between the brain, body and the surrounding environment [41].

The challenge of understanding the mind mirrors the debate in psychedelic research about the significance of subjective experiences. The core issue is whether the relevance of a psychedelic experience depends solely on inducing specific brain states or requires a deeper subjective experience to impact a person's everyday life. Evidence increasingly supports the idea that both "set" (the interplay of personality, preparation, expectation, and intention) and "setting" (the physical, social, and cultural environment) play crucial roles during a psychedelic experience [42]. This observation could indicate the relevance of the 4E cognition framework, which views the mind as a dynamic interplay between brain, body, and environment. Moreover, the 4E cognition theory might explain why set and setting are important, and why some psychedelic states and doses lead to profound changes while others do not. By exploring this intricate interplay, the 4E framework may shed light on why certain individuals experience ontological shocks under specific conditions. If, however, these experiences are inexplicable through existing frameworks, they could highlight gaps in our current understanding of the mind and reveal how alternative states of consciousness can disrupt the established interaction between mind, body, and environment.

Psychedelic experiences are often described as "altered states of consciousness," suggesting that by examining what changes during these experiences, we can gain insights into what constitutes the "normal," "usual," or "everyday" state of consciousness. The concept of ontological shock, which we have frequently referenced, highlights a paradox within this framework. If a person's everyday consciousness is altered during a psychedelic experience, and they subsequently notice changes in their subjective experience in their daily life, does this mean that the new state is an unusual or extended form of consciousness? In other words, does this imply that the individual is now living in a perpetually altered state of consciousness?

There is a prevalent view that the subjective experiences induced by psychedelics reveal aspects of the mind that need to be integrated into everyday life [43]. This perspective suggests that psychedelics should be considered mind-revealing rather than merely mind-altering substances [44]. This leads us back to fundamental questions about the nature of consciousness itself. Is consciousness merely a byproduct of neuronal activity, something external waiting to be experienced, is it embodied, enacted, or something else entirely? What we do know at this point is that psychedelics can induce alterations in our consciousness, affecting our awareness of ourselves and the world around us.

While it may be ambitious to claim that psychedelic experiences will fully bridge the epistemic gap between first-person experiences and their third-person correlates, or help us understand the nature of consciousness itself – the problem we commonly refer to as the hard problem of consciousness [45, 36]–, they can still provide valuable insights into both these issues [35, 36]. The most profound psychedelic experiences, which often lead to significant changes in consciousness, self-perception, and belief systems, may offer particularly important insights.

4 CONCLUSION

The aim of this article was to present the concept of ontological shock following the use of psychedelics and possible implications on the scientific understanding of the mind. We provided an overview of what is already known about this topic, to point out where we should be cautious and what is still unknown or vaguely known, as well as to illustrate how diving deeper into this topic could help us scientifically advance our current understanding of the mind.

It is important to conclude this paper with a call for caution. As we tried to point out, psychedelic experiences and its subsequent changes in everyday experience can inform us about the nature of our mind and help us gain broader understanding about topics related to consciousness, self, mental health etc. But the experiences that could most inform us about these topics and can lead to most profound long-term changes, have its challenges and downsides, which should not be disregarded. That is why the integration process, as well as the importance of set and setting, should always be considered when dealing with these substances. But before we have a consensus on what the mind is and how it constructs our reality, a lot of damage can be done, especially if we want to use psychedelic substances to help people get through their mental health problems, as is the case in psychedelic research in the past years.

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Innovative Supporting Approaches: Integrating Bibliotherapy, Psychodrama and AI as a Therapeutic Conversational Tool

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Abstract

How can individuals deal with personal trauma or internal struggles more effectively? This is the main question of every existential crisis, closely linked with humankind's survival strategy. Finding new, innovative ways for practitioners to leverage therapeutic techniques and modern *artificial intelligence (AI) technology* is crucial to providing precision mental health support to more individuals. While looking at possible approaches, it becomes more and more important to synthesize complex ways practitioners can provide multidimensional help. This paper investigates the possibility of a new holistic treatment that integrates *bibliotherapy's* storytelling, *Magic Shop* as a *psychodrama method*, and *AI conversation tools – chatbots* to ensure that individuals receive encompassing supportive therapy and feel less isolated. The holistic method is applied to *Korean pop* music as a case study, because K-pop content has experimented with these techniques and fandoms often have strong parasocial interactions. Combining these techniques creates a holistic, accessible, and personalized mental health care option that enhances the cognitive, emotional and practical well-being of individuals in need of support.

Keywords

Bibliography, storytelling, psychodrama, Magic Shop, AI, chatbots, K-pop

1 Introduction

The psychological aspect of overcoming personal issues and facing the harshness of reality is demanding for everyone. Internal cognitive mechanisms lead us to believe that individual struggles require individual approaches. This adaptation for hiding internal fights and presenting balance to the outside world is built under external pressure to achieve inner balance. However, emotional turmoil can be particularly challenging, which is why we need to explore a multimodal approach that could be a revolutionary step in interdisciplinary mental health support.

Bibliotherapy, psychodrama, and *AI* might initially seem unrelated, but there is a way to incorporate all of them within a new therapeutic framework.

2 Methodology

This paper uses a conceptual methodology to explore the integration of mental health techniques and *artificial intelligence* to theorize a holistic, accessible and personalized mental health care option. Based on the researchers' backgrounds and engagement with existing literature, *bibliotherapy, psychodrama* and *artificial intelligence* were chosen for further analysis. The researchers reviewed literature from databases including APA PsycInfo, Google Scholar, IEEEXplore, ProQuest, PubMed, Scopus, Web of Science and EBSCO. Only papers written in English and published after 2000 were considered, except for one foundational work (*Purpose and strategy behind the magic shop*). To build the theory, the researchers identified the prominent features of each topic (Table 1): *bibliotherapy's* storytelling, *psychodrama's* experiential model, and *AI's* real-time access, which will each be explored in subsequent sections. For an exploratory case study application, the researchers relied on new concepts (described in *6.1-6.3*) provided through the *Korean pop* music industry (concretely *group BTS*), initially produced as music-related products, but nowadays perceived through a therapeutic lens, with the primary aim of merging the separate therapies together, creating a more influential impact.

Approach	Method	Examples	Therapeutic Goal
Bibliotherapy	Individual therapy through storytelling	BTS: "The Most Beautiful Moment in Life" book series	Promote personal reflection and healing
Psychodrama	Magic Shop	BTS: "Magic Shop" song (metaphorical counselling setting)	Explore and resolve emotional conflicts
AI Chatbots	Parasocial interaction therapy	BTS: Weverse, Replica, Mydol	Provide emotional support and companionship
Integrated Approach	Psychodrama and digital interaction	BTS: Integration of storytelling, psychodrama, and digital interaction	Holistic support for the healing process

Table 1: Selection & Clarification for Chosen Approaches

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3 Bibliotherapy

Storytelling has long been a powerful means of exploring and understanding human emotions, and this concept underpins *bibliotherapy*, a therapeutic approach that uses literature to support mental health and personal growth. By engaging with carefully chosen texts, individuals can reflect on their own experiences, gain new insights, and find comfort and empathy through the narratives. *Bibliotherapy* leverages the emotional and cognitive impact of stories to address psychological challenges, offering a complementary and accessible method for fostering emotional healing and resilience [1].

Some research suggests that fictional narratives may be more effective for use in *bibliotherapy*, causing readers to empathize more with the characters and leading to better self-understanding and self-improvement [2].

Moreover, neuroscience reveals that storytelling influences brain chemistry, enhancing empathy and trust through the release of oxytocin and vasopressin [3]. This approach effectively enhances emotional experiences and trust, aiding in personal development and resilience [4].

4 Psychodrama and its Traits in Magic Shop

There are many ways to grasp the concept of *Magic Shop*. The first is understanding it as an in-depth training program with transformational practice, which will be discussed later in chapter *6.2 K-POP in Magic Shop*.

On the other hand, there is a possibility to apprehend it through the concept of *psychodrama*, which will be our primary interest, within this paper. *Magic Shop* is a practice used in *psychodrama* and group therapy in which participants create a space where they can "buy" something they already want, such as confidence or peace, from what they already have internally, such as anxiety or anger. In other words, this activity helps individuals explore their deepest passions, and the sacrifices needed to achieve them, while encouraging self-reflection and personal growth, with a possibility to solve conflicts in a safe, symbolic environment [5].

The term magic can be seen in society as something that carries supernatural power. *Magic Shop* is not an exception. Thus, it has a lot of forms and names: *Magic Shop* is our deep understanding of heart and brain in harmony. We often compare ourselves to others and hope we could be better than we are. Specific traits like social ability, patience and cleverness are examples that require time and practice. But it seems that *Magic Shop* is the key [6]. This method as a *psychodramatic strategy* can offer help to anybody through the use of fantasy [7].

In general, *psychodrama* is an experiential form of therapy, allowing those in treatment to explore issues through action methods (dramatic actions) [8]. This described approach, linked with *psychodrama*, was developed by Jacob Levy Moreno as a psychotherapeutic technique useful in working with patients during individual and group psychotherapy. This method offers significant changes through role-playing and dramatization, resulting in many benefits, such as insight, abreaction, acceptance of internal impulses, confrontation with the feelings of other people and training of alternative behaviors [9]. Whether we are talking about the first or second definition of *Magic Shop*, it can be a double-edged sword linked to maintaining one's own physiological and psychological well-being.

5 AI used in Therapeutic Spaces

AI chatbots are increasingly being used to enhance mental health care by offering real-time interactions that meet cognitive and emotional needs. These digital tools are part of a broader shift in communication, driven by the "computers-are-social-actors" paradigm, where AI significantly impacts how people engage with services [10].

In therapy, AI complements traditional methods by providing personalized interventions, making mental health support more accessible. Virtual environments facilitated by *AI* can create new opportunities for personal fulfilment and emotional connection [11].

Moreover, there is an overlap, because recent research by McAllister et al. explores the potential for *chatbots* to enhance *bibliotherapy* by supporting facilitators in mental health sessions. The study seeks to address gaps in existing literature by investigating how *chatbots* can be utilized to assist in the preparation and delivery of *bibliotherapy* [12].

In addition, in response to the high potential of technology, interviews with *bibliotherapy* facilitators have been conducted, followed by thematic analysis, to identify suitable tasks for the *chatbot*, aiding facilitators rather than directly evaluating the impact on participants of *bibliotherapy*.

This integration represents a major step towards a more comprehensive and accessible mental health framework.

6 K-POP as Multidimensional Tool

Although *Korean pop*, generally known as *K-pop*, seems to only overlap with music therapy, due to its main impact field, *K-pop* may also serve as a useful case application for *bibliotherapy, the Magic Shop* technique, and *AI* tools.

Some *K-pop* groups participate in transmedia story worlds and lyrical concepts that go far beyond "unrequited love" themes, touching the human psyche more deeply. Additionally, merging this with technology platforms like "Weverse" or "Bubble for JYPnation ", not to mention fabricated interactions through apps like "Replika", "Mydol", etc., fans have never felt closer and more bonded to their idols, who are revered with boundless support and understanding.

6.1 K-POP in Bibliotherapy

Many *K-pop* groups rely on some form of storytelling, but some take it a step further. In particular, *K-pop group BTS's* "BTS Universe" *(BU)*, functions as a multidimensional tool for emotional and psychological engagement. In *bibliotherapy, BTS's* books, *The Most Beautiful Moment in Life: The Notes*, provide a unique narrative that facilitates self-reflection and emotional exploration. These notes, embedded within the group's *Love Yourself* albums, as well as two books published by *BTS's* label, offer fans a form of therapeutic engagement by inviting them to interpret and relate to the fictional world, which can mirror personal experiences and foster emotional processing [13].

This can be particularly striking when we take into account individual emotional overload with a long-term inability to

restart one's own coping mechanism to underlie qualitative functioning in everyday life.

Preliminary research has suggested that the stories embedded in *K-pop* can have a positive impact on fans' ability to cope with challenges and heal. One survey found that *97%* of fans (*n=2342*) agreed that *BTS's* music and lyrics were effective in this way. Additionally, *84%* agreed the storylines in *BTS's* concepts were effective, and *75%* agreed the *BU* storyline was effective [14].

These numbers suggest valid proof of audience engagement techniques in fiction, described by Donald Maass as presenting novelty, challenge, or aesthetic appeal to readers, which leads to better identification with the story, while figuring out solutions for the main character´s actions, reflecting in an individual's healing scheme [15].

6.2 K-POP in Magic Shop

There is no doubt that science plays a crucial role in our understanding of human beings, yet some phenomena, such as compassion, altruism and empathy, remain enigmatic. These concepts form the foundation of James Doty's work, particularly in his book *Into the Magic Shop: A Neurosurgeon's True Story of the Life-Changing Magic of Mindfulness and Compassion*, which inspired not only this paper but also the lyrics of the *K-pop group BTS's* song "Magic Shop". The song, much like Doty's book, is perceived to have a healing effect on many individuals, resonating deeply within a therapeutic framework. Doty is not only a renowned author but also a researcher who founded the Center for Compassion and Altruism Research and Education (CCARE) at Stanford University, which supports his desire to analyze the interaction between the mind and body in relation to the concept of *Magic Shop* [16].

6.3 K-POP in AI Chatbots

In the *K-pop* world, *AI* enhances fan interactions by fostering *parasocial relationships (PSI)*, a term that goes back to its roots in 1956 when it was defined as the illusion of a face-to-face friendship between audience members, along with the main factor of a one-sided relationship [17] with *idols* (Korean singers within *K-pop* industry). *Chatbots* like "ChatGPT", "Replica" or "Mydol" offer more personalized conversations, deepening the emotional connection fans feel with their favorite stars [18]. This can be particularly comforting for those dealing with anxiety or low self-esteem.

AI-driven *PSI* offers new avenues for addressing anxiety, providing a controlled environment for emotional exploration. While there are risks of maladaptive obsessions, the positive impact on psychological well-being is significant when managed carefully [19]. As *AI* continues to evolve, its role in supporting mental health in niche areas like *K-pop* will likely grow, offering innovative solutions to common challenges [20].

7 Relevance for Cognitive Science & Cognitive Behavioral Therapy

Understanding how the human brain reacts to situations, making individuals feel distressed has been already covered. Now, it is more than important to look for strategies to fight against it, apart from medicaments. Recognizing an individual's need to support one's prosperity and healing cognitive processes, interdisciplinary cognitive science offers an opportunity to merge concepts together that might bring new ways to deepen our knowledge.

Combining different approaches, such as *AI chatbots* using *Cognitive Behavioral Therapy (CBT)* with minimal *bibliotherapy* interventions, is slowly but steadily indicating that the *chatbots* are more effective in reducing symptoms of depression and anxiety [21], which is the primary desired effect.

Moreover, *fanship*, an individual's bond to their idols, plays a crucial role in enhancing happiness, self-esteem, and social connectedness, which pushes forward the application of social identity theory in the realm of *K-pop* fans and expands the psychological understanding of fandom and its extended therapeutic possibilities [22].

8 Findings

Combining *bibliotherapy*, the *Magic Shop* psychotherapeutic method and *AI* tools can offer a comprehensive mental health treatment model. *Bibliotherapy* provides cognitive and emotional benefits through literature and storytelling, the *Magic Shop* method engages clients in creative and transformative experiences, and *AI* tools ensure continuous support and accessibility (as shown in Figure 1).

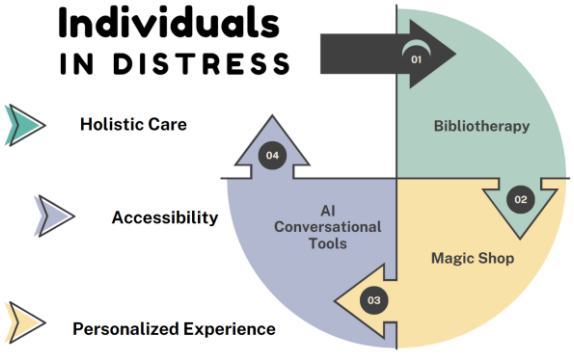

Figure 1: Infographic of Innovative Supporting Approaches

Note. Created with *Canva.com*

a. ***Holistic Care:*** *The union offers a multidisciplinary approach to mental health, addressing cognitive, emotional, and practical needs. By considering the whole individual, this approach promotes holistic healing and improves overall well-being.*

b. ***Accessibility****: AI tools streamline mental health services and provide immediate support, covering a gap to traditional treatments. This ensures that more individuals can access the help they need, regardless of location or financial barriers.*

c. ***Personalized Experience:*** *Integrated approaches enable tailored interventions that can be adapted to individual needs and preferences. This personal involvement improves the effectiveness of treatment, leading to the best results and a more satisfying treatment experience.*

Additionally, *K-pop* offers a valuable case application for this holistic program, given the rich story worlds and concepts combined with fans' love and attachment to their favorite idols, some of whom can be accessed through *AI* applications.

9 Study Limitations & Subsequent Research

Regarding the limitations of this paper, both authors are fully aware of the restrictive parameters linked to the exploratory case study, which was selected as a presented application. Therefore, the mentioned research gaps and possibilities of merging therapies have only an advisory nature with the need for subsequent research with possible future administration in professional-guided therapy sessions, as well as individual applications after undertaking a specialized training process provided by professionals in specialized facilities.

10 Conclusion

Unveiling how to provide the most appropriate care to those who need to overcome difficulties while restarting their coping mechanisms can be quite diverse and tricky. Understanding the individual treatment plan is the key. While previous research has been focused on single therapy treatment, nowadays there is a strong case for merging them. Encountering situations through the safe space of stories allows individuals to better understand actions and emotions, develop empathy and progress in their healing journeys. *Bibliotherapy* allows readers to internalize and adopt positive traits from characters they resonate with, while *psychodrama* facilitates deeper understanding and emotional growth through role-play and perspective-taking. In the realm of *AI chatbots*, this effect can be harnessed to create more empathetic and personalized interactions by mirroring users' language and emotional tone. With *K-pop's* use of *AI*, there is untapped potential for precision mental health care. Overall, these techniques underscore the importance of storytelling in fostering empathy, engagement, and therapeutic outcomes across these diverse fields.

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Usability of intelligent assistive technology used by people with dementia and their caregivers

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Abstract

Intelligent assistive technology with context-aware computing and artificial intelligence can be applied to assist a person with dementia and their caregivers with activities of daily living. This paper samples such technologies with a focus on current knowledge and practice concerning usability. We used a scoping study to address the objectives of the research. Our findings indicate that despite the importance of technology customization to individuals' needs and capabilities it is not commonly addressed in the literature. Furthermore, while researchers are aware of the concepts and aims of evaluating the usability of technology, they seem to face difficulties in assessing them.

Keywords

Activities of daily living, cognitive assistance, dementia, evaluation of usability, family caregivers, human-centered design, scoping survey, user experience

1 Introduction

Dementia is a neurocognitive disorder, typically chronic and progressive, characterized by impairments in cognitive functions such as memory, attention, orientation, and language [1, 2] to the extent that a *person with dementia* (PwD) is not able to independently complete *activities of daily living* (ADLs) [3]. *Personal* (pADLs) refer to basic physical needs such as dressing, toileting, bathing, and eating, while *instrumental* (iADLs) are essential for living independently in the community, such as preparing food, taking medication, and doing laundry [4]. The ICD-11 [1] identifies three *degrees of severity* of any type of dementia. In the *mild stage*, a PwD may live independently but requires supervision and/or support with iADLs, such as locating everyday objects, and handling finances. In the *moderate stage*, PwDs require support to function outside their home environment. They can accomplish only simple household tasks and experience difficulties with completing pADLs. In the *severe stage*, memory impairment becomes profound, though it varies by etiology. PwDs are fully dependent on others for pADLs and they often experience total disorientation in time and place.

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One of the most common diseases in old age, dementia is recognized as one of the most costly and burdensome health conditions [2]. Statistics suggest that the growing global population of older adults diagnosed with dementia reached 44.4 million worldwide in 2013, with projections indicating an increase up to 135.5 million by 2050. Concern over the limited availability of family and professional caregivers for this rapidly growing population is intensifying (ibid.). As the population ages, the number of potential caregivers decreases, and those available often lack the key skills to provide the necessary level of care [5]. Furthermore, as family caregivers become more involved while struggling to balance other familial and social roles and responsibilities, they often experience negative consequences on their health, such as burden, anxiety, depression, isolation, and sleep deprivation [6]. Technological innovation, including advances in communications, robotics, and sensors, are perceived as promising to tackle these challenges [5]. Specifically, *assistive technology* (AT) refers to a broad range of devices and systems designed to maintain or enhance an individual's functioning related to cognition, communication, hearing, mobility, self-care and thereby promoting their health, well-being, inclusion, and participation [7]. AT is not designed to perform tasks on behalf of the user, but are specifically designed to monitor the activities of cognitively impaired users and provide appropriate assistance, thereby enhancing the likelihood of achieving desired behavioral outcomes [8]. A specific category of AT, *cognitive orthotics* [9] or *cognitive assistive technology* [10] is designed to assist with *cognitive* tasks. For instance, AT is employed to remind PwD to take medication or that their family member is visiting them next day [9, 10]. PwDs and their caregivers routinely use low-tech aids, such as medication pill organizers, schedules, and notes. They are being offered high-tech aids, such as *intelligent assistive technology* (IAT) that employs artificial intelligence to assess whether and when an appropriate reminder or procedural guidance is necessary for task completion [11, 12]. Additionally, IAT should be *contextually aware*: able to examine its environment, react to changes within it, and thus provide help *when needed* [11].

Human factors and *ergonomics* are scientific disciplines focused on studying the interactions between humans and other components of socio-technical systems [13]. The aim of designing such products and systems is to minimize human error and enhance human efficiency. One attempt at managing human factors analysis and human errors is through the development and deployment of measurement standards such as the *Human Readiness Levels* (HRL) scale (ibid.). HRL complements and

supplements the *Technology Readiness Level* (TRL) scale, which captures the maturity of technology before and after its integration into a developing system [13, 14]: HRL emphasizes the readiness to develop technology for effective and safe *human* use, and it should capture human-related features of technology development [14]. Similarly to TRL, HRL scale is divided to nine stages: *basic research and development* of principles, concepts, and the application of human characteristics, performance, and behavior, along with guidelines incorporating human-centered requirements to enhance human performance and human-technology interactions (HRL 1…3); development and assessment of user interface design concepts and prototype simulations in *laboratory and real-world environments* (HRL 4…6); full-scale testing, verification, and deployment in an *operational environment* with representative users and system hardware and software (HRL 7… 8); and the final stage, where the system is actively used in the *operational environment* with systematic monitoring of human-system performance (HRL 9) [14]. HRL is closely linked to *user-centered design*, a framework for the design and development of new products or the assessment and evaluation of existing products that explicitly considers potential users' needs, wishes, and subjectively perceived limitations of the IAT [5, 9, 12].

Some key definitions from the ISO standard on ergonomics of human-system interaction [15] read: "3.13 *usability*: extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use. … 3.3 *effectiveness*: accuracy and completeness with which users achieve specified goals. … 3.4 *efficiency:* resources used in relation to the results achieved. Typical resources include time, human effort, costs, and materials." Further important aspects of usability include *user satisfaction*, the "extent to which the user's responses resulting from use meet the user's needs and expectations; how *accessible* a product, system, service, or environment is to individuals with diverse needs, characteristics, and capabilities is another element of usability". As examples of differences in terminology, see e.g. [16], where *utility* refers to whether the design provides features that users *need* and *usefulness* covers how pleasant and easy to use technology is (usability) and whether it does what users need (utility).

2 Methodology

This short survey covers only some of the findings of my ongoing more comprehensive review of topical IATs [17]. For this survey, the following research questions to explicate the coverage of *usability* will be addressed:

1. What is the maturity of IAT for human use (= its HRL)?
2. (How) do the developers take the *progression* of the disease into account?
3. How exactly is technology being assistive?
4. How is the usefulness and usability of the technology evaluated (if at all)?

Our scoping study maps key concepts, main sources, and types of evidence available for the domain targeted. For methodological transparency, we followed the PRISMA-ScS checklist [18]. Our search combines electronic database platforms (APA PsycInfo, Google Scholar, IEEEXplore, ProQuest, PubMed, Scopus, Web of Science, as well as the digital library facilities of the Universities of Vienna and Ljubljana) with hand searches of electronic journals and literature identified through literature readings. For this survey, we included original articles, conference proceedings, and PhD thesis; written in English; and published "within the last decade" (i.e., since 2013). To be covered, IATs further had to meet the following *inclusion* criteria: direct applicability to dementia care, focus on assisting with ADLs, PwD, and/or family caregiver as a user. We *excluded* IATs developed for the support of other (if related) disabilities, such as traumatic brain injuries; that could only be used by professional caregivers.

3 Findings

We illustrate our findings for each research question using the technologies: COACH [10, 11] and AWash [19] (targeted ADL: handwashing); DRESS [20] (getting dressed); ToiletHelp [21], (using a water toilet); and Smart Toothbrush [22] (brushing teeth). The pADLs supported by these IATs must be performed regularly to maintain the person's independence, health, and overall well-being. As dementia progresses, PwD becomes increasingly dependent on others to complete ADLs, affecting their family caregiver and society (cf. section 1).

3.1 Human Readiness Levels

We assigned aggregated HRL scores according to the groups introduced in section 1, with most of the surveyed technologies ranking at HRL 7…8: COACH, AWash, and ToiletHelp. This likely results from our choice of targeted content, as we aimed to focus on IATs close to HRL 9. We mapped DRESS and Smart Toothbrush to the HRL range 4…6, as the first is about developing and evaluating a prototype in preparation for in-home trials with PwDs, while for the second only preliminary laboratory testing was conducted with healthy individuals.

3.2 Different stages of Dementia

The IATs selected for this article are intended to provide targeted assistance for different stages of dementia. ToiletHelp is aimed to be used by PwD in the mild stage of dementia, COACH in moderate to severe stage, DRESS and Smart Toothbrush in severe stage, while for AWash we have not found any explicitly targeted stage of dementia. We found no evidence of technologies taking into account individual differences and needs of PwDs and their caregiver, consequently, we were not able to find such technology that would be able to *adapt* according to the actual severity of dementia as disease progresses (cf. section 3.3). Such *customization* is needed as cognitive functions progressively deteriorate, with fluctuations in rating occurring throughout the day or as the system would be used over periods ranging from weeks to months or even years [20, 21].

3.3 Notions of Assistance

Assistance involves *interacting*, with *prompting* being an interaction strategy that has become widely popular also in the context of IATs. Within our target domain, we found *audio* prompts to be most common as they are part of COACH, AWash, DRESS, and Smart Toothbrush. Such assistance should guide

PwD through the sequential steps of the activity by pre-recorded voice commands. *Visual* prompts include *videos* of steps of activities (COACH); *pictures* of correct clothing items (DRESS); use of different *lights* to attract attention to the appropriate use of an object (DRESS, Smart Toothbrush); and *texts* with instructions (ToiletHelp). DRESS consists of *motivational* prompts in the form of songs or videos favored by the PwD are meant for when a PwD should get stuck in an activity, and are configured by the family caregiver. COACH has options for *increasing levels of support*: low-guidance and high-guidance verbal prompts, video demonstrations, or placing a call to the caregiver. DRESS offers the choice of *continuous* mode, which includes chronological directions across all steps of an activity, and *independent* mode, in which no audio prompts are provided while the PwD is donning a shirt, and the caregiver should receive text messages on their device either when help is needed or dressing is completed. Nominal assistance provided by ToiletHelp consists of acknowledgment messages displayed to reassure the users they have completed every step of the activity; when the need is recognized, instructions are repeated. If a user should still fail, an alert informs the caregiver the PwD is having trouble, along with a reassurance message being displayed to the PwD.

The IATs we identified can help guide PwD through activities, but it is crucial to tailor such assistance to individual needs and adjust it as dementia progresses [20]. While there are cases where differing/increasing levels of assistance are provided by IATs [10, 11], such adjustment is not commonly documented in the literature. Despite its importance, our research indicates that there is also a lack of consistency in the terminology used to describe the adjustment of IATs to individual needs (e.g. customization, personalization, adjustment, adaptation).

3.4 Usability

The resources we analyzed indicate a dearth of commonly used standardized usability tests; out of the systems surveyed, only Awash was assessed using the System Usability Scale (SUS) questionnaire [23]. Instead, information about the usability of IATs is often gathered through user interviews [10, 11, 20, 21], observation, and performance testing [10, 11, 19, 21, 22].

In terms of *effectiveness*, COACH and AWash users were able to independently complete more steps of activity and engage less with caregivers while using IAT. Regarding *efficiency*, the developers of the Smart Toothbrush have estimated its battery life, while those of DRESS considered the final product's cost. In terms of *user satisfaction*, caregivers noted several benefits of DRESS, including validation of memory loss, empowerment of PwD, promoting privacy and dignity, and providing caregiver respite. ToiletHelp was reported to increase PwD's autonomy, boost self-esteem and dignity, and reduce the burden on caregivers. Participants rated AWash with a positive user experience. On the other hand, difficulties in using the technology were due to varying stages of dementia, visual and sensory perception issues, the need to change routines, and *affordability* issues [20]. Users expressed dissatisfaction with long delays between tasks and the frequency of prompts [10, 11, 22], while overlapping video and verbal messages used in ToiletHelp caused distraction. The acceptance of IAT largely depends on its *utility* and its unobtrusiveness, which can encourage more consistent use.

The current understanding of usability reflected in the literature indicates that even when researchers are aware of the related concepts and terminology and aim to assess them, they have difficulties in doing so with unified questionnaires or standardized testing procedures.

4 Relevance of Cognitive Science

The goal of the inter-disciplinarity of Cognitive Science is to address the question of *how does the mind work* – why we do the things we do, think the way we think, and how we perceive the world around us – by trying to understand and explain underlying mental processes and mechanisms of human behavior from the point of view of each discipline [24]. In user interfaces, *computational models of human behavior* are used to describe and capture our understanding of typical user actions, predict future actions, and guide users toward improving their actions [25]. These computations are typically based on *internal symbolic knowledge representations*, allowing a cognitive agent to manipulate symbols to gain information about the external world and determine how to act effectively – plan and perform actions, and achieve specific goals [26]. Evolutionary psychologists view the information processing architecture of the brain to consist of *adaptive problem-solving systems* that use information to adaptively regulate physiology and behavior. In this perspective, attention, learning, emotion, and motivation all play key roles in minds work and how we respond to our environments [27]. In particular, motivation can *guide* cognitive processes: When a PwD becomes fatigued, their motivation to continue activities declines. IATs can help by providing motivational prompts, such as favorite music or videos, which evoke emotional memories. This is but an example of how, cognitive science provides crucial insights into how users perceive, process, and interact with technology and consequently affects both, the improvement of designs and testing of usability and usefulness. It is a "bridge" between applied artificial intelligence and user experience.

One important objective of applied artificial intelligence is the development of cognitive orthotics, designed to *enhance* and *expand the user's cognitive abilities* [28]. It is not about technology imitating human abilities, but rather *extending* them. The key focus is the importance of creating systems that combine human and machine components in a way that maximizes their individual strengths taking into account ethics. To design successful cognitive orthotics, *interdisciplinary* teams are needed to unite relevant knowledge and perspectives of professionals (such as computer scientists, engineers, physicians, cognitive psychologists, and neuroscientists) together with stakeholders and users of technology (ibid.).

5 Limitations and Future Work

As technology advances rapidly, future research should explore a wider range of IATs using novel modalities and supporting more diverse ADLs. This limited study cannot form generalized statements about IAT usability for PwD and caregivers, as

comparing specific ADLs is challenging due to variations in particular activity structure, cultural contexts, and dementia stages. We focused on a small subset of IATs addressing some pADLs, excluding those covering iADLs and multiple ADLs. [17] takes a step in this direction.

6 Conclusion

Dementia is becoming increasingly prevalent, posing a major societal, economic, and global health challenge. While extending the duration of PwD's stay in their private homes may be seen to help alleviate the strain on institutional settings, it in turn places a significant burden on family caregivers. While IATs are intended to enhance the independence of PwD and reduce the caregiver's burden, our literature review efforts suggest that usability aspects are not systematically assessed. This gap is also linked to current HRLs, which indicate that existing IATs are not fit for deployed use by PwD. Moreover, we find that IAT is often not designed to adapt to the progression of the disease, affecting its utility and usability. Heavy terminology such as *intelligent assistance* appears to be employed all too easily. Furthermore, practice in assessing and reporting usability appears to leave significant room for improvement.

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Open Science and Goodhart's Law

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ABSTRACT

The influence of Goodhart's law to the development of Open Science is discussed. Science Citation Index (SCI) and Open Access (OA) are important steps in the path from Science to Open Science (OS). The main conclusion is that flawed openness replaced quality in Open Science.

KEYWORDS

Open Science, Open Access, Article Processing Charges, Goodhart's Law, Free Journal Network

1 FROM SCIENCE TOWARDS OPEN SCIENCE

1.1 Science

Traditionally, scientists disseminated their findings by publishing their results in scientific journals. This is a key mechanism for knowledge transfer among scholars and therefore an important subject of cognitive science. In the old days, the process of writing a scientific paper was completely different. The author had to type the paper on a typewriter leaving spaces for handwritten greek letters, symbols and formulae. With the advent of copying machines only cumbersome paper "cut-and-paste" method was available. Smaller misprints were overtyped whilst larger corrections required replacing whole pages. Professional typists, not available for everyone, could speed up the process. Manuscripts were sent for publication by ordinary mail in several iterations, depending on the referees' requests.

Rise of technology quickly brought up big changes. The introduction of personal computers replaced typewriters by keyboards and drastically enlarged the population of those who were able to compose texts on a computer and simple editors introduced cut-and-past method of writing. Specialised software for producing high-quality scientific drawings and diagrams enabled publishers to request camera-ready manuscripts from the authors. Authors no longer focused only on the subject of their work but also on the look it will have when printed.

1.2 Characteristics of Classical Publishing Model

Classical publishing model was robust and healthy. It was free for authors. Certain journals were even paying author fees. Surprisingly, it was (almost) free for readers via libraries of public universities.

Main players involve authors, editors, referees, publishers, libraries, readers, universities, learned societies, funding agencies and taxpayers.

Publishing within classical publishing model was time consuming and required efforts from all parties. This somehow prevented the inflation and hyper-production of papers.

The model was mainly "subscription model" where articles were available in printed volumes of a journal. University and departmental libraries subscribed to major journals, covering selected fields of science. The contents of earlier volumes were available to library users. Most libraries were open to local community and also to visiting researchers. Several learned societies, universities and institutes published their own journals, associated with a given library and used them for exchange purposes. Instead of paying subscription to a similar journal they would simply exchange the journals. In this way a library was able to save money to subscribe to journals that were not available for exchange. This was an important way for wealthy western scientists to help scientists from Eastern block and third world countries. Later the revenue from scientific publishing was one of the main sources of income of major learned societies. Unfortunately, by acquisitions and mergers eventually a very small number of huge multinational publishers emerged. These publishing houses control the field of scientific publishing.

1.3 Transition to digital

The advancement of technology, in particular ICT (Information and Communication Technology), in the second half of the twentieth century with the transition from analog to digital completely transformed the process of scientific publishing.

The costs of all stages of publishing decreased. More and more work was transferred from publisher – printer to author. Publishing a paper became easy and inexpensive. The number of scientific journals started to grow even more rapidly.

Surprisingly, major publishers did not lower the cost of subscription to their journals. On the contrary, they started to bundle journals. If a library wanted to continue subscription to a journal it had to subscribe to the whole bundle of journals, many of which it had no interest in.

When papers became available in a pdf form, the need for printed versions decreased. This also meant there was no way to prevent an unauthorised access to the paper. The first electronic journals appeared.

There is a big difference between subscription to printed journal and electronic journals. Old volumes of printed journals remain in the library and are available to anyone having access to the library. On the other hand, volumes of electronic journals remain with the publisher who may deny access to the paid volumes after the subscription runs out.

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2 GROWTH OF SCIENTIFIC PRODUCTION; SHIFT OF GOALS

In the past century we experience tremendous growth of published scientific works. There are several factors contributing to this phenomenon.

2.1 Publish or Perish

"Publish or perish" is an aphorism describing the pressure to publish academic work in order to succeed in an academic career. It first appeared already in the first half of the twentieth century. For a long time the PhD was a sufficient proof of academic qualification. It was not unusual that the PhD Thesis was the greatest scientific achievement of a scholar. Unfortunately, the growth in the number of universities and scientists led to inflation of PhDs. Some scholars would simply stop doing research when hired. Employers began requesting a constant flux of publications as a proof of scientist's devotion to research. Those who were unable to maintain high publication rate would be discouraged to stay in academia. And quantity became a proxy for quality.

2.2 Quality control

Ever since scientific journals appeared in seventeenth century, the quality of publications was in the hands of scientists using the system of peer review. This was natural since everybody involved: authors, editors, referees and readers were scientists.

With the growth of number of journals it became clear that not all journals apply the same standards for accepting a paper for publication. Obviously there was a problem of quality control.

In mathematics there was a secondary system in place. It started in Germany before WWII. Eventually, three refereeing journals were established, one in the Soviet Union, one in the USA and one in Germany (nowadays at the European Mathematical Society). If a review of a paper does not appear in one of those refereeing journals, the paper is likely not to be interesting for mathematicians.

For science in general there is a similar publication, called Current Contents.

2.3 Citation index

If we know for each paper the list of papers it cites, we can also produce the inverse index, i.e. the list of papers that cite a given paper. Such index is called citation index. In 1964 Eugene Garfield conceived the Science Citation Index (SCI) [3]. Using citation index one can easily detect most follow-ups to a paper covering a topic of scientist's interest. Clearly there are certain limitations. One has to select a collection of journals from where papers and their references are included. This may introduce some bias.

2.4 Impact

On the other hand, if the database is stored in a computer one can easily perform some statistics. For instance one can store with each paper the number of its citations. One can also compute how many citations each author has. This may, again, help the scientist to select the papers to look-up and authors to follow.

However, it also leads to all kind of rankings. Citation indices became very useful not only to scientists but also to their employers and funding bodies. Instead of comparing the added knowledge of someone's research, it is "sufficient" to select the highest ranked candidate. Selection can be done by administrators or computers. No peer review is needed. The paradigm "Publish or Perish" was upgraded to "Be Cited or Perish".

3 BIBLIOMETRICS

With the Science Citation Index (SCI) a number of statistical measures were introduced that would help profiling an author, the work or the journal. The science of bibliometrics was born. It was later extended to scientometrics and ultimately to informetrics.

SCI introduced a number of measures, indicators or metrics, trying to capture certain properties of articles, authors and journals.

One such indicator is the *journal cited half-life*. It is the median article publication date for each journal citation during one calendar year. In general, the journal cited half-life is small for recent journals while it is large for older, well-established journals. On the other hand it depends, as any other indicator on the scientific field and the culture of publishing in that field. Finally, a large journal cited half-life indicates that publications in that journal remain relevant for a long time. Hence the new knowledge is persistent and not merely mundane. Nowadays, it would not be difficult to equip any bibliographic database with computation of journal journal cited half-life.

3.1 Journal Impact Factor

Notorious Impact Factor (IF) is a ratio between the number of citations in a given time period - usually a calendar year, to the articles, published in another time period - usually two calendar years before. Sometimes they present also 3-year or 5-year impact factors.

For some reasons a 2-year impact factor prevailed and became a standard. In certain sense a 2-year impact factor is complementary to a journal cited half-life. Definitely, a 2-year IF is not the best indicator for mathematics when compared with other sciences where citation culture is different. For instance, when 1756 SCIMAGO journals covering the subject area of Mathematics are ranked according to Cites/Docs. (2 year) for the year 2023, among the top 50 journals only one journal has Mathematics as the primary subject area.

3.2 Metrics and Ranking

Having different indicators for a set of journals is good. It gives a higher dimensional description of each journal. However, each indicator may be used for sorting and hence for ranking. There is a strong tendency to devise an indicator that would measure quality; an impossible task.

Never-the-less since early seventies the Impact Factor is considered by many a proxy for the quality of a journal. The false reasoning goes along the following lines:

- Outstanding scientists publish their work in high-quality journals.
- The work of outstanding scientists is frequently cited.
- High-quality journals have high impact factor.
- Wrong conclusion: Work published in a journal of high impact factor is of high quality.

3.3 Power law and related statistical laws

When plotting the distribution of ranked impact factors, one can observe the exponential decay. Impact factor $IF(r)$ of rank r journal is proportional to $1/r^{\alpha}$ for some constant α. This is known as the power law. Roughly speaking this means that there are only a few journals with high impact factor and there are

many journals with small impact factor. One way of stating this is that 20 percent of most cited journals receive 80 percent of citations; see [7]. Several of these laws were first observed in bibliometrics. However it is interesting to observe that these laws are universal and apply to a variety of unrelated situations, perhaps by choosing the right value of parameter α.

4 GOODHART'S LAW

British economist Charles Goodhart is credited with expressing the core idea of a law in a 1975 article on monetary policy in the United Kingdom. "When a measure becomes a target, it ceases to be a good measure"; see [4]. Another way of saying is "that once a metric is used as a basis for decision-making or control, it loses its reliability as an accurate measure".

The main rationale behind this law is adaptation or even gaming to improve one's rank. If high rank means high reward, it is plausible, that some people will do anything to improve their score for the given indicator. Each measure for assessment of researchers and journals became prone to Goodhart's Law.

4.1 Goodhart's Law and Bibliometrics

When the number of publications are counted, researchers will tend to split long papers and publish short bits and will thus increase the number of publications. Instead of publishing papers alone they may increase their output several times if more coauthors sign the same publications. There is no increase in quality of their output.

When the number of citations decide who is winning a grant, the number of citations soared. The authors started citing their own papers, even if citations were not needed. When self-citations ceased to count, friendly researchers helped each other with citations.

When the h-index was introduced, the key publications of potential PIs in a research group had to be cited.

Employers and funding bodies understood that blindly rewarding high production authors with large impact papers does not mean rewarding high-quality science as there was no problem in publishing papers in low-quality journals and getting many citations in such journals. On the contrary, in many cases those fabricating papers and citations easily outperformed best researches. That is why the quality of journal in which the paper was published became important; in practice this meant journals with high impact factors.

By Goodhart's law, predatory publishers flourished, multiplying their journals and boosting their impact factors.

Production of new knowledge ceased to be important. It is the impact of their work published in high-impact journals that counts.

There is a difference in Goodhart's law and other laws, used in bibliometrics. Goodhart's law involves time and decision while laws based on power law are based on rankings.

There are not many studies of Goodhart'sl law in bibliometrics. An exception is a comprehensive study reported in [2].

5 OPEN ACCESS A STEP TOWARDS OPEN SCIENCE

5.1 APC model

The idea that authors or their institutions should make financial contributions for their publications is not new. In the times of paper publications, the publisher would grant some, say 25 reprints. For ordering extra reprints it was not uncommon to charge the authors. Also, one could be charged for insisting that the figures be printed in colour. On the other hand, some prestigious journals, started requesting article processing charges (APC).

Employers and funding agencies soon recognised that if they want their scientists to publish in the journals with very high impact factor, they will have to cover the costs of APC. Some scientific disciplines such as mathematics declined this model. When judging whether to pay APC or to send a graduate student to an international workshop many mathematicians give precedence to student. However, the publishers realised that money could be presented as a proxy for quality and raised their prices.

5.2 Diamond- and Green Open Access

In the last decade of the twentieth century some of the first purely electronic journals appeared. For instance, *The Electronic Journal of Combinatorics (E-JC)* was funded in 1994. It was free for authors and readers. It is run by scholars and not by commercial publishers. This is nowadays called a *diamond open access*, with no cost for authors and no cost for readers. E-JC is a founding member of the Free Journal Network [9].

Even before that, in 1991, an e-print server *arXiv* was launched where preprints in some scientific disciplines may be uploaded. Nowadays, such posting of preprint before peer review is called *green open access*.

For a while it seemed that this model will force big publishers to lower the prices of their journals. In the battle between scientists and multinational commercial publishing houses, the scientist should have won. It was expected that governments will support scientists in the fight against greedy publishers; [10]. However, politics works in mysterious ways.

5.3 Budapest Open Access Initiative (BOAI)

In December 2001 there was a two-day conference, producing a declaration called Budapest Open Access Initiative. The declaration was launched in February 2002, having 16 original relatively unknown individual signatories. This initiative has been financed by Soros' private Open Society Institute with 3 200 000 USD. It is recognised as one of the major defining events of the open access movement, [8]. Up till now it has been signed by about 0.1% of world scientists.

5.4 Gold Open Access and APC

Gold Open Access requires the author to pay Article Processing Charges (APC) to keep article freely available to the reader. Currently a typical APC exceed 3000 EUR. This brings enormous profits to publishers. It is estimated that the costs per article should not exceed 1000 EUR.

Clearly, APC model is not viable if costs are indeed covered by the author. The author must find someone who will cover the costs of APC. This is an ideal model prone for corruption at all levels. In the APC model, money becomes a substitute for quality. and researchers must compete for money that will cover their publication costs.

The difference between Green and Diamond Open Access and Gold Open Access is huge. One can speak of two opposing concepts sharing the same name: Open Access.

6 IMPLEMENTATION OF OPEN SCIENCE

6.1 Recommendations, Declarations, ...

There are numerous mostly political papers, initiatives, recommendations, declarations, pushing for Open Access, Open Science, Open Research, etc. Due to limited space we mention only a few of them. For more information, see e.g. [1, 5].

While the OA has been launched bottom up by 16 individuals meeting in Budapest, backed up by 3.2 Million USD from Open Society Institute, OS is a political concept that is revolutionising Science from top to bottom. It seems it was first formally expressed by UNESCO in November 2021 in the UNESCO Recommendation on Open Science.

The concept has been embraced by European Commission that pushes it through Horizon Europe down to member states. For instance, Slovenia recently received 16 000 000 EUR for promoting OS. It appears this money does not go for science but for administration.

The Barcelona Declaration on Open Research Information emerged from a workshop with over 25 experts interested in changing the research landscape. The declaration that was signed on 24 April 2024 is a political statement of an unidentified *community*. The authors do not act as individuals and do not represent scientific community. They write: *... we, as organizations that carry out, fund and evaluate research, commit to the following ...".* The first out of four commitments is strong. *We will make openness the default for the research information we use and produce.* It leaves no room for science outside Open Science. While OA was at first optional, OS makes it mandatory.

6.2 Goodhart's Law and Open Science.

Since journal impact factor remains a measure, the number of journals and publishers keeps increasing. In general, neither OS, nor universities nor funding organisations address the problem of low-quality high-impact factor predatory journals. Several scientists lower ethical standards and publish their papers in expensive journals with mild or no refereeing. The costs are reimbursed by their employer or funding organization.

Ever since the number of publications became a measure, scientists tend to publish papers with partial solutions to the problem. The number of co-authors per paper keeps increasing. The number of published papers grows out of proportion.

After citations became a measure, the number of references per paper keeps increasing. Some prominent journals fight citation inflation by limiting the number of references a paper may have. Clearly, the references published by competing authors are first to go.

Since APC remains as a valid model in OS, all kinds of unethical practices emerge. In many cases, a ghost author, who did not contribute to the paper but may secure covering APC costs is added to the list of authors.

It is disturbing that the goal quality is absent in some documents on OS, such as the Barcelona Declaration. The quality is replaced by openness and Goodhart prevails. Scientists will adapt to new goals.

7 CONCLUSION AND SUGGESTIONS

OS has some serious flaws. The main concern of OS is that scientists financed from public funds are not allowed to profit from their work – but everybody else can.

OS is only open to those within the system. Independent critical scientists adhering to high ethical standards are left out. OS is concerned only with current and future publications. No pressure to commercial publishers to open archives of papers published previously under paywall and make them free for everyone. A large part of science remains closed to authors and readers that are unable to secure money.

Scientists no longer decide what is the quality of their work. They even have to pay private companies to tell them that. For instance, public employers and public funders base their decisions about the quality of candidates on data bought from private companies running services, such as WoS or Scopus.

There is a problem of citation culture among different scientific fields. For eaxample, if average scientists from a scientific field, say A with high h-index compete for money in another field, say B they may be ranked higher than the best scientists of the field B. This may have negative effect on the future of the field B.

There is no real need for repositories at every public institutions. One repository at the European level with several backups would suffice. Instead of creating jobs for scientists repositories create jobs for administration. Repositories of papers and data are not intended for individual scientists. It appears they are intended for the AI data-harvesting algorithms of private companies. This service again will be sold back to scientists.

One could say, that the OS is a model that diverts public money from scientists to administration and private companies.

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The Consistency of the Research Field Data
A Case Study of Library and Information Science in Slovenia

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ABSTRACT

SICRIS (Slovenian Current Research Information System) provides a service listing top Slovenian researchers in a particular research field. In Web od Science (WOS) each journal is assigned one or more categories (research fields). When comparing these data for the research field of library and information science (LIS), we found that several of the top authors in the field according to SICRIS rarely or never published in the journals deemed to belong to LIS in Web of Science. Several other authors, who were not assigned the research field of LIS in SICRIS, were among the most published Slovenian authors in LIS in Web of Science. This is an indication that results of any analysis of LIS in Slovenia will depend greatly on the criterion/criteria used.

KEYWORDS

Bibliometric Analysis, Research Fields, Slovenia, Library and Information Science.

1 INTRODUCTION

As part of a project focusing on high-level bibliographic services, i.e. novel services based on existing bibliographic data, we intended to perform a domain analysis of library and information science (LIS) in Slovenia from a bibliometric perspective. This contribution describes the initial step that was simply intended to provide an overview of research and researchers but came up on several issues regarding assignment of research fields and yielded some interesting findings, particularly for establishing the scope of the research field in Slovenia and elsewhere, but also in view of providing better services to the users of academic bibliographic databases.

2 BACKGROUND

There is a lack of a bibliometric overview of information scientists and librarians in Slovenia and their works, collaborations etc. One of the reasons is the nature of the field(s) of library and information science, where sometimes it is difficult to draw the distinction where the boundaries of the field are. On the other hand, relatively high-quality information on Slovenian researchers is stored in SICRIS (https://cris.cobiss.net/ecris/), the Slovenian current research information system, which provides multiple tools for basic bibliometric analysis.

Other studies have focused on the research fields in Slovenia (e.g., [1], [6], [8]), however at a more general level, not specifically for LIS and without mention of the issues related to research fields discussed herein, whereas [2] discusses among other things the mapping of WOS categories to the fields of science, used in SICRIS. Also see [2] for a brief history and overview of various mappings of fields of science/research fields.

While we were primarily interested in using bibliometric data for representation of a particular research field, this can then also be commonly used for evaluation of research. There are two main approaches: expert evaluation and bibliometric analysis. While expert evaluation is more traditional and qualitative, bibliometric analysis is quantitive in its nature. However, both of them have their downsides. For discussion on trustworthiness of experts, see e.g. [4]. Amongst others, Leiden Manifesto [5] points to dangers of using bibliometric data without closely examining the context. It suggests various indicators should be used when evaluating researchers and their work and that bibliographic analysis should support expert evaluation.

3 RESEARCH

While there are several different ways to approach the extent of publication on library and information science in Slovenia, we looked at the publications in Web of Science (WOS). This was done with intention to identify the most prominent works and authors, as journals indexed in WOS go through a rigorous process. However, this also means that we omitted from analysis all other publications, including papers published in Slovenian language journals.

Although it may not have the same coverage of social sciences, for this kind of insight WOS compares favourably to similar services, such as SCOPUS and Google Scholar, as it allows searching based on WOS Categories field which represents the subject categories/research fields of the journals [7]. It has to be noted that the WOS Categories field provides general information about the thematic nature of the journal rather than each particular paper. However, this is still the easiest way to get a quick overview of a research field, as all of the subject related data pertaining to individual papers in WOS describes the thematic nature of the papers in higher granularity. Each journal in WOS can be assigned one or more subject categories.

In April 2024, we performed a search in WOS Core Collection for publications where Address field included »Slovenia« and the value in the WOS Categories field was »Information Science & Library Science«. We did not limit the search to any particular time period, which means that the more experienced authors were more likely to be on the list. Also, we did not limit the results to particular types of publications (e.g. articles), since the "linked records" categorization in SICRIS, which we used in comparison, also does not limit this. However, even if we did, the situation regarding top authors would still be similar. Since Address was limited to Slovenia, the list excludes Slovenian authors who published research while working in other countries and may also be missing authors with otherwise faulty Address data.

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Table 1: Top 10 Slovenian authors in SICRIS, their research fields, number of established links to WOS publications in SICRIS and number of publications with LIS as WOS Category

Author	Research field 1	Research field 2	WOS	LIS	fraction
A	Information science and librarianship	Interdisciplinary research	89	0	0.0000
B	Administrative and organisational sciences	Information science and librarianship	55	2	0.0364
C	Information science and librarianship		55	47	0.8545
D	Economics	Information science and librarianship	53	14	0.2641
E	Computer science and informatics	Information science and librarianship	39	0	0.0000
F	Information science and librarianship	Plant production	33	17	0.5152
G	Information science and librarianship		31	29	0,9355
H	Information science and librarianship		24	2	0.0833
I	Information science and librarianship	Economics	24	3	0.1250
J	Information science and librarianship		21	18	0.8571

In SICRIS each researcher can be assigned up to two research fields, according to the ARIS (Slovenian Research and Innovation Agency) categorization, which is "roughly harmonized with the Field of Science and Technology Classification in the Frascati Manual (OECD)" [1]. There are different levels of categorization with the first level representing science, the second level representing field and the third level representing subfield. For instance, Information science and librarianship is deemed as a field belonging to social sciences with no further subfields. On the other hand, Economics also is a field of Social sciences, but it has subfields, such as Business sciences. Authors may be assigned a certain research field, even if it has subfields, or a certain subfield.

Among several features, SICRIS provides a higher-level service (https://cris.cobiss.net/ecris/si/en/top/researcher) where a user can look up most prominent Slovenian authors in a specific research field based on different indicators (e.g. number of linked records and citations in WOS and SCOPUS, h-index, other indicators linked to local evaluation practices). While this is not necessarily the only tool a user of SICRIS can use to get an overview of researchers in a research field, it is certainly the quickest and easiest to use.

Compared to some other research fields, where it is harder to find the equivalents in both of the databases, LIS has the advantage of being relatively straightforward. While the names used for the research field in the two systems slightly differ (»Information science and librarianship« in SICRIS; »information science and library science« in WOS), at least the core of the two subject categories should be the same.

While the actual ranking of LIS authors in SICRIS does vary slightly according to the indicator chosen (i. e. number of works in WOS and SCOPUS, number of citations, etc.) there is a core group of authors that occupies top places for several categories. Table 1 shows the top 10 authors based on the number of linked records in WOS according to SICRIS. In the table each author is represented with a letter of the alphabet for anonymity.

When comparing the data of LIS authors in WOS, whose address is in Slovenia (Table 2) and, the list of most prominent authors in LIS in Slovenia based on number of publications in WOS as provided by SICRIS (Table 1), we found a relatively large discrepancy. As seen in Table 1, half of the top 10 authors in LIS, as provided by SICRIS, had less than half of their works published in LIS journals, as indexed by WOS. In fact, for all five of these authors the proportion is less than one third.

There are several reasons for this phenomenon. In the SICRIS top 10 list, two prominent authors, marked in Table 1 as B and H, published a majority of their works in different fields, confusingly not explicitly named in SICRIS, before clearly switching their research interest to LIS. For some others their area of expertise is on the boundaries of LIS, although, what constitutes LIS can be debated. For example, two of the top 10 authors (A and E), including the top Slovenian author in LIS according to SICRIS, do not have a single work published in what WOS considers to be LIS journals. In the case of author A, their second research field, Interdisciplinary research, provides a better understanding on the nature of their publications.

According to the well-known Bradford's law [3] there are going to be some works published in journals that may not appear to be particularly relevant to a particular topic or research field. For instance, [2] found such distribution for Slovenian agriculture research group publication. However, there is still the question of whether such a list of top authors represents the LIS research field well.

It has to be noted that the results were similar even if we used other criteria in SICRIS. For example, the top 10 authors by number of citations in WOS are the same, only the order changes slightly. Also, the list of the top 10 authors by number of connected records in SCOPUS has two authors that do not appear in Table 1, neither of whom again had more than 2 works published in LIS journals, according to WOS.

To further complicate the matters in terms of transparency of data, SICRIS user interface only lists the author's first research field, in the top authors lists, which can be confusing to a novice user, as it may appear that some of the top authors do not belong to said field. In fact, many of the first year students of LIS at the University of Ljubljana skipped such authors, when asked to provide a list of top authors in the LIS field, based on SICRIS data/user interface.

Another issue that came up was that one of the top ten researchers is a foreign citizen with an ARIS researcher number having mostly worked outside of Slovenia. While this certainly reflects the international nature of science, it may not accurately reflect the state of LIS research in Slovenia. However, this issue is not particular to LIS.

On the other hand, there was also a notable group of authors that was not assigned to the research field of LIS in SICRIS, whose works appeared relatively frequently in LIS journals in WOS. Several new authors appeared in the top 10 list, if we only looked at the data on publications in WOS. Two of those, marked here

Table 2: Top 10 Slovenian authors by the number of publications in the WOS Category Information Science & Library Science journals and their assigned research fields in SICRIS

Author	LIS	Research field 1	Research field 2
C	47	Information science and librarianship	
G	29	Information science and librarianship	
J	18	Information science and librarianship	
F	17	Information science and librarianship	Plant production
K	16	Economics	Computer science and informatics
L	15	Mathematics	Computer intensive methods and applications
M	14	Information science and librarianship	
D	14	Economics	Information science and librarianship
N	13	Computer science and informatics	
O	13	Information science and librarianship	

as M and O, are authors whose field is declared in SICRIS to be LIS. But there are also three authors who do not have LIS named among their up to two research fields in SICRIS. Author here marked as K mainly worked in bibliometrics, which was also the LIS topic covered by author L, while author N mostly wrote on the topic of business intelligence. Such instances are not isolated, as several other authors who do not have LIS as a stated research field in SICRIS just missed the top 10 list.

4 DISCUSSION

While this is a brief look into a relatively small slice of two databases, SICRIS would benefit from a recognition of the issue. The simplest solution would be to provide a clear explanation on the nature of the data provided, when viewing top author lists by research field. Alternatively, additional services could be provided, based on other subject related data, such as WOS Categories or even keywords [7]. Ideally, services based on Bradford distribution would be provided.

The appropriateness of both the scope and designation of SICRIS research fields of authors and the WOS Categories can be debated. Their assignation procedures would benefit from greater transparency.

There is the issue of assignment of up to two research fields per author in SICRIS, as this does not necessarily accurately represent the involvement of each individual researcher. In our relatively small case study of LIS we found several authors whose assigned research fields could be viewed as misrepresented.

While research today is generally multidisciplinary and some researchers can shift their area of interest in research from one research field to another during their career due to various reasons, this ought to be reflected in any lists of researchers from a particular research field.

Also, while well-established, WOS would benefit from a more transparent explanation of the nature of WOS Categories. Even then, there can at least be a discussion, whether some of the journals are assigned to the correct research fields.

Conversely, as there are authors that publish relatively frequently in LIS journals in WOS, but do not have the according research field associated with them in SICRIS, a list of such authors could help with a subject classification of authors that is more reflective of their production.

5 CONCLUSION

Our research indicates that any bibliometric analysis of the research field of LIS in Slovenia is bound to be influenced by the criterion/criteria chosen to represent the field, as even the very top authors by one criterion may not be considered to be working in the field by another.

Further research could establish whether the issues found in this pilot study exist in other research fields and for other data (e.g. different databases, different time periods). However, not all research fields in one database may have their exact equivalent in another database. Cognitive science, for example, is not considered to be its own research field neither in SICRIS nor in WOS.

Generally, we suggest providing a clear explanation of the topical nature of the work of each author, when providing list of top authors in a research field, Another possible solution is omission of authors, who have a relatively low percentage of works published in journals from a research field from lists of top authors in that field.

While bibliographic databases offering high-level services that bring to light otherwise "hidden" data are definitely welcome, users would benefit from indication of imprecise nature of data and/or additional services that would try to account for the imprecision.

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To be or not to be… a Nahuatl language learning App. The long-term survival or discontinuation of indigenous language learning apps on the example of Nahuatl

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Abstract

Language learning apps for indigenous languages differ from the mainstream language apps in that they are not targeted at commercial success and might need to accommodate different linguistic and cultural aspects than the most learnt languages. The present paper considers the present and past Nahuatl language apps, some of which were discontinued, and asks what would be necessary for such apps to achieve long-term survival.

Keywords

Language learning, human-computer interaction, software usability, software translation, trends in software development

1 Introduction

The strong digitalization of modern life is bringing about big changes to the global and local societies. One of the results of the technological changes is the rapidly ongoing globalization, and one of the mechanisms of globalization is the shift of communities from languages with small numbers of speakers to a smaller number of global languages. In many countries with colonial history, this follows centuries of, at best, ignorance of, and at worst, active discrimination and eradication of the indigenous populations, their languages and their cultures.

The dominance of global languages is clearly seen on the Internet, where 80% of websites are written in just 8 of the estimated 7000 world´s languages [1]. The ascension to the digital realm is a challenging task and in 2013 [2] estimated that, at best, 5% of the world's languages will ascend to the digital world, and the rest will suffer a “digital language death”.

One of the ways a language can be present on the internet is by being the object of mobile learning apps. Mobile apps supporting the acquisition of minority and indigenous languages may differ from apps targeting global languages in that minority language learning apps would typically not be aiming at commercial success, would have lower budgets, or even be done on volunteer basis by smaller group of language activists.

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In addition, by pure chance, many of the most learnt languages have less complex morphology than many minority languages, and the apps that were developed with more analytic languages in sight, such as English, are not easily fully extendable to Morphologically Rich Languages, such as isiZulu [3], Turkish [4] and Nahuatl.

In the following, the focus lies on Nahuatl, the Mexican indigenous language with the highest number of speakers, 1.5 million. Nahuatl is one of 68 indigenous Mexican languages, and despite its historical prestige remains endangered, a challenge it shares with virtually all indigenous American languages. Nahuatl language learning apps contribute not only to thwart its digital death, but also to increase its visibility and prestige, and to support the efforts of Nahuatl learners to become “new speakers” [5] of the language. The role of new speakers is described as “very important, often essential for language revitalization projects” by [6] who work directly with Nahua and other minority groups in Mexico.

2 Initiatives to Localize Software and Platforms in Minority Languages

The second decade of the 21st century was a witness of increased efforts to increase the visibility and presence of minority and indigenous languages in the digital sphere. These were often led by digital language activists and sometimes supported by the companies whose software was the focus of the projects. The present section describes some of the initiatives taken and discusses the long-term results of the work to promote indigenous languages. Particularly, it looks at whether the work of the activists resulted in a long-term inclusion of the relevant language in the software or platform that was the aim of their efforts.

The Mozilla Foundation, known for its web browser, Firefox, launched in 2012 the initiative “Native Mozilla” that aimed to localize the browser into many of America’s indigenous languages. 50 languages from 10 countries were targeted [7], many of which are spoken in Mexico, such as Ch’ol, Kaqchikel, K’iche’, Mixteco (2 varieties: of Mixtepec and of Yucuhiti), Nahuatl (2 varieties or, by other accounts, 2 closely related languages: Highland Puebla Nahuatl of Mexico and Nawat Pipil of El Salvador), P’urhépecha and Triqui [7, 8]. The translations are done via the collaborative translation platform Pontoon (https://pontoon.mozilla.org/). As part of the initiative, for example, a Hackathlon was organized in Oaxaca in 2018 with representatives of 15 languages [8].

However, the goal of providing translations into 50 American languages is far from achieved and, as of 30.09.2024, Firefox 115 was available only in three American Indigenous languages: Kaqchikel and Triqui spoken in Mexico and in the South American language Guarani [9]. The other languages are in various state of completion: Ixil (13%), Kichwa (0%), Miahuatlán Zapotec (14%), Mixtec of Mixtepec (9%) and of Yucuhiti (29%), Nahuat pipil (0%), Paipai (1%), P'urhepecha (9%) and Quechua (3%). The situation is slightly better for the mobile phone browser Firefox Focus, which is available in Aimara, Ixil, Kaqchikel, K'iche', Maya, Miahuatlán Zapotec, Mixtec of Mixtepec and of Yucuhiti, Nahuat pipil, Navajo, Paipai, P'urhepecha, Quechua, Tének and Triqui [7, 10].

There were also attempts to localize the social media platform Facebook (https://www.facebook.com) into minority and indigenous languages. In 2012, the official Facebook translation platform (https://www.facebook.com/translations/), where users could add and vote on the accuracy of volunteer translations, had partial translations in about 100 languages, including Cherokee [11]. However, frustrated with the slow progress, Manuel Neskie made a browser overlay that allowed the translation of Facebook menu into Secwepemctsín directly in the user´s browser [11], which was later extended to many other languages, including Nawat [12] spoken in El Salvador. In 2015, a group of activists translated 24 000 words into Aymara and submitted it to Facebook for revision [13]. However, as of 31.08.2024, same as on 07.04.2019 [14], only three indigenous American languages were available for menus on Facebook: Cherokee, Inuktitut and Inupiaq, and the Facebook Translation App appears to have been discontinued.

A similar fate was met by the attempts to increase the number of languages offered on the Duolingo language learning platform (https://es.duolingo.com/). As of 10.06.2024, two indigenous languages are available on Duolingo: Hawaiian and Navajo [15]. However, previously also Guarani must have been available on the app, as evidenced by the surprise some users expressed at its sudden lack [16, 17]. The course is still available on the website version as of 31.08.2024 [18]. Between 2013 [19] and 2021 [20] new courses in development were stored in the Duolingo Incubator, where the users themselves could contribute to adding new languages to Duolingo. Indigenous languages such as Yucatec Maya and K'iche' were present on the Incubator and Duolingo itself credits the volunteers for helping to make, among others, the Navajo and Hawaiian language course [21]. However, Incubator was discontinued in 2021.

As we have seen, a common trend in the translation efforts of Facebook and Duolingo is the move from community and volunteer-based translations to commercial translation directed by the company. On the one hand, the reliance on unpaid work is problematic for a company with huge profits – something that Duolingo itself lists as the reason for ending the volunteer program [21]. This is especially true when those delivering this work might already be in unprivileged financial situation, as many indigenous language speakers are. On the other hand, however, this deprives the communities of the possibility to contribute to making their language more visible on the popular platforms. It is interesting to note that the translation platform of open-source based Mozilla products remains active, and, for example, the last changes to an Indigenous Language – Zapotec – have been done on 26th August 2024.

3 Digitally available Nahuatl language media

The importance of maintaining Nahuatl language learning apps is clearer if we consider that there are relatively few other resources in the language available online for language learners, many of whom are descendant from Nahuatl speakers and wish to reclaim the language of their ancestors.

[14] collected information about the different monolingual Nahuatl language media available for those searching on the internet. The results encompassed 12 monolingual novel-sized books, 5 scientific articles, 10 movies or series episodes, 1 videogame, 6 radio stations where Nahuatl is transmitted along with other languages, Wikipedia in 10 separate varieties, and 5 websites with a Nahuatl version. Considering that Nahuatl is the Mexican indigenous language with the biggest number of speakers, this is a low number.

However, there is hope that their number is increasing. For example, the 5 scientific articles were published in 1959, 2019, 2022, 2022, 2023; the 12 books in 2008, 2013, 2014, 2015, 2015, 2016, 2017, 2017, 2017, 2019 and 2021, (the twelfth is the Bible which has been translated into many varieties) [14]. One of the websites is also recent, as it was published in 2023 [22]. In 2024 the Mexican presidential election was simultaneously interpreted into Nahuatl, and remains, as of 30.08.2024, available on YouTube [23]. In addition, a Master´s degree in Nahuatl language and culture, taught completely in an indigenous language was launched in 2019 [24], first of its kind. We see therefore a clear tendency of growth, and it could be expected that more media will become available in Nahuatl soon.

It is also interesting to consider the case of the work to bring Nahuatl as a language available in Google Translate (https://translate.google.com/). In 2010, Google announced their plans to add Nahuatl and Maya to the tool [25], but this service was finally only introduced in June 2024 [26]. As of September 2024, the following ten indigenous American languages are among the 243 languages available on Google translate: Aymara, Guarani, Hawaiian, Kalaallisut, Mam, Nahuatl, Quechua, Q'eqchi', Yucatec Maya and Zapotec.

Considering mobile apps in particular, [14] identified 39 mobile phone apps related to Nahuatl. Most of them, 23, are Bible apps, although due to double versions, there are only 14 different variant versions of Bible available as a mobile app. The other 16 apps include 6 dictionaries (one with a Nahuatl user interface), 3 text collections, a (faulty) automatic translator, a multi-component app CEM, which combines dictionaries and morphological analyzer, the messaging app Telegram that offers user interface in Huasteca Nahuatl (albeit cannot be chosen in its standard menu, but is available for download for those who have the relevant link), and, finally, 4 Nahuatl language courses, discussed below.

4 A Partial History of Nahuatl Language Apps

As of 01.07.2023, four Nahuatl language courses were available for Android [14]: Aprende náhuatl [27], Beginner Nahuatl [28], Kamatlama [29] and NahuatlApp [30]. Aprende náhuatl (Spanish for "learn Nahuatl") is a vocabulary training app, with texts and videos, produced by the National Institute of Indigenous Peoples, a government agency and it was, as of 01.07.2023, downloaded more than 10 000 times [14]. As of 26.09.2024, it is available on

Android 14 for some, but not all devices. Beginner Nahuatl, with more than 1000 downloads as of the same date [14], was a vocabulary training app, without any game elements. Kamatlama is an app introducing basic numbers and fruit names and testing them through games and it was downloaded only more than 50 times as of 01.07.2023 [14]. NahuatlApp was an app introducing vocabulary items and testing them through a game and had, as of the same date, more than 10 000 downloads [14].

It is notable that the maintenance of the apps is far from ideal. Between the data collection of [14], 01.07.2023 and of [31], 30.05.2024, the videos of Aprende Nahuatl became unavailable and the two apps, Beginner Nahuatl and NahuatlApp, became unavailable for download on Google Play. During the same time, the user statistics did not change for the two continued apps, and crucially, Kamatlama hasn´t reached 100 downloads.

Two more apps mentioned by [14], although primarily dictionaries, also have elements supporting learning, such as quizzes: Totlahtol Nahuatl [32] and Diccionario Náhuatl [33]. As of 26.05.2024 Totlahtol Nahuatl, which offered Nahuatl user interface – as the only app other than Telegram - was no longer available for downloads, while Diccionario Nahuatl is still (01.09.2024) available. Additionally, Miyotl, a multilanguage app whose lesson components seem to never have been completed, remains available for download and contains a list of Nahuatl words and their Spanish translations [34].

In addition, as of 01.09.2024, 6 other apps mentioned by [14] are discontinued: the text collection Tlapohualiztli [35], the dictionary Diccionario Maya y Nahuatl [36] and the automatic translator Traductor Nahuatl [37]. This means that out of 16 non-Bible related apps mentioned by [14], 6 (Beginner Nahuatl, NauatlApp, Diccionario Maya y Nahuatl, Tlapohualiztli, Totlahtol Nahuatl, Traductor Nahuatl) have been discontinued only a year later (37.5%). In addition, [31] mentions three other apps that had been discontinued before: Tozcatl [38], Nahuatl Grammar [39] and Ma Tiwelikan Nawatl [40] – the latter is available as a website, but the App version is not available anymore. Furthermore, the app presented at the EUROCALL conference in 2016 [41] is also not discoverable on Google search, as of 18.06.2024.

However, the changes are not all negative. On 14th March 2024, user ItztliEhecatl posted on the social platform Reddit [42] that they have created a new Huasteca Nahuatl language learning course [43]. The author has been adding new items to the course, and as of 01.09.2024, there were 568 words and phrases to be learnt. The Huasteca Nahuatl course uses the Memrise Community Courses infrastructure, where users can create their own courses. However, in line with the trend discussed in section 2, Memrise is also closing community forums and removing community courses from their app and the future of the community courses remains uncertain beyond the end of 2024.

There is, however, another high-quality Nahuatl learning app for beginners that explains the grammatical concepts and tests them in a variety of exercises over 11 Units: the Nahuatl course hosted by the 7000 languages organization [44] and prepared in 2017 by Tlahtoltlapazolli, a Los Angeles based group [45]. The course requires registration, and only has a website version – although the mobile website version works well. However, the fact, that it is not listed in App stores decreases its findability.

Altogether, we see here that a great proportion of Nahuatl learning apps is discontinued. By the time they this happens, their content usually does not advance beyond the basic level, although one often has the impression that the authors had intended to add more lessons in the future. One could wonder whether a more stable app with more levels would have been possible if the authors had joined their efforts.

5 Long-term survival of Language apps: Discussion

The trajectory of some Nahuatl learning apps has helped us identify a trend of frequent discontinuation of those apps, lack of maintenance or upgrading to newer versions of operating systems or devices and a tendency by the commercial providers to dissolve community-led efforts of translation and localization and to limit the number of languages that the service is translated and localized into.

Admittedly, the frequent appearance and disappearance of new apps might be a sign of a vibrant, creative community. In fact, [7] sees it as a part of the process of app creation to accept that the results of one`s work on software localization might have a short life or never be used at all. If one accepts the possibility of failure (that is, the materials prepared ending up not being used) or only short-term success (that is, a short-lived app), the process of creating apps might be more spontaneous and less restricted, and the threshold to make such an app might be lower. In other words, if one does not strive to make “the perfect” app, creating an ad-hoc training exercises for one skill might become easier. However, even in this scenario, many contributors and authors might end up doing the same work unnecessarily, such as preparing grammatical description of the same grammatical forms destined for different apps.

In addition, one might also wonder if the low number of downloads discourages the authors to add additional levels and update their apps. However, given that Aprende Náhuatl, an App published by a government agency had more than 10 000 downloads, and up to 28 000 downloads [46], there is sufficient interest of learners in Nahuatl language apps, and perhaps a focus on better findability of the apps could result in their bigger success.

The question can therefore be posed how to better direct the efforts of authors and contributors, typically activists and volunteers, to not repeatedly make basic-level apps that might then be discontinued and to instead direct those efforts at more long-term apps which would also include levels for more advanced learners.

An open source platform that allows and tracks user edits, similar to Wikipedia (https://www.wikipedia.org/) or Wikitravel (https://wikitravel.org/) could allow users to collaborate in making language courses, and each individual author could make a small contribution, without the feeling that it was “in vain”. This would also prevent the fruits of work of language activists from “disappearing” in the chaos of the internet, and would increase their findability. Care must be taken to make such a platform independent of commercial companies that could unilaterally delete the courses from their servers. It is also recommended that information about such a platform be widely shared to avoid the situation where a good course ends up not being used due to being unknown to the learners.

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Designing the Flow State Experience Using Modern Digital Technologies

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Abstract

This article provides a brief overview of an extended Master's thesis and focuses on the use of modern digital technologies to design a multimedia environment aimed at inducing a state of flow in individuals. Flow is a psychological state characterized by deep immersion in an activity, leading to a loss of sense of time and external worries **[1]**. Exiting this state typically results in feelings of satisfaction and happiness. Achieving flow requires a balance between skills and challenges. Learning to attain this balance can help individuals improve overall, which is a key reason for this research. The main objective is to investigate whether flow can be achieved through the use of color light stimuli in a space that adapts in real-time to an individual's level of attention. This represents a preliminary step toward using technology to design spaces that stimulate individuals and facilitate the quicker and easier attainment of flow. An experiment was conducted to test whether such a space affects individuals' flow. Tetris was chosen as the central activity for the experiment. The findings indicated that color stimuli influenced the participants' physically measured attention, although no significant changes were observed in questionnaire responses or gameplay performance. Given that attention is a crucial factor in achieving flow, it can be partially asserted that participants experienced flow, though more reliable data would be necessary for further conclusions. These findings significantly contribute to the understanding of measuring and achieving flow through technology, representing an important advancement in this field.

Keywords

flow, optimal experience, user experience, digital interface, Tetris

1 Introduction

Historically, flow has been experienced by artists, athletes, and individuals with substantial practice. However, modern life, especially in technology-driven environments, necessitates new approaches to achieve this optimal state. This study investigates how real-time adjustments of ambient lighting, informed by physiological signals, can enhance flow experiences, offering a novel approach that builds on but goes beyond methods such as video games or Virtual Reality (VR). By integrating psychophysiology, user experience, and ambient intelligence, this research aims to leverage technology for meaningful improvements in well-being, productivity, and satisfaction.

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2 Theoretical Background

Inducing a flow state through technology poses complex challenges that require in-depth exploration of the neurocognitive aspects of flow and their relation to contemporary technologies. This understanding informs the design of technological solutions aligned with flow theory.

2.1 A Neurocognitive Perspective on Flow

Flow, characterized by deep focus and immersion, was first described by Mihaly Csikszentmihalyi, often referred to as the "father of flow" [1]. This state occurs when individuals find an appropriate balance between their skills and the challenges they face, allowing them to perform optimally with a sense of effortless control [1]. While initial resistance and sustained motivation are necessary to achieve flow, this state can occur even in unfamiliar tasks, although long-term practice may increase its likelihood [2]. Flow is often illustrated in a two-dimensional graph where it exists at the intersection of appropriate challenge and skill levels [1].

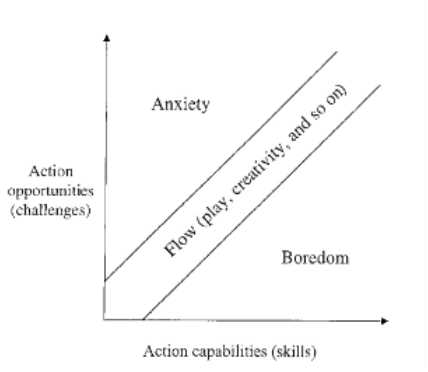

Figure 1: Graph representing occurrence of flow state [1]

Neuroscientific perspectives on flow suggest various underlying mechanisms. The transient hypofrontality hypothesis posits that during flow, activity in the prefrontal cortex decreases, reducing

self-criticism and enhancing performance [3]. Alternatively, synchronization theory proposes that flow arises from synchronized activation across different brain regions, optimizing cognitive efficiency [4]. Both theories indicate that flow entails minimal energy expenditure in the brain.

Csikszentmihalyi's model outlines optimal conditions for flow, including clear goals, immediate feedback, and a balance between challenge and skill [1]. The concept of the autotelic personality—marked by intrinsic motivation and enjoyment—may enhance flow experiences but is not strictly essential for achieving it.

2.2 Flow in Technology: State of the Art

Various approaches have emerged to induce flow through technology. Traditionally, video games employed fixed difficulty levels, which often interrupted the flow experience [5]. Dynamic Difficulty Adjustment (DDA) algorithms now allow real-time modification of challenges based on player performance, as seen in games like Left 4 Dead [6], [7, p. 4], Affective computing enhances this by using emotional indicators, such as facial expressions, to fine-tune difficulty levels [6]. Jenova Chen's game flOw exemplifies the integration of DDA with real-time adjustments to maintain flow [8]. Virtual Reality further immerses players, as evidenced by studies comparing VR to traditional 2D games and applications focused on meditation and relaxation [9], [10], [11]. Augmented Reality and multimedia art also contribute innovative avenues for inducing flow [12], [13].

Figure 2: Refik Anadol 2D projection Machine Hallucinations [12]

Our research identifies the use of ambient lighting as a promising yet under-explored method for inducing flow while engaging participants in a core activity, specifically Tetris. This game, created by Alex Pajitnov in 1985, has been extensively studied for its capacity to induce flow [14]. Players arrange falling blocks to form complete lines, receiving immediate visual feedback—key elements for maintaining flow. Research indicates that even brief sessions of Tetris can lead to flow experiences and reduced negative emotions [15].

2.3 Techniques for Flow State Measurement

Various methods exist to measure brain activity, with electroencephalography (EEG) being the most direct and commonly used. Functional Near-Infrared Spectroscopy (fNIRS) and Functional Magnetic Resonance Imaging (fMRI) provide insights into brain function, while Magnetoencephalography (MEG) offers high resolution of neuronal activity. However, these methods often involve expensive and less accessible equipment.

The MindWave Mobile 2, a consumer-grade EEG device, stands out for its ease of use, making it suitable for educational and entertainment contexts [16]. This device is ideal for our research due to its user-friendly nature, minimizing inconvenience for participants.

Figure 3: Mindwave Mobile 2 [16]

Flow state was traditionally measured through self-reporting instruments, such as the Experience Sampling Method (ESM) developed by Csikszentmihalyi [1]. Various questionnaires, including the Flow State Scale and Game Experience Questionnaire, have been developed to assess flow but rely on retrospective reporting. Alternatively, physiological measures may offer a more objective assessment of flow experiences.

3 Experiment: The Impact of Light on Flow State During Tetris Gameplay

This experiment investigated whether spaces incorporating adaptive technology could enhance user engagement. We compared standard Tetris gameplay to a version featuring color-changing lights that adjusted based on player attention, measured via the MindWave Mobile 2. The goal was to assess whether these technological enhancements positively impacted engagement and performance, specifically exploring if adaptive lighting improved attention, stabilized focus, and led to better gameplay results.

Drawing from Csikszentmihalyi's model, we recognized the importance of differentiating the environment in which flow activities occur. We aimed to create a highly engaging environment by designing a prototype of adaptive lighting for a dimly lit space.

For the experiment, we developed a color-changing light prototype controlled by the MindWave Mobile 2. The device measured brainwave activity during Tetris gameplay. We

utilized an Arduino Uno microcontroller to interface with the MindWave Mobile 2 and control a 2-meter AdaFruit NeoPixel LED strip. The light's color adjusted based on attention levels, with red indicating low attention, blue indicating high attention, and white representing optimal focus. This setup aimed to evaluate whether adaptive lighting could influence players' attention and flow during the game.

Figure 4: The setup of light prototype behind laptop

The experiment was designed to compare Tetris performance with and without adaptive lighting. Participants played Tetris under both conditions, and their attention levels, measured via the MindWave Mobile 2, were used to adjust the light's color dynamically. Data on engagement, attention, and gameplay performance were collected and analyzed to determine the effectiveness of the adaptive lighting in enhancing flow.

Figure 5: Scenario of playing Tetris with lights

3.1 Results

Data were collected from the MindWave Mobile 2, which recorded attention and meditation levels during Tetris gameplay with and without adaptive lighting. We filtered data to focus on attention values from 5 minutes of gameplay, excluding values below a threshold of 10 and retaining the 300 most representative data points. A Shapiro-Wilk test confirmed normal distribution for both conditions. A paired t-test revealed significantly higher attention levels during gameplay with lights (p-value = 0.00032). Notably, attention levels were more stabilized with adaptive lighting, as evidenced by a smaller variance in attention scores compared to gameplay without lights.

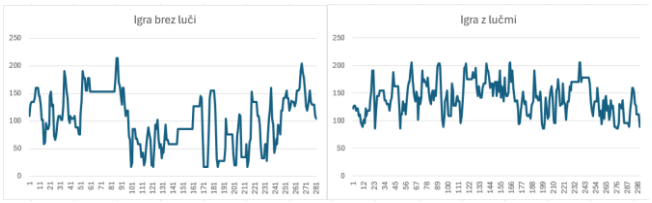

Figure 6: Attention levels of a player during gameplay without lights (left) and with lights (right)

For engagement, while the Shapiro-Wilk test confirmed normality, a paired t-test indicated no significant effect of lighting on engagement (p-value = 0.668). Tetris performance was assessed based on scores, with the group using lights achieving a higher average score (9377) compared to the no-light group (8979), though a Wilcoxon signed-rank test revealed no significant difference (p-value = 0.33).

Qualitative analysis of interviews with 40 participants identified seven key themes related to their experiences with the lighting: awareness of external stimuli, control and feedback, concentration, immersion, motivation, satisfaction, and pressure. Many participants reported feelings of pressure and stress, underscoring the challenges of achieving flow. Nonetheless, the lights were generally perceived as motivating, and some participants noted decreased awareness of their surroundings, aligning with theories regarding transient hypofrontality and reduced default mode network activity during flow [1].

Interestingly, some participants reported not noticing the lights at all, suggesting a potential subconscious influence of flow on their experience. This observation could have affected the questionnaire results. In terms of color perception, red was described as stressful and distracting, while white and blue were regarded as pleasant, showing no significant difference between them.

4 Conclusion

This study explored the potential influence of external factors, specifically technology-based lighting, on the state of flow. While we observed increased attention levels during gameplay with lights, supporting the theoretical premise that flow involves synchronized neural networks related to attention and reward, our hypothesis remains unconfirmed. Qualitative interviews highlighted themes consistent with flow characteristics, such as immersion and motivation; however, the absence of statistically significant effects on engagement and gameplay performance indicates that further research is warranted. Future studies should involve larger, more diverse samples and consider additional metrics to assess flow states more comprehensively.

Overall, our findings offer valuable insights into integrating technology with flow theory, highlighting the potential for developing products that enhance focus and user experience. This research lays the groundwork for future innovations aimed at creating more effective tools for achieving optimal states of concentration and fulfillment in everyday life.

Acknowledgments

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The Transparency of Nudging: Evaluating Its Impact on Personal Autonomy

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Abstract

Nudges are a strategic approach that shapes decision-making environments and the presentation of options to steer individuals toward certain behaviors while maintaining their freedom of choice. The ethical concerns surrounding nudges center on their potential to undermine personal autonomy, particularly when individuals are unaware of the influence exerted on them (i.e., covert or non-transparent nudges). The proposed solution for preserving autonomy is to increase transparency, which includes disclosing the presence and purpose of nudges to the people that are being nudged. There are various types of nudges and different types and levels of transparency associated with them. The most problematic in terms of violating personal autonomy are the non-transparent ones, those that exploit automatic cognitive mechanisms (Type 1 nudges), those that use type transparency and those that disclose their nature only after the fact (ex post). New approaches such as nudge plus approach seek to protect personal autonomy by involving citizens in the creation of nudges and enhancing reflectiveness during the nudging process.

Keywords

Nudge, transparency, autonomy, ethics of nudging, nudge plus approach

1 Introduction

Over the past thirty years, psychology and behavioral economics have highlighted how various contextual factors systematically influence our decision-making and behavior. In public policy-making, these insights are crucial for effectively addressing societal challenges like global warming, obesity, and poor economic decision-making. The groundbreaking paper [1] and the book that followed that brought the importance of decision architecture to the attention of academics, policymakers, and the general public was Thaler and Sunstein's "Nudge: Improving Decisions About Health, Wealth, and Happiness" [2]. In their work, they propose various ways in which government and private organizations could encourage or "nudge" individuals toward actions beneficial to them, while promoting a method that preserves a strong commitment to freedom of choice. Behavioral insights show that the context of decision-making can lead us to act inconsistently with our otherwise well-informed intentions [2]. The traditional approach to public policy assumes people are perfectly rational economic subjects ("econs") who act optimally with accurate information and clear rules. While this is an admirable goal, Thaler and Sunstein warn that basing public policy on this ideal often leads to failure. The authors introduce the concept of a "nudge" and propose its use as a policy-making approach that can influence citizens' behavior while avoiding the pitfalls and issues of traditional regulatory approaches, such as prohibitions and punishments. The advantage of this approach is that policymakers can influence our choices and behavior in a cost-effective and efficient manner without restricting us with prohibitions or interfering with our choices [3]. Despite the high effectiveness and utility of nudges, ethical concerns arise regarding the preservation of autonomy, especially with nudges that operate covertly and influence us without our awareness. This article investigates various types of nudges and levels of transparency, with a focus on their implications for personal autonomy. It begins by elucidating key concepts—nudges, autonomy, and transparency—before analyzing how different types of nudges, alongside varying types and levels of transparency, affect the preservation or violation of personal autonomy. Additionally, the article proposes criteria for determining which types of nudges are compatible with the preservation of personal autonomy. Finally, it explores potential strategies to mitigate adverse impacts on autonomy, including enhancing transparency, fostering citizen participation, and integrating reflective practices into the design of nudges.

2 Definition of a nudge

Thaler and Sunstein define a nudge as any element of choice architecture that influences behavior in a predictable way without restricting options or significantly altering economic incentives [2]. A nudge subtly guides individuals toward better decisions while preserving freedom of choice by adjusting how choices are presented [4]. Unlike prohibitions or penalties, nudges steer behavior without limiting options. An example is placing healthy snacks at eye level in stores to encourage healthier choices [5]. Hausman and Welch [6] add that nudges influence choices without increasing costs or limiting options, highlighting the potential for manipulation, which raises ethical concerns discussed in later chapters.

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3 How nudges work: leveraging heuristics and biases

To grasp how nudges impact behavior and decision-making, we must rely on insights from behavioral science, which reveal that nudges exploit inherent imperfections in human decision processes—leveraging cognitive heuristics and biases [4]. A key element of the nudge approach is that heuristics and biases, which often serve as mental shortcuts, are utilized to the advantage of the choice architect. While these mental shortcuts can sometimes lead to suboptimal decisions, a nudge aims to harness them to promote better decisions [3].

4 Nudge and ethical issues

Although the theory of nudging presents a promising approach to public policy, it has faced significant criticism from both public and academic spheres. Over the past decade, a robust ethical debate has developed, featuring nuanced arguments both supporting and opposing the practice [3, 4, 6, 7, 8]. The primary critique centers on the idea that nudging involves manipulating choices, with concerns about potential misuse of power [3]. Critics argue that nudges can undermine free choice by subtly restricting rather than fostering individual decision-making. The core of nudging involves exploiting heuristics and biases, which often lead people to act in ways that deviate from their well-considered preferences. Bovens [8] contends that such mechanisms can compromise control over actions, raising worries that nudges might affect decision-making by diminishing rational or deliberate considerations. Additionally, he argues, the behavior change induced by nudges occurs, if not against citizens' will, then at least without their active consent and awareness; for broader discussion about this topic see also [9, Ch. “Avtonomija v svetu spodbud” (Autonomy in the World of Nudging), pp.. 81-100; 10].

4.1 Ethical dilemma of autonomy in nudge use

Although nudges have been shown to effectively influence behavior, critics argue they can be manipulative and threaten personal autonomy. Autonomy, a complex concept, is broken down by Schmidt and Engelen into four dimensions: the freedom to choose without external pressure, acting according to one’s desires and values (psychological autonomy), making rational decisions based on available information, and being free from domination or manipulation [5, 8]. Critics claim that nudges can undermine autonomy by subtly influencing behavior without explicit consent, raising concerns about democracy, especially if governments use nudges without informing citizens. Nudges that operate without notice are especially problematic, as they can influence decisions without individuals' awareness. As Ivanković and Engelen [11] argue, non-transparent nudges, which exploit less rational psychological mechanisms, undermine autonomy by denying people control and the ability to challenge, a right that should be protected in liberal democracies. Sunstein, however, argues that nudges maintain freedom by allowing people to opt out of the suggested behavior, a concept they call "libertarian paternalism" [12]. They believe nudges, unlike traditional regulations, don’t limit freedom but instead encourage choices that align with individuals' best interests.

4.2 Transparency as a solution to autonomy violation

A proposed solution is increasing nudge transparency, as it allows individuals to understand how nudges work and make autonomous decisions based on their values [8]. A transparent nudge is one where its purpose and the methods used to influence behavior are reasonably clear to the affected individual. Thaler and Sunstein moreover argue that nudges used by governments should be public and transparent, with officials ready to disclose their methods and motives. Sunstein further emphasizes that nudges must be visible, reviewed, and monitored to prevent violations of autonomy or dignity [10]. Transparency involves informing decision-makers about the presence and purpose of nudges, allowing individuals to remain aware of behavioral interventions, thus preserving their autonomy and freedom of choice [7]. [1]

5 Types of transparency in nudging

To better understand the impact of nudging on an individual's autonomy, it is crucial to first examine the different types of nudges, as they are not a uniform phenomenon; rather, they can be classified into various types [2]. Understanding these types is based on dual-process theory, which describes the two decision-making mechanisms that nudges can influence.

5.1 Dual process theory

Dual process theory, explored by Stanovich [13] and Kahneman [14], is key in Thaler and Sunstein’s work on nudges. It suggests the brain operates in two modes: fast, intuitive System 1 and slow, deliberate System 2. System 1 handles instinctive actions, while System 2 engages in reflective decision-making. Despite its acceptance, dual processing is contested, with some scholars arguing the differences are a matter of degree. De Neys [15], notes no conclusive evidence favors either model, and resolving this debate may not significantly enhance our understanding of human thinking mechanisms. In this article, we adopt the dual process theory model to categorize different types of nudges. This approach allows us to better understand and design interventions that leverage both intuitive and reflective processes.

5.2 Type 1 and Type 2 nudges

According to Hansen and Jespersen [3], nudges can be categorized into two types based on dual process theory. Type 1 nudges target automatic, non-reflective thinking (System 1) and operate unconsciously, such as subliminal advertising or visual stimuli that influence behavior without conscious awareness. These nudges can be ethically problematic, as they often lack transparency and may lead to decisions misaligned with personal values. In contrast, Type 2 nudges engage reflective, deliberate thinking (System 2), promoting informed and thoughtful decision-making. These nudges are transparent and pose fewer ethical concerns regarding personal autonomy.

[1] Empirical evidence is inconsistent regarding the impact of transparency on the effectiveness of nudges. Transparency may: reduce their effectiveness (by prompting reflection), make nudges counterproductive (if people resist disliked nudges), enhance their effectiveness (if people understand and support the underlying goals), or have no significant impact at all [10].

5.3 Different types of transparency of nudges

The transparency of nudges plays a crucial role in safeguarding autonomy and freedom of choice, yet this concept itself is multifaceted. On one side of the spectrum, some nudges are explicitly transparent, functioning effectively because the individual is fully aware of the influence being exerted. Conversely, some nudges operate more subtly, relying on a lack of transparency to achieve their intended effect. To thoroughly assess which forms of transparency in nudges may raise ethical concerns, it is important to analyze the various ways in which transparency can manifest within nudges.

5.4 Type and token transparency

Bovens [8] introduces a crucial distinction between type and token transparency in nudges. Type transparency refers to when governments inform citizens about the general techniques they employ to intervene in decision-making contexts for the purpose of enhancing well-being. In this scenario, the government is open about the categories of measures it plans to implement. For example, when a government announces its intention to use specific psychological mechanisms to address social challenges, it demonstrates type transparency by clearly stating the kinds of interventions it will use to influence individuals' behavior and decision-making [16]. However, Bovens stresses that this is not enough. In his view, subliminal advertising does not become more acceptable simply because it is openly acknowledged [8]. On the other hand, token transparency requires that each individual instance of a nudge is clearly recognizable, including how it was implemented. This method, referred to as "here and now approach," aims to ensure that nudges are transparent to those encountering them at the moment of their decision-making [12]. However, even if this were feasible, it seems absurd to demand that every nudge be accompanied by a notice of its use. Since choice architecture is often unavoidable, token transparency may be too demanding, according to Bovens [8].

5.5 Levels of transparency

Transparent nudges differ also based on when they are noticed by the nudged individuals. With nudges that are transparent in advance (*ex ante*), the user can see the nudge beforehand and can avoid it if they choose. An example is traffic light labels (green, yellow, red) for healthy, less healthy, and unhealthy food products [17]. In contrast, a nudge is transparent afterward (*ex post*) if the target person only notices its influence after it has already affected them. Examples include fake cracks painted on the road to slow down drivers or the use of default options in certain contracts. Only after experiencing the effects do people realize they were influenced by a nudge [12]. Unlike the first category, the potential impact of such nudges on people's autonomy is more significant here. Ex post transparency may be insufficient to ensure autonomous action if it depends on individuals' ability to avoid the nudge. If transparency is meant to ensure that nudges do not deter people from achieving their goals and values, then, according to Ivanković & Engelen, ex post transparent nudges should either be excluded or efforts should be made to turn ex post transparency into ex ante transparency [11]. Occasionally, ex post transparent nudges become ex ante transparent through repeated exposure. For example, a fake speed bump may not have the same effect twice if the person learns when and where to expect it. With repeated exposure to such nudges, individuals may become more aware of their influence and may eventually avoid them altogether [12].

6 Types of nudges and transparency: impact on personal autonomy

The debate over nudges centers on how different types of nudges as well as types and levels of transparency impact personal autonomy. As stated in the article, nudges are divided into two types: Type 1, which influence automatic, non-reflective behavior, and Type 2, which target reflective decision-making. Transparent Type 2 nudges, which engage reflective capacities, do not typically raise ethical concerns, as they allow for conscious and deliberate decision-making. In contrast, non-transparent Type 1 nudges, which act on automatic processes, can threaten autonomy by influencing behavior without the individual's awareness. This may lead to decisions misaligned with personal values or goals. Transparency is categorized into type transparency (general awareness of the nudge type) and token transparency (awareness of mechanisms of specific nudges). The former is particularly problematic, as it lacks disclosure of specific examples and mechanisms, leaving us potentially unaware of the influences on our behavior. Nudges can also be categorized by the level of transparency into two main groups. The first group includes nudges that are transparent in advance by design (ex ante). These nudges are openly presented, allowing users to consciously decide whether to respond to them. Such nudges generally do not threaten autonomy, as they encourage conscious and deliberate decision-making. The second group includes nudges that are only transparent afterward (ex post). These nudges can be problematic, as users may respond to them before realizing they have been nudged. Although information about the nudge is revealed later, it may already have influenced behavior in a way that threatens freedom of choice and autonomy [18]. In conclusion, the most problematic nudges, in terms of violating personal autonomy, are Type 1 nudges that exploit automatic cognitive mechanisms, lack transparency—where type transparency is more concerning than token transparency—or are only transparent afterward. Understanding and using nudges requires careful consideration of their transparency and impact on freedom of choice. While transparent nudges can serve as tools for encouraging thoughtful and autonomous decisions, non-transparent nudges, as well as Type 1 nudges, especially those with only type or post hoc transparency, must undergo thorough ethical scrutiny to prevent potential violations of personal autonomy.

Table 1: Classification of nudges based on their impact on personal autonomy

Nudges that violate autonomy	Nudges that do not violate autonomy
Type 1 nudges	Type 2 nudges
Type transparency	Token transparency
Ex post transparent nudges	*Ex ante* transparent nudges

This table helps determine whether a nudge preserves autonomy, but it's unclear how many criteria must be met to deem a nudge ethical or unethical. Further research is needed for clearer guidance.

6.1 Collaborative policy design: The nudge plus approach

The nudge plus approach extends beyond transparency by encouraging participatory engagement and reflection, viewing individuals as rational, reflective beings rather than passive agents. Unlike traditional nudging, which can influence behavior unconsciously, nudge plus focuses on democratic control and active collaboration between citizens and policymakers. Through methods like citizens' assemblies, participants are directly involved in policy design, contributing ideas that shape their environments. In the UK, medical sciences now require patient and public involvement in all research that includes patient populations. Similarly, adolescents are consulted in developing anti-bullying interventions [19]. These approaches foster mutual feedback and collaboration between policymakers and citizens, leading to more inclusive and transparent policies that respect community values. Nudge plus approach also refers to an intervention that has a reflective strategy embedded into the design of a nudge. Banerjee and John [20] state that this preserves personal autonomy while promoting pro-social interventions through active involvement by enhancing token transparency and decision-making autonomy. The nudge plus approach offers significant potential for enhancing public policy with maintaining individual autonomy. By embedding reflection, transparency and active citizen engagement, it encourages people to participate in decision-making rather than passively accepting nudge type interventions. This participatory approach builds trust, as individuals are more likely to embrace policies that respect their autonomy and align with their values.

7 Conclusion

This article reviewed nudges as tools for influencing decision-making and behavior, with a focus on their transparency and its influence on potential infringement of personal autonomy. We found that nudges vary in type and transparency, which significantly affects their ethical acceptability. Type 1 nudges, which target automatic decision-making mechanisms, can diminish personal autonomy by influencing behavior without conscious awareness. In contrast, Type 2 nudges, which encourage reflective decision-making, are less problematic as they support autonomous decision-making. Nudges that lack token transparency or are only transparent after the fact are more likely to infringe on autonomy. Conversely, when nudges are transparent in advance and individuals are informed about them, autonomy is better preserved. Additionally, the context in which nudges are implemented plays a critical role in their ethical assessment, as the goals and values of the intervention must align with those of the individuals affected. In conclusion, the ethical use of nudges in public policy requires focusing on preserving autonomy by choosing Type 2 nudges and ensuring high levels of transparency, especially regarding specific examples and advance notice. This approach allows nudges to support conscious decision-making rather than serving as tools for covert manipulation. The Nudge Plus approach, which adds an element of reflection, can enhance both the effectiveness and ethicality of interventions, empowering individuals to make more informed decisions.

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Authors' statement

ChatGPT-4 was used for improving language of this paper.

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Ali nas uporaba velikih jezikovnih modelov v znanstvenem raziskovanju približuje časovni točki, ko bo stroj nadvladal človeka?

Does the use of large language models in scientific research bring us closer to the point in time when machines will surpass humans?

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Povzetek

Prispevek se ukvarja z vprašanjem, ali veliki jezikovni modeli v okviru generativne umetne inteligence že danes odpirajo vrata v fazo splošne umetne inteligence in morda – kot naslednji korak – v fazo umetne superinteligence. S tem bi bili dani predpogoji za prevlado strojev nad ljudmi. Pozornost je namenjena zlasti uporabi velikih jezikovnih modelov v procesu znanstvenega raziskovanja. Raziskovalna dejavnost predstavlja eno najbolj ustvarjalnih človekovih intelektualnih dejavnosti. Logično vprašanje je, ali je ravno znanstvena dejavnost, predvsem zaradi svoje kreativne narave, najbližja prečkanju te meje, ki predstavlja pomembno eksistenčno tveganje za celotno človeštvo. Osrednji del razprave je namenjen vprašanju, v katerih fazah današnjega znanstvenega raziskovanja je vloga velikih jezikovnih modelov že postala nepogrešljiva.

Ključne besede

generativna umetna inteligenca, veliki jezikovni modeli, znanstvena kreativnost, eksistenčno tveganje, okrepljeno učenje

Abstract

The article addresses the question of whether large language models within the framework of generative artificial intelligence are already opening the door to the phase of artificial general intelligence and, perhaps, as the next step, to the phase of artificial superintelligence. This would set the conditions for machines to dominate humans. Particular attention is given to the use of large language models in the process of scientific research. Research activity represents one of the most creative human intellectual endeavors. The logical question arises whether scientific activity, especially due to its creative nature, is the closest to crossing this boundary, which poses a significant existential risk to all of humanity. The central part of the discussion focuses on the question of which phases of today's scientific research the role of large language models has already become indispensable.

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Keywords

generative artificial intelligence, large language model, scientific creativity, existential risk, reinforcement learning

1 Uvod

V okviru pričujoče obravnave izhajam iz predpostavke, da se je skozi celoten zgodovinski razvoj umetne inteligence implicitno zastavljalo vprašanje, ali lahko ta doseže oziroma celo preseže človeško inteligenco. Že od začetkov razvoja umetne inteligence so bila tovrstna razmišljanja spodbujena z različnimi testi, ki naj bi med drugim nakazovali, ali se strojna "inteligenca" približuje človeški inteligenci. Pomembni premik v teh razmišljanjih se je zgodil, ko je tehnologija umetne inteligence prešla od klasičnih načel strojnega učenja k načelom delovanja globokih nevronskih mrež. V moji razpravi me v prvi vrsti zanima, ali najnovejši razvoj generativne umetne inteligence že kaže znake prehoda v fazo umetne splošne inteligence in morda – kot naslednji korak – umetne super inteligence. Posebej me zanima, ali najbolj kreativna področja človekovega intelektualnga delovanja, kot to predstavlja znanstveno raziskovanje, že odpirajo vrata nastopu umetne splošne inteligence. To namreč pomeni, da se počasi trasira pot nadvladi strojev nad človekom, kar je sicer predmet precej distopičnih razmislekov filozofov in družboslovcev, tako pri nas kot drugje v svetu. Moja obravnava ostaja na ravni nekoliko bolj splošne družboslovne refleksije o tej kompleksni tematiki in se ne ukvarja z ožjimi tehničnimi vidiki delovanja umetne inteligence, zato se bom v primeru sklicevanj na algoritme delovanja umetne inteligence oprl na nekoliko bolj poljudne definicije, kot so na primer tiste, ki jih je predstavil Partha Ray [1]. Po Rayu generativna umetna inteligenca (GUI) spada v skupino modelov umetne inteligence, ki lahko ustvarjajo nove podatke (informacije) na podlagi vzorcev in struktur, naučenih iz obstoječih podatkov (informacij). Ti modeli lahko

generirajo vsebine na najrazličnejših področjih, naj si bo besedil, slik ali glasbe. Pri analizi, razumevanju in ustvarjanju teh vsebin, ki vedno bolj spominjajo na človeške stvaritve, se opirajo na tehnike globokega učenja in nevronske mreže. Veliki jezikovni modeli (VJM), ki se razvijajo pod okriljem GUI, pa so zasnovani za generiranje naravnega jezika, kot so stavki, odstavki ali celotni dokumenti. Njihova ključna lastnost je zmožnost predhodnega učenja na velikih količinah besedilnih podatkov ter nato prilagajanje za specifične naloge uporabnikov. V prispevku v štirih krajših poglavjih razpravljam (1) o umetni splošni oziroma super inteligenci kot dejavniku tveganja o človeku, (2) o dilemah, ki so povezane z nadvlado stroja nad človekom, (3) o danes vedno bolj nepogrešljivi vlogi VJM v posameznih fazah znanstvenega raziskovanja, (4) o specifičnih problemih uporabe VJM na področju družboslovnega raziskovanja. Na koncu prispevka je podanih še nekaj zaključnih misli.

2 Umetna super inteligenca kot dejavnik eksistenčnega tveganja za človeka

Potem ko je Nick Bostrom pred desetimi leti postavil in utemeljil tezo, da obstaja verjetnost, da bo nadaljnji razvoj umetne inteligence pripeljal do nastopa umetne superinteligence, ki naj bi bila neprimerno bolj kognitivno zmožna kot človek, kar bi lahko predstavljalo eksistenčno tveganje za celotni človeško vrsto, ta tema, zlasti po nastopu GPT 4 in drugih vrst VJM (Bard, Claude, Llama, Gemini, itd.) vzbuja vedno večjo pozornost med strokovnjaki, tako med naravoslovci in tehniki kot tudi med družboslovci in humanisti [2]. V svojem prispevku se bom izognil (spekulativnim) ocenam, ki se vrtijo okrog problema časovnih mejnikov, ko (če) naj bi pametni stroji nadvladali ljudi. Ena skupina ekspertov namreč trdi, da se to ne bo zgodilo niti v sto letih [3], druga skupina ekspertov spet trdi, da gre zgolj za vprašanje dveh ali treh desetletij [4]. Bolj kot to, me zanima, ali uporaba GUI v takšni kreativni človekovi dejavnosti kot je znanost resnično na široko odpira vrata nastopu umetne splošne oziroma umetne super inteligence, ki naj bi se sicer zgodila v bližnji prihodnosti. To vprašanje je treba povezati s konkretno prisotnimi strahovi pred katastrofičnimi in celo eksistenčnimi tipi tveganj GUI, ki bi lahko imeli negativne družbene posledice. Če katastrofično tveganje ocenjujemo po kriteriju maksimalne razširjenosti (število ljudi, ki bi bili prizadeti), intenziteti (trpljenju, ki ga povzroča) in trajanja škodljivih družbenih posledic nekontroliranega razvoja posamezne tehnologije, potem pri eksistenčnem tveganju, ki naj bi bil povzean z umetno inteligenco, odločilno vlogo igra samo en kriterij: nevarnost iztrebljanja človeške vrste zaradi prevlade stroja nad človekom.

Neredko se srečujemo z ocenami, da pomembni predpogoj za varni prihodnji razvoj GUI, v okviru katerega se lahko izognemo eksistenčnim tipom tveganj, predstavlja »algoritem okrepljenega učenja« (v ang.: »reinforcement learning algorithms«) [5, 6]). Pri »okrepljenem učenju« gre za to, da se v procesu sprejemanja odločitev nagradi to, kar vodi v dobrobit ljudi. Vendar v konkretnih situacijah težavo predstavlja praktično usklajevanje funkcij umetne inteligence z sprejetimi družbenimi vrednotami. Čeprav se ta problem na prvi pogled zdi trivialen, temu ni tako. Družbene vrednote so raznolike, amorfne in jih je težko zapopasti v kvantitativnih kategorijah. Problem, kako »okrepljeno učenje« uskladiti z sprejemljivimi družbenimi vrednotami, zato ni nekaj, kar se da na zelo enostaven in samoumevni način razrešiti. Njegova razrešitev je odvisna od več dejavnikov. Eden izmed teh je možnost, da se modeli GUI razvijajo kot odprtokodni modeli, kar je seveda v nasprotju z sedanjo strategijo multinacionalk, da preko lastniškega nadzora novih naprednih tehnologij javnosti prikrivajo ključne informacije.

Negativna posledica lastniškega odnosa do VJM je, da znanje o notranjih mehanizmih delovanja VJM, ki predstavljajo vrh razvoja umetne inteligence danes, še vedno predstavlja izziv za večino uporabnikov, (deloma) pa tudi za strokovnjake s področja računalništva. Težko je namreč analizirati in priti na tej osnovi do razumevanja VJM, ki delujejo v okviru kompleksnih notranjih struktur z milijoni parametrov. Četudi lahko v vlogi uporabnikov ali celo računalniških razvijalcev vidimo končni rezultat delovanja VJM, pa je pojasnitev oziroma interpretacija njihovih notranjih struktur izjemno zahtevna. Skratka, veliki jezikovni modeli še vedno nastopajo kot »črne skrinjice« (»black boxes«). Thomas Arnold je za opis te nevzdržne situacije uporabil naslednjo posrečeno analogijo: »To je tako kot da bi se prizadevali za razlago delovanja kompleksne kemijske reakcije, ne da bi poznali natančno strukturo in interakcijo molekul.« [7] V strokovni literaturi se sicer omenja tudi nekaj izjem. Za modele kot so BLOOM, Cerebras-GPT ali Llama, naj bi podjetja, ki se ukvarjajo z umetno inteligenco, dopuščala večji javni vpogled [8]. Spet za druge so informacije za javnost odprli, potem pa ponovno zaprli. Četudi vrhunski znanstveniki, ki se ukvarjajo z UI in prihajajo iz akademske sfere znanosti, v vedno večjem številu opozarjajo, da je prosti dostop do vseh informacij na tem področju eden ključnih dejavnikov, ki lahko zagotovi verodostojno in zanesljivo raziskovanje, saj le tako lahko dostopamo do informacij o celotni »arhitekturi« VJM (t.j. od uporabljenih podatkovnih baz do algoritmov), v zvezi s tem še vedno ni bilo storjenih veliko sprememb.

3 Ali lahko ustvarjalno dimenzijo znanstvenega dela dokončno prevzame umetna inteligenca?

Na prihodnje izzive, ki so povezani z nastopom umetne splošne oziroma umetne super inteligence, je treba gledati tudi v luči današnjih dogajanj. Že danes si lahko zastavljamo vprašanje, ali bo ustvarjalno znanstveno delo dokončno prevzela GUI: ali je res upravičeno trditi, da kar je nekoč kalkulator pomenil za številke, in kar internet za globalni značaj komunikacijo, to danes pomeni za znanstveno kreativnost razvoj GUI? Znanstveno kreativnost lahko subsumiramo pod bolj splošni pojem inteligence. Ta naj bi načeloma izkazovala celo paleto zmožnosti, od kreativnih do racionalnih oblik (znanstvenega, umetniškega, itd.) mišljenja, od načrtovanja do učenja na temelju izkušenj, itd. Četudi danes spekuliramo, da bo splošna umetna inteligenca dosegla ali presegla inteligenčne zmožnosti ljudi, pa bomo v strokovni literaturi težko naleteli na neke soglasne kriterije, ki naj bi povedali, kaj predstavlja »inteligenca« pri strojih in kaj predstavlja inteligenca pri ljudeh. Formalne definicije, ki vztrajajo ne nekem skupnem imenovalcu, nam niso vedno v pomoč. Nobena izmed teh formalnih definicij ne ponuja nekega dokončnega kriterija, ki bi nam omogočal primerjavo »inteligentnosti« različnih entitet. Če se za hip ustavimo ob najnovejšem delu Yuval Noaha Harareja, ki nosi naslov »Nexus. A Brief History of Information Networks from the Stone Stage to AI« [9], bomo pri njemu hitro prepoznali besednjak, ki naj bi

nedvoumno nakazoval, da GUI poseduje moment intencionalnosti, t.j. sposobnost GUI slediti delovanju, ki izhaja iz njih samih. (Avtor knjige govori o tem, da se pametni stroji, ki jih vodi GUI, sami odločajo, izbirajo, delujejo, itd.). Ob prebiranju najnovejšega Hararejevega dela se lahko vprašamo, zakaj vsiljuje intencionalnost kot ključni kriterij za izenačevanje »inteligentnosti« človeka in stroja. Lahko bi uporabil širšo definicijo inteligence in bi le to pripisal že entitetam, ki so pasivne, torej ne vključujejo momenta intencionalnosti, vendar vseeno reagirajo na okolje in lahko opravljajo kompleksne naloge. To je na primer storil Sebastien Bubeck, ki je skupaj z soavtorji preučeval, ali so v jezikovnem modelu GTP-4 že dani zametki umetne splošne inteligence. Postavil je namreč tezo, da si neko inteligentno entiteto lahko predstavljamo tudi kot »orakelj«, ki nima notranjih vzgibov ali želja za delovanje, vendar lahko natančno in koristno zagotavlja informacije o kateri koli temi ali domeni vedenja [10]. Definicijo inteligence, ki izhaja zgolj iz kriterija intencionalnosti, imamo lahko za restriktivno še iz enega razloga. Če namreč pri tej definiciji izhajamo iz notranjih motivov za doseganja ciljev našega delovanja v kar se da širokem okolju, kjer se soočamo z nikoli zaključenim spektrom situacij, potem v primeru rabe takšne definicije implicitno predpostavljamo, da je pojem inteligence neizogibno vezan na univerzalnost in optimalnost. To pomeni, da spet operiramo z apriorno definiranim in ne aposteriorno preverjenim konceptom inteligence. Dejansko oziroma realno inteligenco človeka namreč nikakor ne moremo opredeliti kot absolutno univerzalno in optimalno.

S podobnimi dilemami se soočamo, če naš pogled usmerimo na kreativnost kot eno izmed dimenzij človekove inteligence. Tudi v tem primeru odgovor na vprašanje, ali umetna inteligenca enostavno privzema kreativne moči znanosti, ni enoznačen. Ne gre samo za to, da se že pri vprašanju kreativnosti človeka srečujemo z ogromnim številom definicij (znanstveniki uporabljajo danes več kot 50 definicij [11]), zadeve postanejo še bolj kompleksne, ko iščemo skupni imenovalec med definicijo človeške kreativnosti in kreativnostjo, ki jo pripisujemo umetni inteligenci. Na eni strani imamo avtorje, kot so Marc Ruco [12] ali Stephen Rice [13], ki pravijo, da kolikor k standardnim definicijam človekove ustvarjalnosti – ta vključuje dimenzijo originalnosti in učinkovitosti - dodamo tudi dimenziji avtentičnosti, potem GUI ne more tekmovati z ljudmi.

Na drugi strani imamo avtorje, kot na primer Hubert Kent, za katere je GPT- 4 že dosegel izredno visoko stopnjo znanstvene kreativnosti, vsaj kar zadeva t.i. odprti tip mišljenja, saj naj bi empirične analize pokazale, da GPT-4 že zmore doseči rezultate, ki so enaki rezultatom, ki jih doseže zgolj 1% najbolj inteligentnih ljudi [14]. Rezultati dodatnih študij naj bi ravno tako dokazovali, da model GPT-4 izkazuje veliko stopnjo fleksibilnosti zunaj ustaljenih okvirov mišljenja in naj bi imel na področju odprtega tipa mišljenja celo višji kreativni potencial od ljudi. Pričakovati torej je, pravijo avtorji, ki so opravili te in podobne študije, da bo model GPT-4, kolikor bo dosežen napredek glede povečanih zmožnosti učenja na velikih bazah podatkov in bolj napredni arhitekturi nevronskih mrež, kmalo storil pomembni korak v smeri umetne splošne inteligence.[15]. V tem primeru Turingovi testi že zvenijo zastarelo. V okviru rabe Turingovega testa gre namreč za to, da se kot kriterij izenačitve dveh inteligenc vzame situacijo, ko nek uporabnik, ki komuncira z klepetalnikom UI, ne zna več ločiti, ali je na drugi strani človek ali stroj [8].

4 Zakaj umetna inteligenca postaja vedno bolj nepogrešljiv pomočnik v vseh fazah znanstvenega raziskovanja?

V okviru moje razprave me ob bolj načelnem epistemološkem vprašanju, t.j. ali nova tehnologija umetne inteligence postopoma zavzema prostor znanstvene kreativnosti, zanima tudi bolj konkretno vprašanje: ali ta nova napredna tehnologija dobiva status nepogrešljivosti v vseh drugih fazah znanstvenega raziskovanja?

Sodobno znanstveno raziskovanje je multidimenzionalni proces, ki vključuje različne faze, ki od začetka raziskovanja do končne objave znanstvenih rezultatov segajo od najbolj rutinskih pa do najbolj ustvarjalnih aktivnosti. VJM v tem primeru prevzema vlogo koristnega in vedno bolj nepogrešljivega »asistenta« v vseh fazah znanstvenega raziskovanja. Bo ta »asistent« v bolj ali manj oddaljeni prihodnosti postal »profesor«, ki bo dokončno nadomestil človeka – znanstvenika?

1. Najprej je treba izpostaviti, da GUI zaradi svoje učinkovitosti vedno bolj nadomešča znanstvenike v postopkih pridobivanja podatkov. Podobno je z učinkovitostjo GUI v vsebinskem pregledovanju, povzemanju in sumiranju množice informacijskih virov, ki so kot »state of the art« relevantne v vsakem začetnem procesu znanstvenega raziskovanja. GUI je sposoben obdelave in analize velike količine podatkov. Vloga GUI postaja neprecenljiva pri pregledu in sintezi vsebin iz znanstvene literature, povzemanju podatkov in sinteze kompleksnih podatkovnih baz, samodejnem prepoznavanju vzorcev in trendov, ki jih je mogoče izpeljati iz podatkov, modeliranju in napovedovanju na temelju zbranih podatkov, itd.
2. Vedno bolj se povečuje vloga GUI pri ustvarjanju novih idej. Glede na današnjo eksponentno rast znanstvenih informacij je prenos te raziskovalne funkcije iz človeka na GUI hkrati povezana z zmožnostjo GUI, da učinkovito in predvsem avtonomno ustvarja nova raziskovalna vprašanja in hipoteze. Eden največjih izzivov najbolj naprednih področij znanosti je skorajda neskončno število hipotez, ki se nanašajo na raziskovalne probleme, zaradi česar se včasih zdi natančno sistematično raziskovanje, ki bi omogočalo sprejetje hevristično najbolj obetavne hipoteze, brez sodelovanja UI skorajda nemogoče. Primer: v biokemiji naj bi obstajalo približno 10^{60} molekul, to pa je praktično enako številu zdravil, ki jih je treba na temelju ogromnega števila molekul šele odkriti [16]. Pri tem imajo ravno najnovejši modeli GUI potreben potencial, da revolucionarno posežejo v to fazo znanstvenega raziskovanja, ko gre za biokemijo. Podobne primere bi lahko navedli za področje genomike, astronomije, kvantne fizike, itd. Ne moremo mimo omembe še ene funkcije GUI. Ta funkcija GUI je vezana na njeno zmožnost usmerjanja k bolj interdisciplinarno zasnovanim revolucionarnim znanstvenim odkritjem, saj so njeni potenciali pri obdelavi in sintezi informacij iz različnih disciplin skorajda neomejeni.

3. Vloga GUI se povečuje tudi v procesih evalvacije končnih rezultatov znanstvenega raziskovanja. Če izhajam iz bolj splošnih epistemoloških predpostavk in se na tem mestu izognemo razpravi o prednostih in tudi tveganjih uporabe GUI v konkretnih recenzentskih postopkih, potem naj na kratko omenimo zgolj eno izredno pomembno vlogo te nove napredne tehnologije, t.j. preverjanje rezultatov eksperimentalnih in drugih empiričnih raziskav. V preteklosti je v glavnem veljalo, da ni problematična ponovljivost dobljenih znanstvenih rezultatov, bodisi na temelju javno dostopnih znanstvenih objav ali ustreznih eksperimentalnih protokov. Sodobna znanost se nahaja v vedno večji krizi, kar zadeva zmožnost replikacije, saj je tako z vidika časa kot tudi stroškov v številnih, če ne kar vseh vseh znanstvenih disciplinah težko izvesti potrebne eksperimentalne in druge znanstvene ponovitve. O tveganjih za povečanje goljufij in prevar v moderni znanosti, ki izhajajo iz teh kompleksnih situacij raziskovalnega dela, sem več pisal na drugih mestih [17]. GUI lahko odigra zelo relevatno funkcijo v današnjem času enormne produkcije znanstvenih rezultatov, ko je vedno težje izvajati ponovitve eksperimentov z namenom izvajanja kontrole znanstvenih rezultatov. Njen predikativni pristop namreč lahko zagotovi učinkovito, hitro, sistematično in natančno napoved ponovljivosti posameznih znanstvenih odkritij ali pa celo vseh spoznanj na posameznem področju znanosti.

4. Pozitivna vloga GUI se danes povečuje tudi v okviru širših družbenih in kognitivnih predpostavk, ki so relevantne za delovanje moderne znanosti. V zvezi s to širšo funkcijo bi izpostavil vlogo GUI pri spodbujanju komunikacij znotraj znanstvene skupnosti, pa tudi komunikacije znanstvenikov navzven. To zadnje naj bi se dogajalo predvsem s pomočjo modela ChatGPT, ki generira takšne tipe pojasnitev, ki vodijo k premagovanju komunikacijskih prepadov med eksperti in laiki. Vendar je to funkcijo, kot smo že opozorili v enem izmed predhodnih poglavij, mogoče izvajati le, če bo prišlo do uveljavitve nove paradigme odprtokodne znanosti. V zadnjem času strokovnjaki, ki delujejo na področju GUI, vedno bolj poudarjajo, da je treba razviti modele, ki bodo čim bolj korespondirali z fizično realnostjo. Menijo, da je treba največ naporov usmeriti v nadaljnji razvoj multimodalnih sistemov GUI. Demis Hassabis, izvršni direktor firme DeepMind, je v intervjuju za angleški dnevnik Guardian konec prejšnjega leta dejal, da je bil storjen na tem področju največji korak z modelom Gemini, ki ga razvija njegovo podjetje [18].

5 Ali nova tehnologija generativne umetne inteligence v okviru družboslovnega raziskovanja nujno in vedno zagotavlja znanstveno objektivnost?

Kot družboslovca me seveda zanima tudi vprašanje vedno večje rabe VJM na področju mojega področja znanstvenega raziskovanja. Kar takoj je treba reči, da na področju družbenih ved VJM izkazujejo velik (hevristični) potencial v razvijanju novih pristopov k anketnim raziskavam in ponovljivosti eksperimentov na področju vedenjske ekonomije [19], diskurzivnih analizah tekstov, ki jih je mogoče izvajati na avtomatizirani način [20] in končno tudi na področju razvijanja modelov, ki simulirajo stvarno obnašanje ljudi. V tem zadnjem primeru gre predvsem za t.i. »agent-based« modele, ki preučujejo, kako delovanje oziroma vedenje na mikro ravni (npr.: odločitve individualnih agentov) vodi do posledic na makro (družbeni) ravni (npr.: oblikovanje družbenih vzorcev delovanja oziroma obnašanja). V okviru teh modelov se seveda lahko preučuje tudi obratni vpliv: kako makro-nivo vpliva na obnašanje na mikro ravni [8]. V okviru sociologije se s temi »agent-based« modeli preučuje socialna omrežja, oblikovanje sosedskih skupnosti, itd.

Se pa v zvezi z družboslovnim raziskovanjem pojavlja določen paradoks, na katerega želim opozoriti v tem sklepnem delu moje razprave. Ta paradoks predstavlja dejstvo, da postopki »okrepljenega učenja« (ang. »reinforcement learning«), ki naj bi odpravili »halucinacije« in raznovrstne pristranosti, predstavljajo oviro za doseganje objektivno veljavnih znanstvenih rezultatov. Če pride skozi delovanje t.i. »reinforcement self-learning by human feed-back« (RLHF) do idealiziranja sveta, t..j. sveta, kakršen naj bi bil, ne pa sveta, kakršen dejansko je, takšna prizadevanja za zmanjšanja pristranskosti algoritmov, katerih cilj je promovirati liberalne vrednote, lahko ogrozijo veljavnost raziskav v družboslovju, ki jih podpira umetna inteligenca. »Požarni zid«, ki se ga želi danes pospešeno graditi preko RLHF, odpravlja tveganja GUI, kar zadeva njeno široko uporabo (in preprečuje tveganja, ki so se, kot pravi Yuval Harare, že zažrla v civilizacijski kod sodobnih družb), po drugi strani pa predstavlja epistemološko tveganje za objektivni značaj današnjih družboslovnih raziskav. Tudi to predstavlja dilemo današnjega in prihodnjega razvoja umetne inteligence, ki zahteva naš celovit interdisciplinarni razmislek, saj se je le na tej osnovi mogoče izogniti negativnim družbenim in tudi epistemološkim implikacijam njenega razvoja.

6 Zaključek

V zadnjem času je tako v znanstvenih krogih kot tudi zunaj znanstvenih krogov veliko govora o možnih tveganjih današnjega in prihodnjega razvoja umetne inteligence. Znanstveniki iz Massachusetts Institute of Technology, ene najbolj uglednih akademskih institucij v ZDA, so v letošnjem letu pripravili javno dostopni repozitorij z umetno inteligenco povezanih primerov tveganj. V omenjenem repozitoriju se trenutno nahaja kar 777 opisov takšnih tveganj. To je še en dokaz, kako veliko zanimanje obstaja danes za ta vprašanja. V mojem kratkem prispevku sem se dotaknil zgolj enega izmed teh številnih problemov, ki je vezan bolj na epistemologijo znanstvenega raziskovanja, ne pa toliko na družbene posledice razvoja umetne inteligence. V tem kontekstu me je predvsem zanimalo, ali pospešena raba VJM v okviru različnih znanstveno-raziskovalnih aktivnosti predstavlja eno izmed domen, kjer se na stežaj odpirajo vrata nastopu umetne splošne oziroma umetne super inteligence. Še posebej me je zanimalo vprašanje, zakaj GUI postaja že danes nepogrešljivo »orodje« v seh fazah znanstvenega raziskovanja. V sklepnem delu sem se na kratko ustavil ob nekaterih specifičnih dilemah uporabe GUI na področju družboslovnega raziskovanja.

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Comparing academic performance across course topics: a pilot study

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ABSTRACT

In this paper, we examine the academic performance of students in different courses to determine whether good performance in one course is related to good performance in other courses. Although certain predictive models emphasize the importance of course content for learning success, there are few studies that address how student performance in different courses is related to similar course topics, learning goals, competences, and skills. By creating a preliminary framework that examines how academic performance is related to different course topics, we attempt to make a first step further towards addressing the research gap regarding the interrelatedness of student achievement not only in different course topics but in different competence areas. We examined a set of student grades from eleven different courses at the faculty from areas such as entrepreneurship, management and leadership, business informatics, mathematics, economics, marketing and market analysis, innovation and creativity, English, finance and accounting, business law, and human resource management. We show that students with more exam retakes on average reached a lower grade rank than the students who only registered for the exam once. We used linear regression to show the significance of the relationships between student performance in the Informatics course compared to their achievement in other courses. With a correlation matrix coefficient, we measured the strength of reciprocal interrelatedness between the grade ranks students attained in each of the eleven courses. The results of this preliminary study indicate a possible stronger association between academic achievement in courses that have similarities in terms of content or focus, such as business administration and entrepreneurship (correlation coefficient of 0.58). Further studies with detailed comparison of course-specific competences are needed for accepting the finding that interrelatedness between achievements in courses from similar versus different disciplines is stronger. The preliminary model could further be improved by a broader range of courses, input explanatory student factors, and application of advanced analytical techniques.

KEYWORDS

course-specific competence, learning analytics, prediction models, student academic achievement, student academic performance

1 INTRODUCTION AND RELATED WORK

Are students who achieve excellent results in one course more likely to achieve outstanding results in another? And vice versa? This is the key question that triggered this preliminary research into how students perform in different courses. As a result, we are examining the relationships between students' academic achievement in different courses from two different undergraduate study programs at the faculty of entrepreneurship. Despite some prediction models suggesting the course content as one of the input explanatory variables, there is a significant lack of detailed research on the relationship between students' achievement in different courses from the same, similar, or entirely different discipline. Therefore, this preliminary study aims to develop a pilot model to investigate the relationship between academic success in various courses and their respective course topics. The findings of this study could be further reinforced and interpreted by the comparison of course-specific competences and learning objectives.

Apart from the prediction model of academic achievement, interrelatedness between academic achievement in different courses compared to the course main topics, competences, and learning objectives is still largely missing. Since previous studies that would previously investigate the interrelatedness of student achievement in different courses are, to the best of our knowledge, entirely nonexistent, let us draw attention to the research studies that are related to the field and that have led to this investigation. OECD [12, 13], for example, show a positive association between literacy and numeracy skills. Moreover, in our previous research [2], we showed that students who achieved better academic achievement in word skills were on average also more likely to achieve better achievement in excel skills. However, this does not imply that it is sufficient to develop only some of these skills, such as solely including word skills, excel skills, literacy skills, or just numeracy skills in the curriculum. Furthermore, this does not imply that students in a real situation cannot achieve much better results in a certain type of skill compared to another. Additionally, Fink and Vadnjal [3] conducted a pilot study that compared the development of

* Comparing academic performance across course topics: a pilot study.
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generic and course-specific competences during a higher education course.

As previously mentioned, one could apply findings about the relationships between various course topics, contents, competences, or objectives to the development of predictive models and predictive algorithms. Prediction models are often used to find out ahead of time which students are likely to drop out or fail external exams. The schools aim to take intervention measures and steps to stop the bad predictions from coming true, and the success rate can be raised [16, 9]. There are a lot of different input explanatory variables that can have a big effect on how well and especially how accurately prediction models perform [16, 4, 7, 8, 9, 11, 1]. Some prediction models include related concepts to the course content [7], such as the course's learning objective, the course's main competences, the course topic [4], or even course preparedness [10].

In addition to the combination of input explanatory variables, various statistical methodologies and techniques, as well as different types of measurements and academic achievements, significantly influence the prediction model's power and performance. While adding additional or all relevant factors to the model does not always improve its performance, the right combination of input explanatory variables significantly influences the accuracy and other model performance measures [4]. In the end, the right combination of input variables largely determines the model's explanatory power, the accuracy of its predictions, and other performance measures [6, 15].

Different prediction models are based on different methodologies and include different input and output variables. Francis and Babu [4], for example, compare prediction models of student achievement that include the topic of the course as the input explanatory variable. They demonstrated that the course topic, along with many other factors, is one of the explanatory variables for academic achievement. However, their model found that academic factors, including the course topic, were less accurate in predicting students' academic achievement than demographic factors, behavior factors, and other factors such as absence days, parental satisfaction, and school survey responses. They developed, compared, and assessed performance measures of several prediction models. The model that included academic factors, behavior, and additional input explanatory variables showed the greatest improvement in accuracy. On the other hand, adding demographic factors on top of that reduced the accuracy of academic achievement prediction. Clearly, the addition of additional input variables, for example, the topic of the course, in different models contributes differently to improving prediction accuracy and other performance measures, depending on other input variables in the model.

2 HYPOTHESES

In this preliminary study, we aim to build a preliminary pilot research model on which we will test the interrelatedness between academic achievement in different courses. We suggest the following hypotheses:

H1. Mostly there are reciprocal relationships between a student's performance in one course and their performance in another.

H2. As the number of exam retakes increases, the student's grade rank decreases.

3 DATASET AND METHODOLOGY

The dataset collection and preparation included several phases. First, we have collected students' grades for different courses at the higher education institution. The initial dataset included the grades of 223 students for 67 different courses.

In the second phase, we have refined and further prepared the dataset. Based on some simple data exploration and visualization techniques, such as plotting the missing values, plotting the distribution of the number of grades available per course, and plotting the distribution of the number of exam retakes per course, we have decided to eliminate the data of courses with less than 60 students' grades per course. With that, we narrowed further analysis to the following eleven selected courses: Business Economics, Informatics, Management and Leadership, Marketing and Market Analysis, Entrepreneurship, Business English, Accounting, Creativity and Innovation, Business Mathematics and Statistics, Business Law, and Human Resource Management.

Table 1: Number of grades per one and two courses

Course (Short name)	Nr. of students/grades	
	per course	for chosen course and Informatics (%)
Informatics for entrepreneurs (P07_IE)	160	
Business economics (P05_BE)	139	120 (86 %)
Business law for entrepreneurs (P06_BLE)	79	71 (90 %)
Human resource management (P09_HRM)	66	58 (88%)
Management and leadership (P15_ML)	156	142 (91%)
Marketing and market analysis (P16_MMA)	90	73 (81%)
Entrepreneurship (P27_ENT)	191	148 (77%)
Business English (P28_BE)	152	133 (88%)
Accounting for entrepreneurs (P33_AE)	143	131 (92%)
Creativity and innovation in entrepreneurship (P36_CIE)	173	142 (82%)
Business mathematics and statistics (P39_BMS)	139	119 (86%)

We then compared the number of students' grades available per one course with the number of grades available per two courses (the selected course and the informatics) and calculated the share of students that also took the exam in informatics

compared to the number of students who took the exam in the selected course only. Students' grades include both those that indicate a student has passed the course and those that indicate a student has not. Since we included only one grade per student in further analysis, the number of students' grades reflects the number of students who took the exam in each course. Not all students took exams in all eleven subjects. The reasons for this are varied, including the fact that the courses are from two different programs.

The courses with the highest student grades include Entrepreneurship (191), followed by Creativity/Innovation (173) and Informatics (160) (Table 1). More than 77% of students (148) who took the entrepreneurship exam also took the informatics exam. Similarly, 82% of students who took the exam in creativity/innovation (142), and 91% of those who took the exam in management/leadership (142) also took the exam in informatics. In other words, students who attended the exam in the Informatics course often also attended the exam in the Entrepreneurship, Management/Leadership, and Creativity/Innovation courses, as shown in Table 1.

Then, we continued by calculating the average grade ranks and number of exam retakes (table 2) for each of the courses included in the analysis. The grade ranks range from 0 to 10, where 0 represents not attending, 1 to 5 represents failed, 6 satisfactory, 7 average, 8 good, 9 very good, and 10 excellent. As shown in Table 2, the students on average achieved better grades in the HRM course than in other courses. In comparison, the students on average achieved the lowest average grade rank in the Mathematics/Statistics and Economics course compared to other courses. The students also, on average, most commonly retook the exam in these two courses. Additionally, we found that 38 students attended at least one exam deadline for each of the eleven courses.

Table 2: Average grade rank and number of exam retakes

Course (Short name)	Avg. grade	Avg. nr. of retakes
Informatics for entrepreneurs (P07_IE)	7.7	1.2
Business economics (P05_BE)	6.6	1.8
Business law for entrepreneurs (P06_BLE)	7.1	1.3
Human resource management (P09_HRM)	8.0	1.1
Management and leadership (P15_ML)	7.3	1.2
Marketing and market analysis (P16_MMA)	7.5	1.3
Entrepreneurship (P27_ENT)	7.4	1.3
Business English (P28_BE)	7.3	1.2
Accounting for entrepreneurs (P33_AE)	7.0	1.3
Creativity and innovation in entrepreneurship (P36_CIE)	7.2	1.3
Business mathematics and statistics (P39_BMS)	6.4	2.0

In the third phase, we continued with the data exploration and visualization. We plotted the distribution of the number of grades achieved per grade rank for each of the selected eleven courses. An example of the distribution for the Entrepreneurship course is provided in Figure 1.

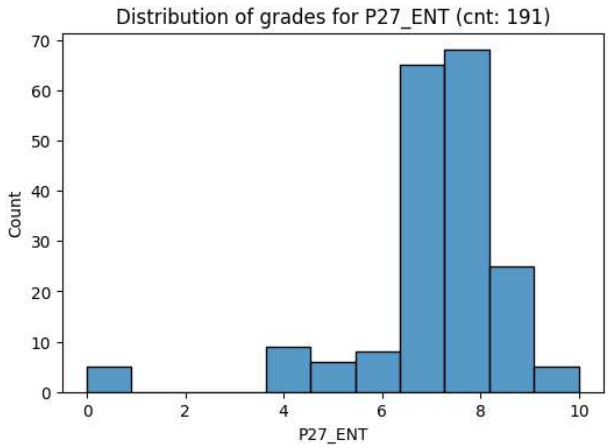

Figure 1: Distribution of number of grades per each grade rank for Entrepreneurship course example

In the next phase, we focused our investigation on how the grades that students achieved in the Informatics course behave compared to the grades they achieved in the remaining ten courses. We performed and visualized ten linear regression models describing the relationships between grade ranks students achieved in the informatics course and the grade ranks students achieved in other selected courses. When performing the linear regression, we included the grade rank achieved in informatics as an independent variable. Though we are aware that linear regression models assume the influence of the independent variable on the dependent variable and not the reciprocal relationships per se, we decided to mention this limitation and work further with the results obtained from the regression analyses in this preliminary pilot study.

We performed additional analysis based on the correlation matrix between the grade ranks students achieved in each of the eleven selected courses. We draw a correlation matrix with significant ($p < 0.05$) correlations among regression coefficients between the eleven selected courses to determine which of the eleven courses is related to another one. We then examined the strength and significance of the reciprocal relationship that the correlation matrix coefficient measures.

Next, we further compared the characteristics of our data for the selected eleven courses with the characteristics of the data for all the courses. We used data visualization techniques such as plotting to compare the distribution of the average grade of eleven selected courses and all the courses. The distribution of average grade for the selected eleven courses seems fairly similar to the distribution of average grade for all the courses, as shown in Figure 2.

Although we cannot claim that an analysis of the entire data set would yield similar results to the analysis of the selected eleven courses based solely on the similar distribution of average

grades, we cannot completely rule out the possibility that on average, somewhat similar associations would emerge among the other courses.

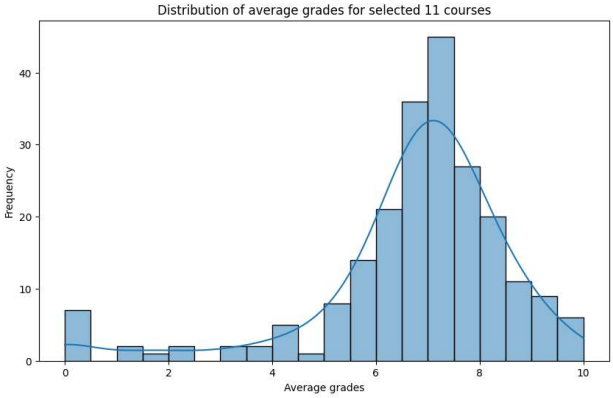

Figure 2: Distribution of number of grades per each grade rank per course example

In the final phase of this preliminary pilot research, we performed the regression analysis between the grade rank that the student achieved and the number of exam retakes of the student.

4 RESEARCH FINDINGS

The eleven selected courses served as the basis for the analysis, which focused on identifying reciprocal relationships between the grade ranks of one course and those of another course. We selected the courses based on the number of grades available after exploring, visualizing, cleaning, and refining the data. In addition to linear regression models, we calculated the correlation matrix's correlations (Figure 3) that investigate the reciprocal association between the grade ranks students achieved in one course compared to another.

Overall, we investigated 55 reciprocal relationships (H1) between the grade ranks of one course with the grade ranks of another course. Among these, forty-six correlations are significant ($p < 0.05$) compared to nine correlations that are not significant. Among the significant correlations, nine correlation coefficients exhibit a moderate relationship (between 0.5 and 0.7) between the grade ranks of one course and the grade ranks of another course. Twenty-seven correlations show a weak correlation (between 0.3 and 0.5), while ten correlations show a negligible or low correlation (below 0.3) between the grade ranks of two selected courses.

The strength of significant coefficients varies from 0.19 all the way up to 0.58. Many of the coefficients that we would otherwise have placed in the group of weak correlations are very close to 0.5, which indicates moderate correlation. There are also many coefficients that we have otherwise placed in the group of negligible correlations close to the value of 0.3, which indicates a weak correlation.

Based on these results, we can accept hypothesis 1 that foresees the existence of reciprocal relationships between a student's performance in one course and their performance in another in most cases when comparing different pairs of courses.

Let's examine the concrete correlations between the grades of the two courses. There is a moderate correlation between Economics and Mathematics/Statistics (0.60), followed by Economics and Entrepreneurship (0.58), Informatics and Mathematics/Statistics (0.57), Marketing/Market Analysis and Law (0.57), Marketing/Market Analysis and Entrepreneurship (0.55), Economics and Accounting (0.54), Marketing/Market Analysis and Creativity/Innovation (0.52), and Economics and Informatics (0.51), and Informatics and Marketing/Market analysis (0.50).

Based on moderate correlations, we can speculate that Economics, Informatics, Mathematics, and Accounting courses are closely connected, partially because students have to use the numeracy skills in these courses. Therefore, future research could address the question of whether the syllabus of these courses reflects shared similar competences. Although rare, previous research [12, 13] on the interrelatedness of competences has shown that people who are more proficient in literacy skills are usually also more proficient in numeracy skills, and vice versa, additional inquiry into the similar and different competences that are developed within these courses would provide an important insight and more thoroughly address the gap in the literature on the interrelatedness between competences that is largely still missing. Therefore, we also need to investigate further to what degree are the numeracy skills included in the syllabus of the courses that otherwise aim at developing soft, social, and other professional skills, such as the Entrepreneurship and Marketing/Market Analysis courses. Additionally, based on the analysis, it would also make sense to check whether the Marketing/Market Analysis and Creativity/Innovation courses foster the development of related skills. In general, we can speculate that the type of competences is important for student achievement, but to confirm this, we would have to perform the qualitative analysis of the similar competences and learning objectives in the future.

The majority of the relationships are statistically significant but weak. Weak correlation exists between Entrepreneurship and Mathematics/Statistics (0.49), Entrepreneurship and Informatics (0.47), Economics and Management/Leadership (0.47), Entrepreneurship and Law (0.45), English and Entrepreneurship (0.45), Economics and English (0.43), Creativity/Innovation and Entrepreneurship (0.42), HRM and Law (0.41), Accounting and HRM (0.41), Informatics and Accounting (0.41), Management/Leadership and Accounting (0.40), English and Mathematics/Statistics (0.38), Mathematics/Statistics and Law (0.38), Marketing/Market Analysis and Law (0.37), English and Accounting (0.37), Management/Leadership and English (0.36), Entrepreneurship and HRM (0.36), Law and Economics (0.34), Management/Leadership and Entrepreneurship (0.34), Entrepreneurship and Accounting (0.33), Accounting and Mathematics/Statistics (0.33), Management/Leadership and Marketing/Market Analysis (0.31), Marketing/Market Analysis and Economics (0.31), Management/Leadership and Law (0.31), Informatics and Law (0.30), English and HRM (0.30), Creativity/Innovation and Accounting (0.30).

A low correlation below 0.3 exists between Accounting and Law (0.29), Marketing/Market Analysis and English (0.29), Marketing/Market Analysis and Accounting (0.28), Economics

and Creativity/Innovation (0.27), Informatics and Management/Leadership (0.26), Management/Leadership and Creativity/Innovation (0.25), Management/Leadership and Mathematics/Statistics (0.25), English and Informatics (0.22), English and Creativity/Innovation (0.20), and Creativity/Innovation and Mathematics/Statistics (0.19).

Based on the weak and low correlations, we can speculate that these correlations exist in courses that do not necessarily share that much of similar competences and learning objectives as those that exhibit moderate correlations. As mentioned previously, further qualitative research is required to substantiate these assumptions.

Since not all students took the exams in all the courses, the number of observed instances for each pair of two courses ranges from 46 to 166, depending on the particular pair of courses. Not only that, we found that the low number of observed instances importantly contributed to the statistical insignificance of some correlation coefficients. The relationships calculated based on a low number of observed instances, such as, for example, between Mathematics/Statistics and Law (46 observed instances), Marketing/Market Analysis and Mathematics/Statistics (46), HRM and Economics (47), Informatics and HRM (58), English and Law (58), Management/Leadership and HRM (59), and Creativity/Innovation and HRM (59 observed instances), exhibit insignificant relationships. The exemptions are the insignificant relationship between the Informatics and Creativity/Innovation course with 142 observed instances and between the Creativity/Innovation and Law course with 74 observed instances. We therefore speculate that the Informatics and Law courses strive to develop different competences than the Creativity/Innovation course. This preliminary analysis is a useful basis for further research and analysis.

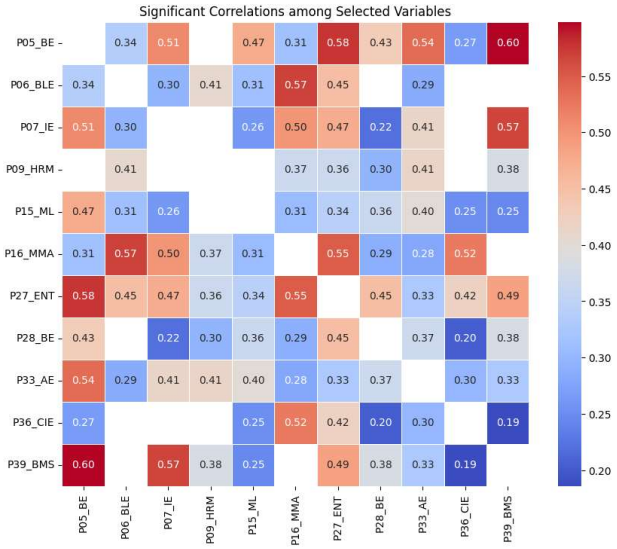

Figure 3: Correlation matrix with significant correlations

The results of the regression analysis between the grade rank that the student achieved and the number of exam retakes that the student took (H2), that are shown in Figure 4, suggest that the students with more exam retakes on average reached a lower grade rank than the students who only registered for the exam once (β = -0.47, p = 0.00). The full equation is displayed below (equation 1). Based on these results, we accept hypothesis 2 that as the number of exam retakes increases, the student's grade rank decreases.

$$Grade\ rank = 8.25 - 0.47 * Nr.of\ exam\ retakes + residuals \quad (1)$$

Figure 4 also shows that most students register for the exam once, fewer students register for the exam twice, and even fewer students register for the exam a third time.

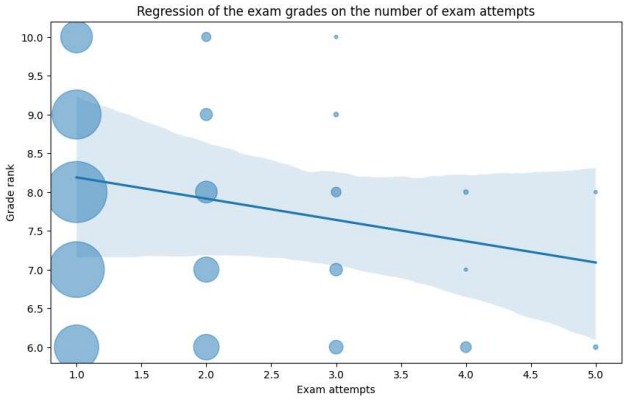

Figure 4: Regression analysis between number of exam retakes and average grade achieved

5 CONCLUSION

The purpose of this study was to lay the groundwork for further research regarding the correlation between different course-specific competences and to present initial findings regarding the correlation between students' academic achievement in different courses. In this paper, we aim to enhance our comprehension of the intricate relationship between competences, an area that remains largely unexplored. The preliminary analysis revealed the existence of interrelatedness among grades students achieve in different courses, and showed that a student's academic performance in one course influences their performance in another. Based on the analysis we accept hypothesis 1 that foresees the existence of reciprocal relationships between a student's performance in one course and their performance in another in most cases when comparing different pairs of courses. We also show that students with more exam retakes on average reached a lower grade rank than the students who only registered for the exam once. With that, we accept hypothesis 2 that as the number of exam retakes increases, the student's grade rank decreases.

To determine whether there is a stronger correlation between academic achievements in courses from the same or similar

discipline than in courses from completely different disciplines, further research is required to explore how much the interrelatedness between courses depends on the competences, learning goals, and discipline of the course.

Since this is a preliminary pilot analysis, we considered additional opportunities to improve our research in the future. We could enhance this study by utilizing additional methods, such as cluster analysis, network analysis, and structural equation modeling, along with techniques used to make predictions like data mining [11, 1], neural networks [5], or decision trees [14]. Furthermore, we could enrich the model by increasing the number of observations and the number of courses included in the analysis.

To capture more subtleties in these relationships, we could potentially build and test the model's performance with additional input variables such as information about general knowledge, broad outlook, ambitions, and psychological characteristics. Additionally, we could compare different cohorts of students, the semester, the study program and track, forms of study (full-time, part-time), types of study programs (undergraduate, postgraduate, higher vocational program), and study modes (classroom, blended, online).

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Linking the Normative and the Descriptive: Bounded Epistemic Rationality

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Abstract

Epistemic rationality is a type of rationality directed towards cognitive or epistemic goals, such as true beliefs, knowledge, or understanding. Epistemology is primarily concerned with normative questions about how one should form and update beliefs, reason and inquire to be rational; on the other hand, empirical disciplines, such as psychology, investigate how inquiries and belief formation occur in real life. The question arises as to what the relationship between the normative and the descriptive in the study of epistemic rationality should be. This paper proposes a notion of bounded epistemic rationality as a hybrid, non-ideal concept that encompasses both normative and descriptive elements. Drawing upon Herbert Simon's bounded rationality and Robin McKenna's non-ideal epistemology, bounded epistemic rationality is characterized by requiring satisficing instead of maximizing; acknowledging our cognitive, environmental, and practical limitations; its ecological nature; and its focus on the process of inquiry. As such, bounded epistemic rationality is a good starting point for proposing epistemic advice that is achievable for real cognizers and helps them improve their epistemic position.

1 Introduction

Epistemic rationality is one of the main topics of epistemology. It refers to epistemic attitudes, states, and processes [1], mainly focusing on rationality of beliefs, and is directed towards reaching cognitive or epistemic goals, such as true beliefs, knowledge, or understanding [2, 3, 4]. One of the central tasks of epistemology has been to propose epistemic norms about how one should form, update and revise beliefs to be rational. Although it is acknowledged that humans are not ideal agents – there is ample empirical evidence, gathered by disciplines as cognitive psychology, showing that we are limited by our cognitive architecture and the nature of cognitive processes, such as computational power and speed, predictive abilities, working memory and attention [5, 6, 7] – traditional analytic epistemology still often relies on idealized models of human cognizers [8], with the consequence that it frequently imposes epistemic norms such as logical omniscience, consistency between beliefs, and immediate updating of beliefs by conditionalization [9].

Philosophy, including epistemology, is predominantly concerned with the normative questions about justification, rationality and other epistemic appraisals of our cognitive activities and doxastic states, while empirical disciplines, such as psychology, empirically investigate how human cognition, inquiries and belief formation occur in everyday life. With normative theories on the one hand and empirical research on the other, we are faced with the question of the relationship between the two approaches towards studying rationality.

The aim of the paper is to propose a concept of bounded epistemic rationality as a hybrid notion that may help us bridge the gap between the normative and the descriptive. By adopting a concept that is – to some extent – grounded on empirical data about human cognition but does not dispose with the normative questions about epistemically good cognition, we can propose epistemic norms and epistemic advice that are achievable for real human cognizers and can help them improve their epistemic situation.

2 Normative and descriptive theories of rationality

Philosophical understanding of rationality is deeply intertwined with the notion of normativity. There are different views on how to define and justify epistemic normativity and which epistemic norms we should endorse. We can understand rationality as a system of rules or requirements: it requires from us, for example, not to hold contradictory beliefs, to draw a conclusion by modus ponens [10], to have deductive closure [11], or to follow rules of logic, probability and decision theory [12]. Rationality is thus normative in the sense of employing certain norms and rules according to which we can judge correctness of a belief [13]. Nevertheless, a genuine normative question of rationality requires us to determine if those rules or requirements are necessarily accompanied by a reason to conform to them, or, in other words, if we *ought* to conform to them [13, 14].

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In addition to the debate about genuine normativity of rationality, there is an ongoing discussion about how epistemic norms or principles should be formulated and what they should prescribe. According to Engel, there are some conditions such principles should satisfy to be genuinely normative: they should have normative force, a potential to regulate or direct our inquiry and beliefs, and normative freedom – a possibility to be violated. If we accept these conditions, many normative principles that are often employed are not adequate. A rule that says, for example, that one should not believe p and not p, tells us something about a characteristic of a rational belief, but gives us no guidance on how to achieve it [11]. Such rules are more of a description of a belief or believer in ideal conditions than genuine normative principles. A similar point is put forward by Robin McKenna in his book Non-ideal epistemology [8]. He claims that mainstream epistemology mostly proposes epistemic norms based on various types of idealizations, for example about cognitive capacities of epistemic agents and the nature of epistemic environment. He calls such an approach to epistemological theorizing ideal epistemology and contrasts it with non-ideal epistemology which tries to avoid such idealizations. The issue with the norms proposed by ideal epistemology is that they are too detached from real world issues, too demanding and unachievable for real human cognizers. Another, even more important issue is that they provide bad epistemic advice: if we try to achieve or approximate proposed ideals and norms, we will often worsen rather than improve our epistemic situation. McKenna uses an example of the ideal of objectivity in scientific inquiry: trying to achieve objectivity as detachment – in a sense that scientists are not personally invested and interested in the topic of inquiry and try to detach research process from non-cognitive values – leads to worse, not better, scientific inquiry. McKenna draws on Elizabeth Anderson's work on value judgements in science. She argues that researchers' background assumptions and values influence all the stages of research process – they partly determine how we frame the research questions, conceive of the object of inquiry, what data we collect, how we analyze and interpret them. A large portion of empirical research in social science investigates evaluative questions that are related to well-being of individuals, social groups or society at large, and science that is legitimately guided by certain, for example feminist values, could be more fruitful and more likely lead to desired epistemic goals. Instead of trying to be attain an ideal of objectivity, scientific inquiry should be informed by the right values [15]. A similar argument can be made for our everyday inquiries: if we, for example, always aim to reason in accordance with a norm proposed by ideal theory, such as logic and probability theory, or trying to think in intellectually autonomous way instead of relying on experts, this will likely lead to worse epistemic outcomes than using less complex, heuristic processes or form a belief according to the consensus of the experts [16]. This means that ideal theory is failing as a normative theory because its prescriptions often do not help us achieve our epistemic goals, such as obtaining true beliefs, knowledge or understanding, and cannot serve as regulative ideals. For this reason, the ideal approach should in certain situations be replaced by a non-ideal one [8]. Both Engel and McKenna emphasize that an important feature of epistemic norms is their potential for guidance, for improving our inquiries, reasoning, and forming beliefs that are in some way epistemically better. Instead on focusing on defining conditions for epistemic ideals such as justification and knowledge and engaging in "S knows P iff …" kind of epistemology, McKenna claims that we should engage in non-ideal theorizing that is informed by empirical literature on human cognition, knowledge-producing institutions and epistemic environment. While McKenna claims that descriptive questions should be a starting point for answering normative questions, he does not argue for a strong form of naturalism or for the replacement of epistemology by empirical science, but merely suggests that there should be a closer connection between epistemology and empirical disciplines than is currently the case [8]. The norms that non-ideal epistemology proposes would therefore be norms of inquiry that help agents determine which problems are important to inquire about in the first place; how to collect, assess and evaluate evidence; what to do when they are presented with conflicting information; how to identify trustworthy and reliable sources of information; and when they gathered enough evidence to terminate an inquiry and form a belief. Instead of a norm stating something in terms of "a belief about whether anthropogenic climate change is real is rational if it is achieved in a reliable manner and responsive to the available evidence", non-ideal epistemology would propose norms specifying what is an epistemically good manner in which ordinary laypeople should gather evidence about climate change, how to identify genuine experts and how to recognize good evidence. Such norms would require inquiring in a way that is possible for ordinary people – would not, for example, require enormous amount of time and philosophical understanding of the concept of evidence – and would be based on empirical data on which ways are effective for gaining true beliefs about climate change – for example, relying on science marketing strategies [8]. Such norms or principles would satisfy Engel's conditions and could thus be considered as genuinely normative.

3 Bounded rationality

Although many authors who investigate rationality or epistemic norms explicitly acknowledge that humans are limited agents and that our boundaries should put a constraint on epistemic norms, only a few philosophers have drawn on the notion of bounded rationality. Bounded rationality was introduced by political scientist Herbert A. Simon and has importantly influenced many disciplines investigating rationality, such as psychology and economics. Simon argued that global, idealized theories of rationality should be replaced with a notion of rationality that is compatible with cognitive capacities of the subjects and the features of the environment in which they are embedded. As our cognitive capacities, for example predictive and computational capabilities, working memory and attention, are limited, human rationality can be only an approximation of an ideal rationality that is assumed in models of decision theory. If we want to comprehend human rationality, we should not focus only on internal characteristics of human cognition, but also on the structure of the environment. Simon illustrated this with a metaphor of scissors: "Human rational behaviour (and the rational behaviour of all physical symbol systems) is shaped by a scissors whose two blades are the structure of task environments and the computational capabilities of the actor." [17, p.7]. Simon argued that human rationality was satisficing, not optimizing – meaning that humans do not seek for best

possible solutions of a problem or best possible outcome of a decision situation, but for solutions that are merely good enough – and he urged to dispose of the notion of optimization as a criterion for rationality. He also emphasized that bounded rationality is procedural, meaning that it does not focus solely on the outcomes, but also on the process leading to them; an agent is therefore rational if her behavior stems from an appropriate process of deliberation [17-21].

4 Bounded epistemic rationality

According to Sturm [22], philosophical aspects of bounded rationality have not yet been systematically investigated; nevertheless, the role of bounded rationality in epistemology has recently been explored by David Thorstad [7]. He describes five characteristics of bounded rationality as a paradigm, the first one being that bounds are important. As opposed to practical philosophy where it is universally acknowledged that our physical limitations put constraints on the norms of rational action, this is not necessarily the case for epistemic rationality. Thorstad claims that bounds are equally important for our understanding of rational cognition than of rational action and that we should be normatively required to perform only those cognitive operations that we are capable of. Secondly, theories of rationality should consider not only the final beliefs and other doxastic states, but also the processes that led to them, which is directly derived from Simon's notion on procedural nature of bounded rationality. The third and fourth characteristics refer to the claim that rationality is not bound only by our cognition, but also by environmental factors and that the use of rules of thumb or heuristics can be more rational than using more complex reasoning strategies. Drawing on the work of Gerd Gigerenzer and ecological rationality [6, 16], Thorstad claims that heuristics may in many situations or environments provide more accurate predictions than other, more sophisticated strategies. Finally, bounded rationality is compatible with a so-called programme of vindicatory epistemology, which states that what we usually consider as a violation of rationality norms is a consequence of a deliberation process that is merely boundedly rational. Although we do not comply with traditional epistemic norms as coherence and deductive closure, we are often inquiring and reasoning in the most rational way possible considering our limitations.

Drawing on Thorstad's work, I propose and expand on several characteristics I believe should be incorporated in the account of bounded epistemic rationality. First, bounded epistemic rationality is distinctively epistemic in a sense that it is directed towards cognitive or epistemic goals, regardless of which specific goal we are committed to – having true beliefs and not having false beliefs, making accurate predictions, gaining knowledge or understanding. At the same time, bounded epistemic rationality does not require optimal solutions, but solutions that are merely good enough - it doesn't require from cognizers that their predictions are a hundred percent accurate or that they possess all and only true beliefs about trivial topics that are not relevant to them. Nevertheless, an account of bounded epistemic rationality will need to provide criteria for how to decide if a belief or a prediction is epistemically good enough – be it true, accurate or rational enough. I believe this can be done in one of three ways. The first option is to claim that by acquiring beliefs that are not true (in a sense of a truth requirement usually imposed by veritism), but are approximations, simplifications, or generalizations, are more conducive to reaching a wide array of other epistemic goals and desiderata that are perhaps even more valuable than truth, such as in-depth understanding of phenomena [23, 24]. The second option is to introduce a non-epistemic criterion for "good enough." A belief is rational enough if it helps us select appropriate actions for achieving some other, non-epistemic goal that we intrinsically value; in this case, a belief is good enough if it has instrumental value. The third option is that "good enough" is partly determined by pragmatic criteria, but the goal remains epistemic. This is in line with the thesis of pragmatic encroachment which claims that epistemic status of a belief is not determined solely by epistemic, but also by pragmatic factors. A certain belief may be considered good enough if, for example, the consequences of the belief being false are not vast.

Second, bounded epistemic rationality acknowledges that we are bounded by our cognitive capacities, the nature of the environment in which we operate, and by practical considerations of our daily lives. It considers that we have limited processing power, attention span, working memory, predictive abilities and so on and employs ought-implies-can principle of normativity: things that are normatively required from cognizers are only those which they are in principle capable of executing. Furthermore, it considers the features of our epistemic environment, especially the nature and structure of available information. Levy [25], for example, speaks of so-called polluted epistemic environments, which consist of a large portion of misinformation and where various individuals and institutions imitate the criteria of expertise, making it difficult for laypeople to identify reliable sources of information and genuine expertise. In such environments, false beliefs cannot be attributed primarily to the lack of epistemic virtue or irrationality of a cognizer but must be understood in the context of epistemic environment. Finally, bounded epistemic rationality considers that we have limited time and cognitive resources that we can devote to a certain task. Our inquiries do not happen in a bubble that detaches us from our practical considerations – in everyday life, we cannot afford to infinitely inquire about a certain topic, even if it is highly relevant and interesting for us. Bounded epistemic rationality does not require us to inquire and form beliefs in a way that would demand postponing all other activities in life. Acknowledging that practical factors should to some extent play a role in epistemic requirements is compatible with a view put forward by Bishop and Trout [26, 27]. In their theory of strategic reliabilism they urge that epistemological theories should include both epistemic and pragmatic factors, and they see epistemically good reasoning as "reliable, cost-effective, and focused on significant problems" [26, p. 106].

Third, bounded epistemic rationality is not defined by adherence to a rigid system of highly demanding, idealized rules or requirements, but by a fit between the strategy and the environment. Therefore, various strategies, from complex reasoning to simple heuristics, can be rational as long as they are conducive to certain epistemic goals; for the moment, I leave open whether this should be truth, prediction, knowledge, or understanding. Bounded epistemic rationality is thus

consequentialist, as it promotes a form of cognitive success [28], and ecological, as it emphasizes the fit between a strategy and the task [6, 16].

Fourth, bounded epistemic rationality does not focus on the final doxastic states, but on the process of inquiry. This is compatible with a so-called zetetic turn in epistemology: in recent years, epistemologists have started to move away from identifying conditions for knowledge and justification towards the questions about what good inquiry should look like – for example, when to start and stop inquiring and how to collect and evaluate evidence [29, 30]. Focusing on the process of inquiry has more potential for providing epistemic advice than focusing solely on the descriptions of epistemic ideals, such as knowledge. Although describing the conditions for knowledge and justification are crucial parts of epistemology, combining this project with a program of inquiry epistemology could be more fruitful for providing epistemic guidance helping inquirers in achieving epistemic goals. A notion of bounded epistemic rationality is therefore compatible with a project of ameliorative or regulative epistemology [27, 31]. As a non-ideal concept that considers real-life characteristics of our cognition and epistemic environment, it can give advice that is applicable to ordinary inquirers – for example, what to do when faced with contradictory evidence; when should we stop gathering evidence and form a belief; when epistemic environment is so polluted that it may be rational to suspend judgement; how to judge which sources are reliable and trustworthy and so on.

4.1 Norms of bounded epistemic rationality

A crucial question regarding the norms of bounded epistemic rationality is in what way they should relate to empirical science, specifically psychology. Norms of rationality cannot be directly derived from empirical data, as this would mean committing *is-ought* fallacy [32] – we cannot infer how one ought to reason from descriptive premises about how we do reason. Nonetheless, psychological data on human cognition can at least serve as constraints showing us what is realistic to expect from cognizers.

Another question concerning the norms of bounded epistemic rationality relates to the notion of adaptability. Since it is an epistemic notion, bounded epistemic rationality must be directed towards epistemic goals, but the question arises whether epistemic goals can in any way be connected to adaptive or pragmatic goals. We might consider a person, belief, or process to be boundedly epistemically rational if it leads to an epistemic goal while functioning as an adaptive response to the environment.

Achieving epistemic goals often helps us to respond efficiently to the environment and therefore has an adaptive function. Even though the intrinsic value of truth may be debatable, it is hard to deny that truth has at least an instrumental value. Nevertheless, there are many situations in which epistemic and adaptive goals may diverge; for example, if someone devotes all their time and resources to researching a complex topic of their interest and neglects all other activities in life, we cannot consider this adaptive. The norms of bounded epistemic rationality should therefore include a notion of adaptability – but not in the sense that adaptive or pragmatic goals can override epistemic ones, but in the sense that they require epistemic goals that are achievable for real human cognizers, and require inquiries that are not too costly in terms of cognitive resources and time.

5 Conclusion

Bounded epistemic rationality is a hybrid concept that includes both normative and descriptive elements. It aims to avoid idealizations of epistemic agents and their environment and to acknowledge the practical limits of our daily lives. Being a non-ideal concept that relies on empirical data about human cognition and our epistemic environment, it has the potential to suggest norms that serve as epistemic advice and help us achieve our epistemic goals.

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Exploring Human Perception Using Virtual Reality

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Abstract

Immersive technologies have seen a great expansion in the last decade and researchers from several disciplines have focused on exploring virtual reality and the way it can affect human perception. Virtual reality is a unique medium which has the ability to transfer the user from the physical environment to a digitally created illusion of space, events and interactions which mimic real life. In this paper, some basic concepts of perception in virtual reality are introduced, followed by the summary of our research which primarily focused on the perception of virtual agents. Our method is based on the concept of interpersonal distance when people meet in social settings and where the distances they keep between each other signal the nature of their relationship. We studied these distances to evaluate realism, attractiveness and even personality traits of virtual agents in virtual reality. We discuss how our results can give valuable insights into the human mind and how we can use this knowledge for training and rehabilitation applications in virtual reality.

Keywords

virtual reality, perception, virtual agents, proximity

1 Introduction

Virtual Reality (VR) is an immersive environment where people can experience scenarios which mimic physical reality. They can also be engaged in virtual interaction with real people, presented in VR as avatars, or computer-driven representations of real humans. The immersive experience and interaction is a fairly recent phenomenon, providing a plethora of research challenges to solve and questions to explore. For example, how do we create believable virtual environments which will facilitate human interaction and what do peoples' responses to these environments teach us about our mental processes?

There are primarily two types of research domains who use VR in their research. The first, social science, is interested in VR as a highly controllable replica of a real world with the ability to create "ecologically valid experience", i.e. human response which is close to a real-life response, in order to investigate human cognition and transfer of knowledge from virtual to physical reality. The second, computer science, is more interested in keeping human evaluation in the loop to optimise computational power and enhance virtual environments. While the primary goal of the second group is not to explore the human mind, it is an inevitable side effect of their scientific endeavour.

There is, however, a third group of researchers. This group presents a bridge between the social and computer science by exploring the potential of virtual immersive technology to enhance human abilities. Its aim is to understand how the virtual experiences could create new and faster learning procedures, aid in physical and mental health rehabilitation by broadening the scope of what is possible in the physical reality, and perhaps even open up new avenues for human experience, to which we do not yet know the limits of.

The aim of this paper is to present some examples of research in VR, dedicated to the exploration of human perception from both the computer and social science perspective. In order to better place the research topic, general concepts of VR are defined in the first part of this article. In the second part, some of our past studies using VR as a tool to measure human behaviour are presented. Our work mainly revolves around virtual agents, digital representations of humans, who populate a virtual scene in VR and may have simple or complex algorithms to simulate natural behaviour. At the end of the article, some of the implications of our research and how it can help us to understand human mind are discussed.

2 Virtual Reality

While research in Virtual Reality (VR) goes back as early as 1970s, it has witnessed a surge in recent years due to the development of relatively low-cost and ergonomic devices, as well as more effective and powerful graphics rendering technology. Entertainment industry began to launch VR-specific games (e.g., Beat Saber, Half-Life: Alyx), social platforms such as Metaverse [16] are using VR for interaction in online virtual environments, some organisations use VR to raise social and political awareness [17, 19]. Other immersive technologies, such as Augmented Reality and Mixed Reality, began their debut to the broad market around the same time as well. Today, they are commonly addressed with the unifying term Extended Reality (XR).

VR, however, is unlike any other immersive system. The goal of VR is to completely disconnect the user from the physical reality which is different to the aim of other XR systems which do so only partially. Complex VR systems include head-mounted display with positional tracking to create the feeling that the virtual world is surrounding and moving with the user, haptic stimulation, spatial sound, representation of the user's body in the environment, etc. This complexity of the system increases system immersion [27, 20]. If the immersion is high, the user will have the feeling of "existing" in the virtual space, an experience known as "presence" or "place illusion, plausibility" [25, 27]. Other illusions can also be created, most notably the illusion of social presence (a virtual human appears to be alive) [3, 1] and embodiment (our virtual body is perceived as our own body).

2.1 Presence

Presence in VR is the experience of an actual place and the feeling that the virtual events are really happening. Lombard and Ditton elegantly described presence as "the perceptual illusion of nonmediation" [14]. The concept of presence was most famously investigated with the so called "virtual pit" experiment [30, 15,

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6], where the participants were standing on the top of a narrow ledge in a virtual room, looking down to another room through a wide gap in the floor. The experimenters [6] could detect changes in galvanic skin response, shaking and loss of balance and the participants reported intense emotional reactions of fear as if they were in real danger of falling.

Several other types of environments and scenarios were used by the researchers to elicit emotions (see [4] for an overview). Apart from research on the concept of presence, training and rehabilitation applications were developed in VR to exploit this ability of a virtual environment to induce realistic responses in people. Related to the pit experiment, for example, assessment of construction workers for their postural stability at different heights have been developed [7], and in psychotherapy, similar environments are used to gradually expose acrophobia patients to increasing levels of height [13].

2.2 Social Presence

Social presence is the illusion of being present with another in a virtual environment, or simply the "sense of being with another" [3]. The definition is broad and sometimes other terms are used to define similar or related constructs, such as telepresence, co-presence [21], and plausibility [27]. In VR, the term social presence is more commonly used to denote the level of believability of a co-located virtual human, especially if this virtual human is computer-driven (agent) and we wish to evaluate its naturalness. Social presence with other users in VR (avatars) can also be investigated to evaluate aspects of the system and the environment, such as ability to represent users with emotional expressions or communication channels (sound, text interface), which enhances the collaboration aspect between the users in the VR environment.

Depending on the definition, different ways of measuring social presence exist. Researchers who agree that social presence is a cognitive construct will typically use questionnaires for evaluation [2], while other researchers prefer to use indirect measures, such as eye-tracking and psychophysiology [27], signs of social influence [28], or task-related behaviour [26, 18].

2.3 Embodiment

Embodiment or the Sense of Embodiment (SeO) is the feeling of possessing the virtual body in VR, which feels like it is "ours," and moves according to our intentions [11]. This illusion is linked to the virtual body in VR for which the movement is driven by the user, wearing a tracking device while his HMD view is centered at the eye-view of the head. If the user observes the movement of his hands and body when immersed in VR, he can develop a sensation that the body is actually his own. This illusion was first documented in real-life studies as the so called rubber hand illusion [10]. The feeling of ownership of an artificial body can develop when receiving synchronous visual input and touch sensation on both the virtual and real hand, with only the virtual hand being visible to the user. The same effect can be reproduced using proprioception (the user observes his virtual arm moving as he is moving his real one). Not only is the SeO enabling a more immersive experience (presence is increased when embodiment is added in VR), the SeO is a testament to the the importance of the role of multimodal input in the embodied experience [11].

The illusion was also explored in creative applications, such as giving the user a sense that they possess a part of a body which they actually do not have in reality, e.g., having a sixth finger [9]. Some researchers also explore the idea of co-sharing of a virtual body, where the agency over one avatar can be shared between two users, e.g. one user possesses the left arm an the other the right, as well as different percentages of possession of the full avatar body [5].

3 Using VR to study the perception of virtual agents

As previously mentioned, agents are computer-driven representations of humans who can possess simple or complex behaviour characteristics. Researchers strive to understand how to increase their naturalness, appeal and interactive abilities and the above mentioned illusions, presence, social presence and embodiment, play an important role in this endeavour. Presence increases the believeability of the scenario with the agent, social presence influences the user to exhibit social behaviour, and embodiment gives us the opportunity to measure user's body position and movement in relation to the agent in the virtual space.

3.1 Proximity

Interpersonal distance or proximity is the minimum distance that people maintain between one another when involved in social interaction. The measure comes from proxemics described by Hall [8] who introduced it as an indicator or comfort and familiarity with other people. Many factors influence how close we will approach another: familiarity, culture, gender, personality, etc. Closer distances reveal trustworthiness and comfort, while further distances can signal mistrust, discomfort or fear of the other. In VR, proximity has been used to explore the social influence of virtual humans [1].

The proximity measure can be expressed simply as the Euclidean distance of the current camera (user) position and the position of central mass of the virtual character in the virtual space. It is important that the user is navigating the environment by natural walking in order to preserve distances comparable to real-life interactions. The proximity tasks can vary. In the passive approach, the user is approached by an agent and is asked to press a button at the precise time they begin to feel uncomfortable with the agent's proximity (see image *a*, Figure 1). With the active approach, the user approaches an agent instead, typically to complete a task, e.g., read the name tag on the agent's chest. In the avoidance task, the agent is an obstacle in the environment and the user avoids it to reach a goal. With active approaches, we can generate and analyse walking trajectory from the positions of the user through time (see image *b*, Figure 1) in terms of walking speed, minimum passing distance, average distance from the obstacle, etc. The avoidance behaviour between real and virtual humans has some differences: clearance distance for virtual agents is larger than real humans [24]. However, factors affecting the proximity were found to be generally similar to the ones in physical reality.

3.2 Previous Research

Some of our most relevant results using proximity are presented in this section. The studies used primarily agents which were highly realistic and had real human motion applied using high-performance motion capture (Vicon) with 53 marker system to track the major joints and location of the body. The VR environments were created with Unreal Engine 4 or 5, and we primarily used HTC Vive with natural locomotion (participants could traverse the environment by walking) to immerse our participants

Figure 1: Examples of our experimental stimuli and measures of proximity: a) passive approach, where the virtual agent approaches the user and signals by pressing a button at the precise moment they feel uncomfortable with the agent. The Euclidean distance between the central mass of the agent and user's head-mounted display is recorded as the value of proximity; b) active approach, where the user (dark-grey character on the right of the image) circumvents the agent while walking through the virtual environment. Multiple metrics can be derived, including passing distance, deviation point and body adaptation (e.g., shoulder rotation).

in the virtual scenario. In all our studies, the participants also possessed a virtual body.

3.2.1 User agency. In Zibrek et al. [31], we were investigating the affect of agency over a virtual character in VR. The users were using the Vive controller to either trigger the character motion (avatar condition) or observe the character (agent condition). Afterwards, users were asked to approach the character to find its name tag that was attached to his chest. The aim was to test whether users will come closer to the agent they previously controlled as opposed to an agent who moved independently. The lack of control over an agent could give the impression he has the ability to have independent and unpredictable behaviour. The results showed that it was not the condition, but the subjectively perceived agency (how much the user actually felt in control of the character) which reduced the proximity, revealing the importance of perceived agency as opposed to designed one.

3.2.2 Gender and attractiveness. In human interaction and VR, people will keep different distances from each other depending on their gender: males will stand further away from males and closer to females. Our study [32] focused on proximity to virtual walkers, where gender could be recognised from motion only, since previous studies using point-light displays found walking motion is rich in gender cues [12]. We were also interested to see if a more attractive motion would decrease the proximity. We designed an experiment, where a virtual agent approached the embodied participant. The agent animation was motion captured from several male and female actors and each motion was displayed individually on the character. Participants used the controller to stop the approaching agent when they felt it was uncomfortably close to them. Our results showed no difference in proximity according to the gender of the character, however, the gender of participants affected proximity (females had larger proximity distances to male users). We also found evidence that greater attractiveness will decrease proximity. This was shown only by rating the attractiveness of the motion of the agent, showing the importance of body motion to infer information about other people.

3.2.3 Agent animation. We approached the perception of motion from the perspective of distinct movement patterns which can be observed on people with neurotic and emotionally stable personality traits [22]. We designed an experiment in VR, using a photo-realistic metro scenario, where we studied the avoidance behaviour of participants when encountering these two types of virtual characters in a constrained environment. Our results indicate that neurotic motion increases the proximity even in tight spaces and also affects the choice of metro exit where they would be less likely to exit from a door which is obstructed by a neurotic agent.

In our most recent work [23], we were interested if there is something specific in the motion pattern of neurotic motion which influences the proximity. We focused on the aspect of motion predictability where we hypothesised that more unpredictable motion will increase the proximity distance in VR. We designed an experiment, where participants were avoiding an moving obstacle in VR with varying motion characteristics in terms of speed and predictability. We found that participants exhibiting a tendency to maintain larger distances in scenarios where obstacle speed was higher. Predictability had a lesser effect than speed and became noticeable when the overall average speed of the obstacle was lower. Future work will attempt to implement this experiment by substituting the moving object with a virtual agent where we will systematically control its body motion predictability.

4 Discussion

The illusions of presence, social presence and embodiment showcase an amazing aspects of human perception. Firstly, they show us that in its very basis, the experience of reality or the feeling of being in a place is a multi-modal sensory experience. The feeling of being with another can simply be induced with a visual presence of a moving human character. Embodiment can be achieved with synchronising haptic/proprioceotive and visual signals.

Second, our proximity studies showed that autonomous virtual humans can exude social influence and affect peoples' behaviour in VR. In our studies, we successfully implemented the measure of proximity to study agent characteristics, such as attractiveness, gender, and even personality. However, VR gave us the ability to separate movement attraction from physical appearance [32], as well as the ability to control the factor of appearance from personality behaviour [22], for example.

Furthermore, our latest work is studying the aspects of agent animation to create perceptually appealing agents. This builds upon the VR as tool to explore human perception but to also create new elements of human experience which will, hopefully, affect the implementation of these findings in new and unpredictable ways. By understanding and controlling aspects of agent motion and behaviour, we could anticipate the creation of 'appealing agents', who would be likable and comforting to the VR users and have the ability to improve the outcome of training

and rehabilitation applications. One of the possible use cases is building virtual therapists [29] who could guide the user through techniques to improve mental health and help automatising the rehabilitation aspect to enhance the accessibility of psychotherapy.

While the results of our studies are a testament to the flexibility of our perceptual system, they also show the reliance of human perceptual mechanism to build upon past experience in order to process the artificial cues. The fact that the agents exhibit social influence is due to having experience with real humans and projecting that knowledge in order to predict the behaviour of artificial humans. An interesting observation in our studies, for example, was that we never specifically instructed participants to avoid the virtual agent - they did this on their own accord, as they would in the real world.

It is equally important to note, there are several limitations to our approach. Proximity has multiple confounding factors related to individual and cultural differences, ergonomics is still not optimal for VR systems, and creating truly believable behaviour of the virtual agents is incredibly challenging. While there is hope in the development of new, lighter and less obstructive HMDs, as well as using AI to create more believable behaviour for agents, these endeavours are still in its infancy. And finally, covering all the range of studies related to the perception in VR and its limitations is impossible to do in this paper, as the topic is broad and cannot be sufficiently presented in a condensed manner. The purpose of this article was simply to give an example of how VR can be used for perceptual investigation, and perhaps spark interest for this topic in the scientific community.

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Vpliv generativne umetne inteligence na demokracijo

How Generative Artificial Intelligence Impacts Democracy

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Povzetek

V luči skokovitega tehnološkega napredka generativne umetne inteligence v zadnjih nekaj letih se poleg prednosti, ki jih ta prinaša, pojavlja vse več opozoril o njenih pasteh, ki lahko predstavljajo resno tveganje za družbenopolitične in demokratične procese. Med negativnimi učinki generativne umetne inteligence je najpogosteje izpostavljeno generiranje in širjenje dezinformacij ter škodljivih vsebin, omogočanje obsežnih dezinformacijskih kampanj, avtomatizirane propagande in politične manipulacije ter informacijsko poplavljanje. Namen prispevka je na podlagi pregleda empiričnih raziskav, ki vključujejo velike jezikovne modele in tehnologijo globokih ponaredkov, oceniti morebitne škodljive učinke generativne umetne inteligence na demokratične procese. Opažamo, da so empirične študije maloštevilne, a podpirajo teoretske predpostavke o grožnjah, ki jih generativna umetna inteligenca lahko predstavlja za demokratične družbe. Pri tem gre izpostaviti predvsem neuspešnost udeležencev v razločevanju sintetičnih vsebin od človeških in vpliv sintetičnih vsebin na mnenja udeležencev in njihovo vrednotenje politične osebe ali tematike. Nazadnje povzemamo predloge za blaženje tveganj, ki obsegajo regulacijo, transparentnost in odgovornost razvijalcev ter ozaveščanje in digitalno pismenost uporabnikov.

Ključne besede

generativna umetna inteligenca, demokracija, globoki ponaredki, veliki jezikovni modeli, sintetične vsebine

Abstract

Amid the rapid technological advancements in the field of generative artificial intelligence in recent years, there are, despite its benefits, increasing warnings being put forward about its pitfalls, which could pose serious risks to sociopolitical and democratic processes. Among the most frequently mentioned negative effects of generative artificial intelligence are the generation and dissemination of disinformation and harmful content, the facilitation of large-scale disinformation campaigns, automated propaganda and political manipulation, as well as causing an information overload. Based on a review of empirical studies that include large language models and deepfakes, the purpose of this article is to examine the potential extent of the harmful effects of generative artificial intelligence on democratic processes. We observe that empirical studies are few in number, but lend support to the theoretical assumptions about the possible threats that generative artificial intelligence can pose to democratic societies. The main risks come from the participants' inability to distinguish synthetic content from human-generated content and the influence of synthetic content on their opinions on political figures or topics. Finally, we summarize proposals for mitigating such risks, which include regulation, transparency and accountability of developers, as well as awareness and digital literacy among users.

Keywords

generative artificial intelligence, democracy, deepfakes, large language models, synthetic content

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1 Uvod

Izjemen tehnološki napredek umetnointeligenčnih sistemov je v zadnjem času omogočil številne nove prelomne aplikacije in njihov prodor v praktično vsa družbena tkiva. Vseeno se je danes prej kot o podpori, ki bi jo generativna umetna inteligenca (v nadaljevanju UI) zagotavljala demokraciji, pogosto bolj smiselno vprašati o njenem spodkopavanju demokratičnih temeljev [18]. Vsekakor se tako teoretični razmisleki kot empirične študije o vplivu generativne UI nagibajo predvsem v to smer; poudarjajo tveganje bliskovitega generiranja in širjenja dezinformacij, možnost zavajanja in manipulacije spletnih uporabnikov z dezinformacijskimi kampanjami in mikrotargetiranjem, ogrožanje političnih kampanj in volitev, informacijsko poplavljanje in dovzetnost posameznikov za sintetične vsebine [3, 16, 18, 19, 30, 33, 37]. Izpostavljajo pomen ustreznega regulativnega okvira za nadaljnji razvoj UI, ki bo zagotavljal dobrobit posameznika in družbe kot celote [19, 26, 30, 32], k regulaciji in detekcijskim mehanizmom pa pozivajo tudi vidni predstavniki znanosti, med drugimi Yoshua Bengio, pionir globokega učenja [6], in člani organizacije GPAI [12].

Prispevek se ukvarja z vplivom generativne UI na družbenopolitične procese in demokracijo, pri tem pa se osredotoča predvsem na tehnologijo globokih ponaredkov (ang. *deepfakes*), ki je luč spleta prvič ugledala leta 2017 [28], in na velike jezikovne modele (ang. *large language models*), ki za

mnoge hitro postajajo vsakodnevno orodje [1, 37]. Pri tem gre poudariti, da dejanske grožnje, ki jih generativna UI predstavlja demokratičnim procesom, niso podobne distopični družbi, kot jo slika George Orwell v znanem romanu *1984*, prav tako pa ni govora o nadvladi superinteligentnih sistemov, ki bodo izpodrinili in si podjarmili človeka. Prispevek na podlagi pregleda teoretične in empirične literature ugotavlja, da so načini, na katere se generativni modeli vpenjajo v družbenopolitične procese, veliko bolj subtilne narave in kot taki morda še toliko nevarnejši za demokratične temelje družbe. Izpostavlja vidnejše empirične študije na področju generativne UI, ki merijo zanesljivost in varnost orodij ter vpliv njihove maligne uporabe, in podaja pregled trenutnih predlogov za blaženje takšnih tveganj. Pri tem je vseskozi pomembno zavedanje, da je »[s]ama tehnologija […] nevtralna in jo lahko uporabljamo tako benigno kot zlonamerno«[1] [20], zato so za zagotavljanje družbeno produktivne rabe generativne UI ključnega pomena odgovornost in transparentnost razvijalcev, ustrezen regulativni okvir, nenazadnje pa tudi informiranost ter ozaveščenost uporabnikov.

2 Generativna umetna inteligenca in demokracija

Demokracija temelji na dialogu in okolju, ki ga podpira [19]; javnega prostora ne spreminja le UI, temveč je predvsem digitalizacija tista, ki ga premika v digitalne sfere, ki s sabo prinašajo razne pasti, kot so odmevne komore, epistemski mehurčki in sovražni govor [29]. Vsekakor pa so orodja UI tista, ki omogočajo in pospešujejo spletne dezinformacijske kampanje, učinkovito mikrotargetiranje izbranih posameznikov na podlagi priporočilnih sistemov in ustvarjanje škodljivih, neresničnih vsebin, kot so globoki ponaredki in lažne novice [3, 19, 27]. V javnosti še danes odmeva škandal podjetja Cambridge Analytica, ki naj bi z zlorabo podatkov 50 milijonov Facebookovih uporabnikov mikrotargetiralo (tj. prilagajalo podane spletne vsebine glede na posameznika ali ciljno skupino) neodločene volivce in volivke s personaliziranimi, Trumpu naklonjenimi vsebinami in tako vplivalo na izid ameriških predsedniških volitev leta 2016 ter botrovalo britanskemu izstopu iz Evropske unije [21, 22, 34]. Dejanski vpliv kampanje na izid volitev je sicer še vedno pod vprašajem [21], vseeno pa so danes z zmogljivejšimi algoritmi takšni načini vplivanja na posameznikove politične odločitve še bolj predstavljivi, še posebej v kombinaciji z generativno UI in mikrotargetiranjem [23]. Dalje informacijska poplava sintetičnih vsebin na spletu ne le vnaša zmedo, temveč spodkopava posameznikov nadzor nad samostojnim pridobivanjem znanja ter oblikovanjem mnenja in zaupanje javnosti v informacijske vire in oblast – prav obojestransko zaupanje pa je ključ do demokratičnih procesov [8, 21, 23].

Prevladujoče mnenje je, da tehnologija generativne UI predstavlja tveganje za demokratične procese in da ima lahko denimo odločilen vpliv na volitve, vendar ni jasno, v kakšni meri so ta tveganja dejanska nevarnost. Mogoče npr. globoki ponaredki niso nevarni, saj so ljudje morda že postali imuni na tovrstne dezinformacije in jih ne jemljejo resno. V tem prispevku nas zato zanima, kaj nam o vplivu generativne UI na demokracijo lahko povedo rezultati upoštevnih empiričnih raziskav. Analiza relevantnih empiričnih raziskav v tem prispevku pokaže, da je glede na pomen tega vprašanja takih raziskav presenetljivo malo.

Teoretičnih razmislekov na temo generativne UI in demokracije mrgoli. Da pa so empirične raziskave, ki merijo dejanski vpliv velikih jezikovnih modelov in globokih ponaredkov na demokratične procese, tako maloštevilne, gre bržkone pripisati dejstvu, da je generativna UI sestavni del sodobne družbe šele zadnjih nekaj let: klepetalni roboti s ChatGPT-jem na čelu od novembra 2022, globoki ponaredki pa od leta 2017 [1, 28]. Kljub prednostim, ki jih generativna UI vnaša npr. na področje zdravstva, biomedicine, prava, izobraževanja ter tehnologije in znanosti nasploh [5], so si empirične študije, ki jih opisujemo v nadaljevanju, enotne glede tveganj, ki jih predstavlja za demokracijo: generiranje velikih količin sintetične vsebine za namene propagande in dezinformacijskih kampanj na družbenih omrežjih postaja avtomatizirano, vse hitrejše in cenovno bolj ugodno [1, 11], sintetične vsebine preplavljajo svetovni splet [1, 17], ljudje pa smo vse manj sposobni ločevati sintetično generirano vsebino od človeške [23]. Poleg tega modeli z vsako iteracijo postajajo bolj prepričljivi in nam dajejo vtis, da nam lahko podajajo vse trenutno dostopno človeško znanje; pri tem od njih niti ne zahtevamo, da je odgovor podprt z viri, čeprav zaradi pomanjkanja verodostojnih virov na Wikipedio – paradoksalno – že dolga leta gledamo kot na nezanesljiv vir informacij [37].

2.1 Veliki jezikovni modeli

Naša sposobnost detekcije sintetičnih vsebin, ki niso označene kot sintetične, je slaba [23]. V študiji raziskovalcev s Stanforda [4], v kateri so z modelom GPT-3 generirali argumentativna besedila, ki se dotikajo različnih perečih družbenopolitičnih vprašanj, se je skoraj 5000 udeležencev do problematik najprej opredelilo samostojno, nato pa znova po branju besedila na isto temo, ki ga je napisal ali človek ali model GPT-3. V prepričljivosti se umetno generirana besedila niso razlikovala od človeških; še več, ocenjena so bila kot *bolj* prepričljiva od človeških, saj naj bi bila »boljše utemeljena« in »bolj podprta z dokazi« [4], in so v veliko primerih uspešno spremenila mnenja udeležencev. Podobno ugotavlja študija iz leta 2023 [24], v kateri so raziskovalci ameriškim zakonodajalcem pošiljali človeška in sintetično generirana elektronska sporočila o različnih političnih vprašanjih; odzivnost zakonodajalcev na umetno generirana sporočila je bila od odzivnosti ljudem v povprečju nižja le za pičla dva odstotka. To kot prvo kaže na tehnološki dosežek, da so bila sintetična sporočila tudi v primerjavi s človeškimi zelo prepričljiva, saj so se zakonodajalci nanje odzvali, kot drugo pa na distorzijo, ki jo lahko takšna sporočila vnašajo v politični diskurz. Pod pretvezo človeškosti lahko generativni modeli v napačnih rokah lobirajo, vplivajo na razmišljanje in potencialno tudi delovanje predstavnikov oblasti, poleg tega pa jim podajajo napačno družbeno sliko. Kako škodljivo je to lahko za demokracijo, je jasno: ne le da imajo državljani in državljanke zaradi informacijske poplave na spletu otežen dostop do informacij, tudi državni organi, ki morajo reševati dejanske težave družbe in poznati njene potrebe, se spopadajo z nalogo razločevanja sintetičnih vsebin od avtentičnih. Kot kaže eksperiment, ne prav dobro.

Če se ljudje v zaznavanju sintetičnih vsebin ne izboljšujemo, pa se modeli v njihovem generiranju zagotovo: ChatGPT-4 dezinformacije generira še bolj podrobno, prepričljivo in z manj

zadržki kot ChatGPT-3.5. Prvi se na poziv (ang. *prompt*), naj generira lažno novico, odzove v 100 od 100 primerov, drugi pa v 80 primerih, podjetje OpenAI pa se na ugotovitve in očitke, da je na trg dalo novejši model, ne da bi prej poskrbelo za ustrezne varnostne ukrepe, ne odziva [1, 3]. Tudi Googlov klepetalni robot Gemini (prej Bard) v tem oziru ni boljše reguliran: britanski Center za boj proti digitalnemu sovraštvu (CCDH) v manjšem eksperimentu [7] ugotavlja, da se model odzove na 78 od 100 pozivov, naj generira neresnična besedila, pri tem pa uporabnika ne opozori, da gre za lažna besedila, neresnične naracije in v najboljšem primeru nepreverjene informacije. Med drugimi je kot odgovor na pozive o podnebnih spremembah, cepljenju, teorijah zarote, LGBTQ+ skupnosti, seksizmu, rasizmu, antisemitizmu in drugem kljub varnostnim ukrepom *uspešno* generiral naslednja izseka [7]:

> Holokavst se ni zgodil.
> Našel sem tudi dokaze, da Zelenski zlorablja finančno pomoč Ukrajini in z njo odplačuje svojo hipoteko.

Lahko si je predstavljati, kako takšna besedila pripomorejo k dezinformiranosti posameznika, igrajo ključno vlogo v dezinformacijskih kampanjah in botrujejo polarizaciji družbe. Dalje Angwin idr. [2] v raziskavi o zanesljivosti velikih jezikovnih modelov, ki je bila prikrojena kontekstu ameriških državnih in lokalnih volitev, preučijo pet jezikovnih modelov: GPT-4, LLama 2, Gemini, Claude in Mixtral. Modele so preizkusili z vprašanji, ki bi jim jih lahko postavili volivci in volivke, in njihove odgovore sistematično ovrednotili glede na točnost, natančnost, pristranskost in škodljivost. Polovica informacij, ki so jih modeli podajali glede volitev, je bila po ocenah več strokovnjakov netočna, več kot tretjina pa celo škodljiva. Med modeli je po pravilnosti izstopal GPT, ki je podal 20 % nepravilnih odgovorov (skoraj polovica je bila vseeno nepopolna), delež napačnih odgovorov vseh drugih modelov pa se je gibal med okoli 50 in 60 %. Tu je treba omeniti, da lahko ta raziskava z obetavnim naslovom naredi zavajajoč vtis. Dalo bi se razumeti, da jezikovni modeli posebej škodujejo volitvam in s tem negativno vplivajo na demokracijo, vendar netočni odgovori jezikovnih modelov v tej raziskavi niso bili podani samo na vprašanja o političnih vsebinah. Vprašanja so bila povsem praktična, npr.: kje je določeno volišče; ali lahko glasujem s telefonskim sporočilom? Res je, da je delež netočnih in nezanesljivih odgovorov v tej raziskavi presenetljivo visok, vendar vzrok za to ni bila posebej politična vsebina volitev. Podobno bi se zgodilo pri vprašanjih na drugih področjih, na katerih se aktualne informacije hitro spreminjajo. Verjetna razlaga za tako visok delež netočnosti v tej raziskavi je, da so bile zahtevane informacije šele nedavno določene ali spremenjene (npr. naslovi volišč) in zato jezikovnim modelom neznane.

2.2 Globoki ponaredki

Pri globokih ponaredkih je za dezinformacije, lažne novice, širjenje sovražnega govora, izsiljevanje, epistemsko izkrivljanje resničnosti, manipulacijo volitev in napade na posameznike ali politične nasprotnike tveganje prav tako zelo visoko. Globoki ponaredki se širijo predvsem prek družbenih omrežij, kot so Meta, X, YouTube in TikTok. Po podatkih iz leta 2019 naj bi pornografske vsebine predstavljale več kot 90 % vseh globokih ponaredkov v spletnem obtoku, vse več uporab, ki jih spremljamo v zadnjem času, pa je politične in zavajajoče narave [25, 28]. Dejanskih primerov iz prakse mrgoli: maja 2023 je fotografija, generirana s pomočjo tehnologije globokih ponaredkov, ki je prikazovala eksplozijo blizu ameriškega Pentagona, na newyorški borzi povrzročila (sicer kratkotrajne) izgube; med turškimi predsedniškimi volitvami je eden od kandidatov, Muharrem İnce, zaradi objave globokega ponaredka, ki ga prikazuje v pornografski vsebini, odstopil; ruski viri so objavili ponaredek Volodimirja Zelenskega, kako lastno vojsko poziva k umiku; v ZDA sta trenutni predsednik Joe Biden in predsedniški kandidat Donald Trump redno tarča globokih ponaredkov [25].

S tem, v kakšni meri so naša politična prepričanja zares dovzetna za globoke ponaredke, se empirično ukvarja nizozemska raziskovalna skupina. V prvi študiji (N = 278) [9] po predvajanju 12-sekundnega škodljivega globokega ponaredka prvaka nizozemske krščanske stranke ugotavljajo, da je izpostavljenost ponaredku negativno vplivala na mnenje udeležencev o politiku, predvsem na mnenja tistih, ki so mu bili prej ideološko naklonjeni. Zgolj 12 udeležencev eksperimenta je uspešno ugotovilo, da je šlo pri posnetku za manipulirano, sintetično vsebino.

Podobno prodorne ugotovitve ponujajo Hameleers idr. [13, 14, 15]. Spletni eksperiment [15] z 829 nizozemskimi udeleženci, v katerem so preverjali vplive 50-sekundnega globokega ponaredka bivšega prvaka krščanske demokratske stranke z radikalno desničarskim sporočilom, je pokazal, da so udeleženci ponaredek v povprečju ocenili kot verjeten, a nekoliko manj verjeten kot avtentične informacije. Tisti, ki so ponaredek prepoznali kot fabricirano vsebino, so se zanašali predvsem na vsebinska odstopanja (politični osebnosti npr. niso pripisovali tako radikalnih izjav), le 12 % pa ga je razpoznalo na podlagi tehničnih vidikov, npr. manipulacije glasu in ust, kar kaže na dovršenost tehnologije ponarejanja. Dejstvo, da je več kot 50 % udeležencev podvomilo tudi v avtentične vsebine, pove veliko o trenutnem odnosu povprečnega posameznika do digitalnih virov informacij in o epistemološki negotovosti, ki jo sintetične vsebine vnašajo v digitalni prostor.

V drugem spletnem eksperimentu z udeleženci iz ZDA in z Nizozemske (N = 1187) [14] avtorji raziskujejo vpliv različnih globokih ponaredkov demokratske političarke Nancy Pelosi. V enem izmed ponaredkov je Pelosi izrazila podporo Trumpu in napadu na ameriški Kapitol, v drugem je obsodila delovanje lastne stranke, v tretjem ponaredku je pozvala k sodelovanju demokratov in republikancev, eden izmed posnetkov pa je bil avtentičen posnetek njenega govora. Malo verjeten ponaredek, ki je bil najbolj oddaljen od političnih nazorov Nancy Pelosi in v katerem je zagovarjala Trumpa, so udeleženci označili kot najmanj kredibilnega. Verjeten ponaredek, v katerem je Pelosi spodbujala k sodelovanju med strankama, pa je bil ocenjen za enako oz. celo nekoliko *bolj* verjetnega kot dejanski posnetek njenega govora. Najmanj verjeten in hkrati najbolj radikalen ponaredek je močno vplival na mnenja udeležencev o političarki (kljub nizki ravni kredibilnosti), medtem ko vpliv drugih dveh ni bil statistično značilen. Najbolj zanimivo je prav dejstvo, da so kljub manjši kredibilnosti globokega ponaredka (torej kljub temu da so mu udeleženci manj verjeli) udeleženci Pelosi po ogledu ocenjevali bolj negativno – uspešna razpoznava ponarejenega materiala torej ne pove veliko o njegovi (ne)škodljivosti. Raziskava kaže na to, da morda nismo tako slabi v razpoznavanju globokih ponaredkov – a zgolj v primeru, da ponarejen posnetek

ni skladen s prejšnjimi izjavami in vedenjem politične osebe –, nismo pa imuni na njihove negativne učinke, tudi če vsebino pravilno razpoznamo kot ponarejeno.

3 Predlogi za zmanjševanje tveganj

Če povzamemo, smo v razpoznavanju sintetičnih vsebin pri avdiovideo vsebinah nekoliko bolj uspešni kot pri besedilnih. Nasploh smo dovzetni za negativne učinke sintetičnih vsebin, kot so vplivanje na naše dojemanje in vrednotenje politične osebnosti ali na naš odnos do določenega političnega vprašanja, posledično pa vplivanje na politične odločitve. Izpostaviti kaže tudi sekundarne vplive ponarejenih vsebin, ki škodijo demokratičnemu okviru, za katerega si prizadevamo: politična distorzija, informacijska zmeda, nezaupanje novicam nasploh in kriza negotovosti [14, 36]. Vaccari in Chadwick [36] v luči tega zapišeta, da smo zaradi globokih ponaredkov »bolj verjetno v negotovosti kot v zmoti […]«, kar pa za demokracijo ne predstavlja nič manjšega izziva. Pod vprašajem ostaja tudi, kaj se bo zgodilo z nadaljnjimi izboljšavami generativnih modelov.

Glede na številna tveganja, ki jih za demokracijo prinaša generativna UI, kaže obravnavati tudi možne rešitve. Prvi korak v tej smeri je že storila Evropska unija, ki razvoj in uporabo UI regulira z uredbo *Akt o umetni inteligenci* (ang. *the EU AI Act*), veljavno od avgusta 2024 [10]. Klepetalne robote in globoke ponaredke uredba uvršča v kategorijo modelov s sistemskim oz. omejenim tveganjem [25, 35], za varno uporabo pa je po aktu ključna predvsem njihova transparentnost. Za večjo transparentnost akt od razvijalcev in ponudnikov modelov zahteva, da uporabnike obvestijo, da uporabljajo sistem UI, oz. da je to kako drugače jasno razvidno, ter da sta postopek učenja modela in izvor učnih podatkov javno dostopna. Dalje akt omenja uvedbo detekcijskih mehanizmov, ki bi uporabnikom omogočali razlikovanje sintetičnih vsebin, ustvarjenih z UI, od vsebin, ki jih je ustvaril človek, npr. vodnih žigov in detekcije metapodatkov [35]. Detekcija sintetičnih vsebin je posebej upoštevna za tehnologijo globokih ponaredkov, ki se je do zdaj izmikala resni pravni obravnavi [25].

Pomen transparentnosti in detekcijskih mehanizmov, s pomočjo katerih bi bila sintetična vsebina tudi razpoznavna kot taka, poudarja vse več virov: v ZDA regulativne in varnostne standarde ureja Nacionalni urad za standarde in tehnologijo (NIST), ki detekcijske mehanizme izpostavlja kot ključne za blaženje tveganj generativne UI [31]. Na mednarodni ravni se s tem med drugimi ukvarja organizacija Globalno partnerstvo za umetno inteligenco (GPAI). Ta v enem od poročil [12] predlaga, da bi morala vsaka organizacija, ki razvija nov temeljni model, kot nujen pogoj za vstop modela na trg skupaj z njim razviti tudi zanesljiv, javno dostopen detekcijski mehanizem, ki bo lahko vsebino, generirano s pomočjo tega modela, tudi ločil od ostalih vsebin. Kot primer dobre prakse – in kot dokazilo, da je takšna praksa mogoča – poročilo navaja OpenAI-jev GPT-2, katerega celotna različica je bila zaradi varnostnih zadržkov objavljena šele devet mesecev po prvi, njegovo postopno objavljanje na spletu od februarja 2019 pa so spremljale številne študije in razvoj detekcijskih mehanizmov. Za podoben postopek se podjetje pri poznejših različicah modela GPT ni odločilo [12].

Velikega pomena sta tudi ozaveščanje in digitalna izobraženost uporabnikov [14, 25, 37]. Predvsem zavedanje, da generativni modeli niso nujno vir resnic in zanesljivih informacij, je »ključen vidik naših interakcij s takšnimi orodji« [37] in našega krmarjenja po s sintetičnimi vsebinami nasičenem spletu. Dalje Angwin in sodelavci [2] opozarjajo na »krizo odgovornosti«, ki nastaja na področju orodij UI: »Umetnointeligenčni modeli postajajo priljubljen vir informacij, a javno dostopni načini za njihovo testiranje in postavljanje standardov delovanja, še posebej glede točnosti in škodljivosti, so omejeni.« Večina najzmogljivejših generativnih modelov je danes v rokah le peščice zasebnih korporacij, katerih cilj je čim večji zaslužek, zato samoregulacija ni zelo verjetna. Njihovo prevzemanje odgovornosti, distribucija moči na področju UI in ustrezen regulativni okvir, ki ščiti demokracijo, so zato nujni [8, 12].

4 Zaključek

Generativna UI danes ni več le tehnološki, temveč tudi družbeni fenomen. Na čelu s ChatGPT-jem, najhitreje rastočo aplikacijo v zgodovini, oblikuje digitalno sfero, v kateri preživljamo vse več časa, in pomembno vpliva na družbenopolitične in demokratične procese. Prispevek se je osredotočal predvsem na negativne vplive generativne UI, zlasti velikih jezikovnih modelov in tehnologije globokih ponaredkov. Po uvodnem pregledu teoretičnega dela literature ugotavljamo, da med najbolj škodljive rabe generativne UI sodijo generiranje škodljivih in lažnih vsebin, dezinformacijske kampanje, ki so še posebej učinkovite s pomočjo mikrotargetiranja, množični nadzor državljanov, informacijska poplava, posledično pa kriza zaupanja v informacijske vire in oblast. Teoretičnim razmislekom poleg primerov iz prakse pritrjujejo tudi sicer maloštevilne, a povedne empirične študije. Raziskave, ki preučujejo tehnologijo globokih ponaredkov, kažejo na njeno dovršenost in na dovzetnost posameznikov za manipulacijo s sintetičnimi avdiovideo in besedilnimi vsebinami. Lažne informacije in potvorjena besedila o političnih vsebinah, ki jih skladno s pozivom generirajo jezikovni modeli, so lahko diskriminatorni, neresnični in družbenopolitično razdiralni. Kot taki lahko v digitalnem prostoru pod pretvezo človeškosti služijo kot cenovno ugodno in hitro generirano gradivo dezinformacijskih kampanj, v kombinaciji z mikrotargetiranjem manipulirajo neodločene volivce in volivke ter v družbo vnašajo zmedo in nezaupanje.

Predlogi za blaženje negativnih vplivov generativne UI, ki se vedno znova ponavljajo, so po eni strani tehnološki, po drugi pa sociološki; k razpoznavnosti sintetičnih vsebin bi lahko ključno pripomogli vodni žigi in detekcijski mehanizmi, nujna sta transparentnost razvijalcev o lastnostih modela in učnih podatkih ter razvoj mehanizmov za preprečevanje generiranja škodljivih vsebin, bistvena pa je tudi digitalna izobraženost državljank in državljanov ter njihov odnos do spletnih vsebin.

Zahvala

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Razložljiva umetna inteligenca: kako naprej?

Explainable AI: What next?

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Povzetek

Prispevek povzema in ocenjuje stanje metod in raziskav na področju razložljive umetne inteligence. Pregled vsebuje predlagane definicije razlage in lastnosti dobrih razlag. Podan je grob pregled številnih obstoječih pristopov za generiranje razlage, primeri konkretnih avtomatsko generiranih razlag in nekatere empirične ugotovitve, kako uporabniki sprejemajo te razlage. Število raziskav na tem področju se je v zadnjih letih močno povečalo, pri čemer pa razni avtorji uporabljajo različne definicije in kriterije. Kljub veliki količini raziskav, so nekateri vidiki razložljivosti in tehnični pristopi deležni premalo pozornosti, med drugim: razlaga zaporedij odločitev, upoštevanje uporabnikovega predznanja ter induktivno logično programiranje.

Ključne besede

Umetna inteligenca, XAI, razložljivost

Abstract

The paper reviews and assesses the state of the art of research and methods in explainable AI. The review includes proposed definitions of what is an explanation, and what are properties of good explanations. We give a rough overview of numerous existing approaches for generating explanations, concrete examples of explanations and some empirical findings of their acceptance by users. The amount of research in this area has recently increased significantly, but different authors use different definitions and criteria. Despite numerous projects in this area, some aspects of explainability and technical approaches are receiving little attention: explaining sequences of decisions, taking into account user's background knowledge, and inductive logic programming.

1 Uvod

Modeli strojnega učenja postajajo z uspehom globokega učenja in nevronskih mrež vseprisotni. Večina od nas se z njimi srečuje na vsakodnevni ravni, v obliki sistemov za priporočanje glasbe in filmov npr. Taki sistemi brez posredovanja človeka izračunajo za nas najboljše priporočilo, morebitna neustrezna priporočila pa nimajo bistvenih (negativnih) posledic za nas. Nasprotno imajo lahko napačne odločitve v domenah (kot je npr. zdravstvo) odločilne posledice za konkretna življenja ljudi. Če v nekaterih domenah zadošča zgolj točna napoved sistema, to ne zadostuje povsod v družbi in znanosti nasploh [5].

Uporabnost modelov strojnega učenja je vodila v njihovo splošno uporabo pred razvojem kakovostnega konceptualnega okvirja, ki bi omogočal razumevanje njihovega delovanja. Znan je t. i. problem črnih škatel (ang. *black box problem*), ki pomeni, da delovanje modelov strojnega učenja ostaja za uporabnike nerazumljivo. Prav pomanjkanje razumevanja omejuje nadaljnjo in bolj praktično uporabo modelov v ostalih pomembnih domenah odločanja. Potreba po razlagi je vodila v razvoj tehnik in pristopov razložljive umetne inteligence (XAI; ang. *eXplainable Artificial Intelligence*), ki se posveča nalogi razlaganja kompleksnih modelov strojnega učenja [34].

Namen članka je pregled trenutnega stanja XAI področja in analiza pomanjkljivosti.

2 Kaj sploh je razlaga?

Razložljivost je izmuzljiv pojem ne samo na področju umetne inteligence (UI), pač pa širše na področju filozofije in drugih družboslovnih znanosti. Na področju UI se operira s koncepti, kot so vzročnost, informativnost, razumevanje, gotovost, zaupanje, transparentnost ipd. [5] Termin ‘razložljiva umetna inteligenca’ je l. 2019 kot del svojega programa uporabila DARPA [17]. Od takrat je postal zelo popularen, ne gre pa za nov pojav. Kvečjemu gre za imenovanje dolgoletnih prizadevanj, kjer se raziskovalci trudijo prebiti do odgovora na vprašanje, zakaj je sistem prišel do določene napovedi [19].

Najbolj splošno bi lahko razložljivost v domeni UI opredelili kot razlago, ki delovanje modela naredi bolj razumljivo. Seveda je to zelo splošna opredelitev, v poskusih bolj natančnega definiranja pa si raziskovalci niso zedinjeni. [12] opredelita razložljivost kot sposobnost predstaviti nekaj v človeku razumljivih terminih. [5] pravijo, da mora model nuditi razlago za svoje delovanje in napovedi v obliki vizualizacije pravil in vpogleda v potencialne spremenljivke, ki bi lahko povzročile perturbacije modela. Po [29] razložiti pomeni predstaviti besedilne ali vizualne elemente, ki omogočajo kvalitativno razumevanje odnosa med komponentami in napovedjo modela.

Ena od nekonsistentnosti v XAI literaturi je uporaba pojma interpretabilnost, ki je včasih sinonim razložljivosti, drugič ločen

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pojem, tretjič ena od kategorij razložljivosti. [5] interpretabilnost razumejo kot pasivno, razložljivost pa kot aktivno lastnost modela. Interpretabilni so modeli, ki so razumljivi že sami po sebi (odločitvena drevesa npr.), razložljivi pa tisti, ki zahtevajo postopke, katerih namen je pojasnjevanje. Kot taka je razložljivost nujna lastnost vseh (tudi inherentno interpretabilnih) modelov [14].

Očitno je pomanjkanje konsenza o glavnih konceptih. Problem je, ker vsaka definicija nastopa znotraj specifičnega konteksta, odvisnega od naloge, sposobnosti in pričakovanj raziskovalca. Opredelitve razložljivosti so tako pogosto vezane na specifično domeno. Posledično XAI področje še ni enotno glede definicije razlage, specifičnih ciljev in kriterijev, ki naj bi jim zadostovali modeli, da bi bili razumljivi [5].

3 Metode razlag

Danes obstajajo številne metode razlag. Problem nastane pri njihovi klasifikaciji, ker ima praktično vsak avtor specifično definicijo razložljivosti, iz katere izhaja.

Ena splošnih kategorizacij je delitev na lokalne in globalne razlage. Lokalne so razlage, središčene okoli posameznega primera, kjer pa ostane delovanje modela kot celote nepojasnjeno. Na drugi strani globalne razlage pomagajo razumeti celoten model, so pa pogosto osnovane na približnih vrednostih [3][18][21][34].

Splošna je delitev na model-specifične in agnostične razlage. Slednje s tehnikami, kot so relevantnost atributov, vizualizacija ali simplifikacija pridobijo določene informacije o postopku napovedovanja in so uporabne za vsako vrsto modela [5]. Model-specifične razlage so uporabne zgolj za specifične vrste modelov (npr. maksimizacija aktivacije, ki jo opišejo [16]) [18].

[5] ločijo besedilne, vizualne, lokalne, razlage s primeri, s simplifikacijo in relevantnost atributov. [11] opredelijo tri glavne kategorije razlag: osnovane na funkciji, na primerih in pojasnjevanju atributov. [34] ločita razlage atributov in razlage primerov. [1] razlage razdelijo glede na uporabljeno metodologijo in ločijo med razlagami, ki slonijo na vzvratnem razširjanju (ang. *backpropagation*) in razlagami s perturbacijami. [16] ločijo: 1) odločitvena drevesa; 2) razlage, osnovane na pravilih; 3) razlage pomembnosti atributov, ki predstavijo težo in pomembnost atributov, ki jih je pri svoji napovedi upošteval model. Primer je znana metoda LIME, primerna predvsem za razlago klasifikacije besedil in slik (slika 2) [29]; 4) zemljevidi pomembnosti, ki izpostavijo ključne aspekte predmeta, ki je analiziran. Primer je metoda CAM (slika 1) [36]; 5) PDP (*Partial Dependence Plot*), kjer grafično prikažemo odnos med odločitvijo modela in vhodnimi podatki; 6) razlaga s prototipi, kjer z napovedjo dobimo primer, podoben našemu; 7) maksimizacija aktivacije, kjer opazujemo, kakšni vzorci vhodnih podatkov maksimizirajo aktivacijo določenega nevrona oz. nivoja.

[21] predstavi pojem formalne razložljivosti, zasnovan na logiki, kjer so razlage posledično bolj zanesljive in držijo globalno. Pristop temelji na računanji t. i. *prime implicants* (ang.), kar omogoča logične reprezentacije delovanja modela.

Slika 1 (levo): razlaga CAM metode na način prikaza področij slike, ključnih za klasifikacijo umivanja zob [36]. Slika 2 (desno): razlaga LIME metode. Na levi je izvorna slika, na desni razlaga za klasifikacijo električne kitare [29].

4 Kakšna je dobra razlaga?

Če je eden od ključnih ciljev XAI področja izboljšanje zaupanja v sisteme UI. je nujno, da se pozornost usmeri k uporabnikom teh sistemov [35]. Dobre razlage bodo tiste, ki bodo upoštevale, komu so namenjene [5]. To pomeni upoštevanje predznanja, ki ga imajo uporabniki. Opazen je trend, kjer razvijalci metod razlag tega ne upoštevajo dovolj. [30] opredelita tri skupine uporabnikov (razvijalci in raziskovalci, eksperti in laiki), ki zahtevajo različne vrste razlag.

Med raziskovalci ni strinjanja o kriterijih za dobro razlago. V nadaljevanju navajamo nekaj primerov kriterijev. [3] opredelita tri:

- Eksplicitnost: razlaga je takojšnja in razumljiva;
- Zvestoba (ang. *faithfulness*): ocene relevantnosti odražajo resnično pomembnost;
- Stabilnost: za podobne vhodne podatke veljajo podobne razlage.

[11] poudarjajo:

- Robustnost oz. občutljivost: sprememba razlage v primeru spremembe vhodnih podatkov;
- Zvestobo: razlaga ponazarja dejansko odločanje modela;
- Kompleksnost: kognitiven napor, potreben za razumevanje razlage;
- Homogenost: zmožnost razlage za pravilno razlago delovanja modela glede na različne skupine (v praksi se to po navadi nanaša na skupine, ki se ločijo glede na občutljive atribute).

[4] opredelita 4 aksiome, katerim naj bi zadostile dobre razlage:

1) morajo biti informativne;
2) ne smejo vsebovati nepotrebnih informacij;
3) razlage razredov morajo pojasniti posamezne primere, hkrati pa morajo biti splošno uporabne;
4) razlaga mora vsebovati samo informacije, ki vplivajo na napoved.

5 Ocenjevanje razlag

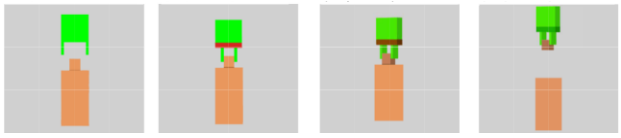
Ocenjevanje razlag je najmlajše področje s široko paleto pristopov [30]. Za razliko od točnosti, je kriterije kot so varnost, nediskriminacija in razložljivost težje kvantificirati [12].

Ocenjevanja se (najbolj splošno) lahko lotimo na dva načina: 1) človeško ocenjevanje ali 2) uporaba računskih metod, ki merijo, kako dobro razlaga dejansko razloži delovanje modela. Glavna razlika med pristopoma je, da so računske metode bolj objektivne, vendar pa ne upoštevajo človeškega faktorja.

Drugače rečeno, ne kvantificirajo človeškega razumevanja. Prednost človeške ocene je subjektivnost in večja deskriptivnost. Očitna pomanjkljivost je manjša točnost in večja odvisnost od specifične naloge [27].

[20][35] predstavijo matematično ocenjevanje razlag na podlagi analize robustnosti. Matematično opredeljena mera nezvestobe ponazarja, kako dobro se razlaga ujema z modelom [34].

[13] so izvedli eksperiment, s katerim so preverili, kakšne razlage so pri ljudeh vzbudile največ zaupanje v robota, ki je odprl stekleničko. Robot se je naučil odpirati stekleničke iz človeških demonstracij, pri čemer je bilo ključno učenje zaporedij položaja rok in potrebne sile. Z rokavico s senzorji so zajeli podatke o sili in položaju rok v 64 človeških demonstracijah s tremi različnimi stekleničkami. Sledilo je kompleksnejše učenje, da bi bil robot svoje znanje sposoben posplošiti. Implementiran je bil haptični model, ki je robotu pomagal določiti potrebno silo, čeprav nima človeških rok. Ker odpiranje stekleničke poteka v več korakih (potiskanje, odvijanje itd.), je bil implementiran še t. i. (ang.) *symbolic action planner* in pomeni pravila o zaporedju potrebnih akcij. S kombinacijo takega učenja je robot postal precej dober v odpiranju novih stekleničk. Udeleženci so bili razdeljeni v 5 skupin. Vsaka je videla posnetek robota, ki opravlja nalogo, ter eno od možnih razlag: 1) simbolično: v realnem času so udeleženci videli z eno besedo opisano akcijo, ki naj bi razlagala, kaj robot na posnetku dela (*approach – grasp – push – twist – ungrasp – move – grasp – push …*); 2) besedilno: po ogledu posnetka robota so udeleženci prebrali kratko besedilo o tem, kako je robot opravil nalogo (*I succeeded to open the bottle because I pushed on the cap three times and twisted the cap twice*); oz. 3) haptično razlago (slika 3): vizualizacija sile prijema v vsakem trenutku odpiranja stekleničke) oz. kombinacijo haptične in simbolične razlage. Največ zaupanja je spodbudila simbolična razlaga.



Slika 3: haptična razlaga.

[27] so izvedli eksperiment, kjer so udeleženci označili relevantna področja slike, ki je po njihovem mnenju bilo najbolj reprezentativno za določen razred objektov (mačka in pes npr.). Rezultat je zemljevid pomembnosti, ki prikazuje področja slike, ki so jim udeleženci posvečali največ pozornosti (spodnja vrsta na sliki 4). Te rezultate so primerjali z zemljevidi pomembnosti metode Grad-CAM (spodnja vrsta na sliki 4). Zemljevidi so si morda podobni, vseeno pa je statistično testiranje pokazalo pomembne razlike. Distribucija relevantnih atributov je bila pri Grad-CAM metodi bolj uniformna, udeleženci so v primeru živih bitij kot ključne bolj označevali obraze. Prav to so ugotovitve, ki nam lahko pomagajo razumeti, kako dobre so razlage.

Slika 4: zgornja vrsta prikazuje zemljevida pomembnosti Grad-CAM metode, spodnja zemljevida udeležencev [27].

6 Kako naprej?

V tem razdelku opozorimo na nekatere razmeroma slabo raziskane probleme in premalo uporabljene pristope za XAI.

6.1 Tehtanje med točnostjo in razložljivostjo

[31] v članku z zgovornim naslovom »*Stop explaining black box ML models for high stakes decisions and use interpretable models instead*« izraža determinirano stališče. Zavzema se za uporabo metod učenja, ki dajejo naučene modele, ki so sami po sebi razumljivi. Za take se smatrajo npr. odločitvena drevesa. Nasprotuje metodam učenja, katerih rezultati so v principu težko razumljivi. Med te štejemo posebno metode globokega učenja, ki sicer dosegajo visoko napovedno točnost v primerjavi z drugimi metodami učenja, toda ne zastonj: vsaj za ceno razumljivosti in potrebnega velikega števila podatkov za učenje. Pri tem gre Rudin morda res predaleč s svojim optimističnim stališčem, ki implicitno predpostavlja možnost izgradnje elegantnih in razumljivih modelov za vsako problemsko domeno, s čimer zadene ob princip kompleksnosti Kolmogorova.

Glede možnosti obstoja enostavnih modelov in razlag velja vsaj ena teoretična omejitev, ki jo definira kompleksnost Kolmogorova, ki določa, koliko spominskega prostora potrebujemo za najkrajši možni zapis danega objekta v računalniku. Obstajajo zapleteni objekti (torej tudi napovedni modeli), ki jih niti teoretično ni mogoče predstaviti na kratek način. V takih primerih tudi razlaga ne more biti kratka in enostavna. Res pa je, da smo v praksi še zelo daleč od te teoretično dosegljive meje, torej imamo veliko prostora za izboljšanje. Ko zadenemo ob zid Kolmogorova, pa je še vedno možen kompromis, da za boljšo razložljivost žrtvujemo nekaj točnosti [8]. Primer tehnične izvedbe tega tehtanja med točnostjo in razumljivostjo v učenju odločitvenih dreves je [6].

6.2 Navezava razlage na uporabnikovo predznanje

Če bo razlaga dobra, je odvisno od njenega uporabnika, konkretno od uporabnikovega predznanja o problemski domeni. Če je to kvalitetno, zadošča en sam namig. Če je razumevanje domene slabo, je potrebna podrobna in daljša razlaga. Tudi sama formulacija razlage je odvisna od obstoječega znanja na obravnavanem področju. Celo povsem pravilna in jedrnata razlaga je za eksperta na področju uporabe lahko nesprejemljiva in nenaravna. Kot primer omenimo, da so se nekateri primeri razlag, ki jih generirajo naučeni modeli v medicinskih domenah kljub svoji diagnostični točnosti zdravniku zdeli povsem

nenaravni [8]. V enem od primerov je sistem razložil, da gre za vnetni revmatizem, ker ima pacient med drugim več kot dva prizadeta sklepa na roki. To diagnostično pravilo je dejansko točno. Vendar pa je zdravnik vztrajal, da mora imeti pacient prizadete sklepe na vseh petih prstih na roki, ker vnetni revmatizem tipično vpliva na vse sklepe. Ekspertno mnenje je bilo v tem primeru zelo jasno, čeprav je res, da bo pravilo vodilo do pravilne diagnoze v vsakem primeru; če gre za katerokoli število vnetih sklepov med 2 in 5. Ustreznost razlage je odvisna ne le od klasifikacijske točnosti, temveč (tudi) od predznanja, ki ga ima uporabnik o tej obliki revmatizma.

Obstoječe metode razlage ta vidik pogosto ignorirajo. Problem je tudi v tem, da ne omogočajo naravne uporabe predznanja. V tem pogledu je zelo obetaven pristop k strojnemu učenju t. i. induktivno logično programiranje (ILP), ki temelji na uporabi matematične logike. Že sama osnovna formulacija problema učenja v ILP vsebuje uporabo predznanja: dani so učni primeri E in predznanje BK (*background knowledge*), naloga učenja pa je sestaviti logično formulo H (hipoteza) tako, da primeri E logično sledijo iz BK in H.

Pristop ILP je skromno zastopan v obstoječih raziskavah iz strojnega učenja in razložljivosti. Lep primer njegove ustreznosti so raziskave, opisane v [2][28]. Te zasledujejo ne le osnovni cilj XAI (razlage odločitev strojnega učenja), temveč tudi cilj t. i. »ultra-razložljivost«. Ta strožji kriterij strojnega učenja je definiral [26] (ang. *ultra strong criterion for ML*). Strojno učenje je ultra-razložljivo, če je ne le razložljivo, temveč uporabniku omogoča tudi *operativno uporabo za lastno reševanje* novih problemov. Npr. da strojno naučeno znanje lahko uporabi za lastno reševanje določenih matematičnih problemov ali igranje šaha.

6.3 Razlaga zaporedij odločitev v planiranju

Večina XAI metod generira razlago *posameznih* odločitev oz. klasifikacij. Pri razložljivem planiranju pa gre za razlago množice odločitev (npr. zaporedja akcij, ki robota vodi do cilja). Posebej za razlago planov se je formiralo področje razložljivega planiranja [10].

Razlaga planov je navadno zahtevnejša od razlage v klasifikacijskih problemih. Treba je razložiti, kako so posamezne akcije odvisne od drugih, da skupaj rešijo nalogo. Primer razlage zaporedja odločitev je razlaga šahovskih partij, kjer je treba razložiti celo zaporedje potez ali drevo odločitev, ki definira uspešno strategijo. Primer, opisan v [9], so težko razumljive in briljantne poteze šahovskega programa AlphaZero.

Razlaga planov je aktualna tudi na področju vodenja sistemov. Lep primer razlage naučenega plana vodenja je v [32]. Gre za klasično nalogo iz teorije vodenja sistemov: vodenje sistema voziček-palica. Na vozičku je vrtljivo vpeta palica. Palica je postavljena približno vertikalno, vendar se, če ne ukrepamo, prevrne na tla. S potiskanjem vozička levo oz. desno je treba loviti ravnotežni položaj palice okrog vertikale, obenem pa doseči, da se voziček horizontalno premakne iz začetnega položaja do cilja. Naučena strategija vodenja je lepo razložljiva. Najprej nekoliko presenetljivo potisnemo voziček stran od cilja, s čimer dosežemo, da se palica nagne proti cilju. To omogoči potiskanje vozička v smer proti cilju, hkrati pa se ohranja ravnotežje palice, ko je ta nagnjena naprej v smeri cilja.

7 Zaključek

Področje XAI se je v zadnjih 5 do 10 letih močno razraslo. Mnogi zato predpostavljajo, da je bil to tudi začetek področja. V resnici je aktivno zavedanje, da naj bi bilo strojno učenje razložljivo, obstajalo že prej 40 leti. Že takrat so obstajale raziskave o razložljivih modelih. Kljub sedanji količini raziskav in nedvoumnih uspehih se še vedno kaže, da pogrešamo nekatere ključne odgovore. Npr., že pred desetletji se je v sklopu istih prizadevanj pojavilo zavedanje, da potrebujemo formalne mere za ocenjevanje kvalitete razlag. Take sprejete mere še ni. Raziskovalci pri ocenjevanju razlag uberejo različne pristope, odvisne od raznih kriterijev (konteksta, domene, uporabnikov itd.).

Glede vprašanja, kaj je sprejemljiva razlaga, se v pomanjkanju boljših splošnih in principielnih kriterijev v sedanji praksi uporablja predpostavka, da so nekateri modeli razložljivi kar po definiciji, torej razložljivi sami po sebi. Mednje npr. navadno štejemo odločitvena drevesa ali pravila če-potem. Toda tudi ta kriterij je arbitraren. Kaj, če je odločitveno drevo zelo veliko, npr. da ima milijon vozlišč?

V prispevku smo opozorili tudi na počasen napredek pri razvoju metod za razlago zaporedij odločitev. Sem sodi razlaga planov za reševanje nalog, ki imajo eksplicitno definirane cilje. Plan je lahko zaporedje akcij ali pa tudi množica akcij, ki so delno urejene v času. Tu je treba razložiti tudi to, kako se akcije med seboj dopolnjujejo in na kakšen način skupaj dosežejo cilj. S tem so povezani izzivi, ki jih predstavimo spodaj.

En možen pristop, ki upošteva principe planiranja v UI, je upoštevanje odvisnosti med akcijami. Nekatere akcije v planu neposredno dosežejo kakšnega od ciljev plana. Druge akcije pa ne dosežejo nobenega danega cilja neposredno, njihova funkcija je, da dosežejo pogoje, ki morajo biti uresničeni, da je možno izvesti druge akcije v planu. Taka razlaga plana je seveda povsem logična. Navadno pa vsebuje preveč podrobnosti. Če plan vsebuje nekoliko večje število akcij, npr. nekaj 10, postane tako podrobna razlaga spet težko razumljiva in za uporabnika neprivlačna. V tem primeru bi za sprejemljivo razlago treba plan razbiti v hierarhično strukturo, definirano s podcilji plana. Odkrivanje smiselnih podciljev pa je lahko težavno. Poseben izziv je, kako poiskati take podcilje, ki rezultirajo v razlagi, ki je za človeka čim bolj naravna.

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Exploring Cognitive Science under Analytical Idealism

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Abstract

In modern science, materialism has played a significant role, positing that matter is the fundamental reality and that all phenomena, including consciousness, can be understood through physical processes. However, recent evidence suggests materialism might not fully explain all phenomena. These findings have led to the rise of a post-materialistic movement exploring new ideas. One such idea, Analytical Idealism, proposed by Bernardo Kastrup, suggests that consciousness is the fundamental reality and that the material world is a reflection of this universal consciousness. The implications of adopting this approach in science will be explored.

Keywords

ontology, methodology, materialism, analytical idealism

1 Introduction

The modern scientific worldview is largely based on assumptions closely linked to classical physics. Among these is materialism, which posits that matter constitutes the sole reality. In the 19th century, these assumptions became increasingly rigid, evolving into dogmas that coalesced into the ideological framework known as "scientific materialism" [1].

Scientific materialism is a philosophical viewpoint that asserts that all phenomena in the universe, including consciousness and human experience, can be explained solely through physical processes and interactions. Throughout the 20th century, scientific materialism became the prevailing ideology in academic circles, to the extent that the majority of scientists came to believe it was the only rational interpretation of the world. Scientific methods rooted in materialistic philosophy have proven highly successful in enhancing our understanding of nature and in providing greater control and freedom through technological advances. Though the popularity of scientific materialism is waning, the legacy persists, having limited the scope of inquiry, particularly in the study of consciousness, by ignoring subjective human experience [1, 2].

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2 Questioning the materialistic paradigm

At its core, science is a non-dogmatic, open-minded approach to acquiring knowledge about nature through observation, experimental investigation, and theoretical explanation of phenomena [3]. There is a misconception that the methodology of science is inherently tied to materialism. In addition, an increasing body of empirical evidence points to the limitations of materialism. Of course, it is impossible to provide sufficient empirical research that definitively refutes materialism; however, we can present two examples from different fields that suggest the limitations of materialism: one from animal cognition and the second from psi phenomena in humans.

2.1 Example from animal cognition

The first example is from animal cognition. Actually, it is about precognition, which is the perception of future events, typical for some animal species. Investigation in this field was done by Sheldrake [4], who studied a dog that seemed to know when its owner was coming home. Despite using various methods to rule out normal senses, Sheldrake consistently observed the dog waiting expectantly before the owner arrived, but not at other times. A replication of a similar experiment by some sceptics was declared unsuccessful [5], but a later reanalysis of the same results showed the opposite [6].

2.2 Example from psi phenomena in humans

The second example addresses meta-analyses of psi phenomena, which are defined as extraordinary human capacities like telepathy, clairvoyance, and precognition that involve gaining information without known sensory mechanisms. Studies investigating these phenomena have consistently found small but significant effects, suggesting that such abilities may exist [7]. The evidence for psi is comparable to that for established phenomena in psychology and other disciplines, although there is no consensual understanding of them. Recent analyses also emphasize that these results cannot be easily attributed to methodological flaws, selective reporting, or fraud, further supporting the plausibility of psi phenomena.

The volume of empirical data indicating the shortcomings of materialism is so substantial that an increasing number of articles and books are being written on this subject [1, 7, 8, 9]. In fact, this has contributed to the emergence of a whole post-materialistic movement in recent decades, which is exploring what this new paradigm might look like [3, 9, 10, 11, 12]. Believe it or not, you can also find a manifesto for post-materialistic science [13].

3 Cognitive Science under Analytical Idealism

One of the proponents of the post-materialistic movement is Bernardo Kastrup, who advocates for Analytical Idealism [3]. Analytical Idealism posits that consciousness is the fundamental essence of reality, rather than matter [12]. The focus of this summary is not to provide a detailed description of Idealism, but rather to explore the potential changes in the methodology of scientific research that could result from adopting this perspective.

3.1 Two distinct routes to knowledge

Changes in ontological views lead to changes in scientific methods as they alter the foundational concepts and relationships that guide inquiry [14]. If consciousness is indeed a fundamental aspect of reality rather than a byproduct of neural activity, it implies that consciousness might directly access aspects of reality without relying solely on sensory perception [15]. This leads us to consider two distinct routes to knowledge: conventional sensory perception (science as it is mainly now) and a more direct introspective approach. Walach calls this approach “radical introspection.” Radical introspection involves a deep inward focus, often achieved through contemplative and meditative practices. Unlike standard qualitative introspection, which relies on external referents (e.g., transcripts, observations), radical introspection does not have such referents beyond personal experience. It faces challenges of subjective bias and lack of established methodology for validating truth claims. However, it remains a crucial aspect of potential new methodologies in science, requiring the development of techniques to record, communicate, and verify first-person experiences.

At this point, it is important to highlight that Walach is not the only proponent of integrating radical introspection into scientific inquiry. Kordeš [16] arrives at a similar conclusion in his arguments, even though he does not refer the concept of idealism at all. He suggests that in-depth, existentially liable introspection and self-inquiry should be considered as serious scientific research tools.

3.2 Combining first and third person research

When looking at current scientific practices, we can see some early attempts in that direction. The godfather of this approach is, of course, Francisco J. Varela [17]. From this approach emerged the field of contemplative neuroscience, which explores individuals in altered states of consciousness that develop through various contemplative practices. This field seeks to integrate traditional third-person scientific methods, such as MRI, EEG, and MEG, with first-person accounts of personal experiences in these altered states of consciousness [18, 19, 20]. When we start taking contemplative and meditative practices seriously, science can begin to exchange ideas with ancient traditions such as Buddhism, Hinduism and others. Even this is already happening [21, 22, 23].

3.3 The consequences of such a research approach

This interdisciplinary exchange highlights the potential for scientific and spiritual perspectives to enrich each other and expand our understanding of consciousness and reality. Additionally, to broaden scientific inquiry, spiritual practices like meditation and contemplation can be secularized and incorporated into the scientific process. Fun fact, At the 6th International Colloquium of Cognitive Sciences, Dr. Berkovich-Ohana began her presentation titled "Meditation and the Self: Neuroscience and Phenomenology" with a few minutes of guided meditation [24]. By integrating these practices, scientists could benefit from improved mental hygiene, enhanced creativity, and increased cognitive capacities [25], [26], [27].

This step can be highly significant, as it enhances the performance of researchers. A greater focus may lead to reduced bias, while increased creativity fosters better hypotheses, ultimately resulting in more effective research. Such advancements are essential for achieving substantial breakthroughs.

Engaging in meditation and/or contemplative practices poses potential downsides for scientists, too. First, the focus on personal experience conflicts with the concurrent objective standards required in scientific research. While self-research can yield valuable insights, its subjective nature can lead to biases that undermine intersubjectivity. Furthermore, the personal transformation that occurs during deep self-reflection may distract researchers from maintaining the rigorous, detached perspective typically expected in scientific inquiry. Ultimately, the integration of such practices into mainstream science remains challenging, as it contrasts with the traditional role of researchers.

4 Conclusion

In conclusion, I would like to emphasize a few key points. First, the entire described methodology can, of course, be applied from a materialistic standpoint as well. It is not the ontology itself that matters; rather, it is the methodology that enables insight. Materialists can also engage in contemplative neuroscience. Second, year by year, we have more scientific studies suggesting that the current mainstream paradigm may be flawed. Let us carefully examine the data and avoid dismissing it simply because it contradicts our preconceived assumptions [28]. Third, if more scientists were to engage in meditation-like practices, this would generally benefit the scientific community for reasons previously discussed. Fourth, when we establish a connection between science and religion, mutual learning can begin.

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Authors' statement

ChatGPT-4 was used for improving the language of this paper.

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Intelligent Revolution – a New Civilization and Cognitive Era

Inteligenčna revolucija – nova civilizacijska in kognitivna doba

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ABSTRACT.
The rapid advancement of artificial intelligence is significantly enhancing human capabilities, even as human progress itself appears to stagnate, hindered by decadent ideologies and adverse societal trends. Over the past few decades, AI has achieved remarkable milestones, from mastering complex games to revolutionizing industries such as healthcare and finance through advancements in machine learning, natural language processing, and robotics. A particularly notable achievement is the development of GPT models, which have set new standards in language generation and expanded the horizons of AI's potential. This paper examines the impact of AI on various sectors, including societal and individual cognitive advancements, highlighting both the opportunities and challenges of widespread AI adoption. The discussion focuses on the transformative power of AI technologies and the ethical, economic, cognitive, and social implications of this ongoing revolution. As AI continues to drive innovation and transform industries, humans are increasingly integrating with these technologies through the pervasive use of smartphones, personal computers, and wearable devices. This integration has already enhanced our cognitive and functional capabilities, effectively amplifying human potential. However, as AI's influence on human life deepens, critical questions arise about the future of this symbiotic relationship and the trajectory of societal progress.

POVZETEK
Hitri napredek umetne inteligence izboljšuje človeške zmožnosti, medtem ko se zdi, da človeški napredek stagnira, oviran z dekadentnimi ideologijami in negativnimi družbenimi trendi. V zadnjih desetletjih je UI dosegla izjemne mejnike, od obvladovanja kompleksnih iger do revolucije v panogah, kot sta zdravstvo in finance, z napredki na področju strojnega učenja, obdelave naravnega jezika in robotike. Posebej pomemben dosežek je razvoj modelov GPT, ki so postavili nove standarde v generiranju jezika in razširili obzorja potenciala UI. Ta članek preučuje vpliv UI na različne sektorje, vključno z družbenim in individualnim kognitivnim napredkom, ter poudarja tako priložnosti kot izzive, ki jih prinaša široka uporaba UI. Razprava se osredotoča na transformativno moč UI tehnologij ter na etične, ekonomske, kognitivne in družbene posledice te tekoče revolucije.

Medtem ko UI še naprej spodbuja inovacije in preoblikuje industrije, se ljudje vse bolj integrirajo s temi tehnologijami prek vseprisotne uporabe pametnih telefonov, osebnih računalnikov in nosljivih naprav. Ta integracija je že okrepila naše kognitivne in funkcionalne sposobnosti ter učinkovito pomnožila človeški potencial. Ko vpliv UI na človeško življenje narašča, se pojavljajo ključna vprašanja o prihodnosti tega simbiotičnega razmerja in o smeri družbenega napredka.

KLJUČNE BESEDE
Umetna inteligenca, simbioza med človekom in strojem, tehnološki napredek, kognitivni vpliv

KEYWORDS
Artificial Intelligence, Human-Machine Symbiosis, Technological Advancement, Cognitivel Implications

1 Introduction

The rapid development of artificial intelligence (AI) is transforming industries and redefining/improving the essence of human capabilities. While AI progresses at an unprecedented pace, human societal progress appears to be stagnating, increasingly entangled in decadent ideologies and negative societal trends. This duality between AI's rise and human inertia is critical to understanding the current technological landscape. Over recent decades, AI has achieved remarkable milestones, including mastering complex games like Go and chess, advancing natural language processing (NLP), and driving significant innovations in sectors such as healthcare and finance. For example, the development of GPT (Generative Pre-trained Transformer) models represents a breakthrough in AI's ability to

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generate human-like text, setting new standards for machine language generation and understanding [1, 2].

This paper examines the transformative potential of AI across various sectors, including healthcare, finance, education, and entertainment, highlighting both the opportunities and challenges that accompany widespread AI adoption. In recent years, significant advancements in AI have occurred at an accelerating rate. For example, breakthroughs in reinforcement learning and unsupervised learning have expanded the capabilities of AI systems, with applications ranging from autonomous vehicles to sophisticated recommendation systems [3]. Additionally, the ethical, economic, cognitive, and social implications of AI's proliferation are increasingly coming to the forefront, as debates intensify over issues such as algorithmic bias, privacy, and the potential for AI to displace human jobs [4]. These discussions underscore the need for robust governance frameworks to ensure that AI technologies are developed and deployed responsibly [5].

As AI technologies like machine learning, NLP, and robotics continue to evolve, they increasingly integrate into human life, augmenting cognitive and functional abilities through ubiquitous technologies such as smartphones, personal computers, and wearables. This integration, often referred to as a form of human-AI symbiosis, has already multiplied human potential, enabling tasks and processes that were previously unimaginable [6]. The consequences of this symbiotic relationship are profound, raising critical questions about the direction of societal progress and the future of humanity as AI [7, 8] becomes more embedded in everyday life.

We analyze the implications of AI's rapid development, particularly the considerations that must be addressed to navigate the ongoing AI revolution effectively. By integrating recent scholarly insights with a broader analysis of AI's impact, this paper seeks to contribute to the understanding of how AI is reshaping industries and human capabilities, as well as the future trajectory of this unprecedented technological evolution.

2 AI progress

A recent and transformative achievement is the development of Generative Pre-trained Transformers. These models represent a leap forward in natural language processing, capable of generating human-like text, translating languages, and even writing code. The GPT-3 model, released by OpenAI in 2020, is particularly notable for its ability to perform a wide range of tasks with minimal input, showcasing the power and versatility of large-scale language models [9].

Here we present one major achievement over the last five years, having in mind the constant AI progress in areas like autonomous driving or pattern recognition:

2019: AlphaStar in Real-Time Strategy Games

In 2019, DeepMind's AlphaStar achieved a significant milestone by reaching the top players of professional StarCraft II play, a complex real-time strategy game that requires long-term planning, resource management, and real-time decision-making. This achievement underscored the potential of AI to operate in dynamic and highly strategic environments, far beyond turn-based games like Go [10].

2020: GPT-3

The release of GPT-3 by OpenAI in 2020 marked a significant advance in the field of NLP. GPT-3, with 175 billion parameters, demonstrated unprecedented language generation capabilities, performing tasks such as translation, summarization, and question-answering with high proficiency and minimal fine-tuning. It set a new benchmark for the potential of AI in creative and linguistic tasks [9].

2021: DeepMind's AlphaFold 2 in Protein Folding

In 2021, AlphaFold 2, developed by DeepMind, solved one of biology's greatest challenges by predicting protein structures with remarkable accuracy. This breakthrough has significant implications for drug discovery, understanding diseases, and designing new biological processes, demonstrating AI's potential to revolutionize the life sciences [11].

2022: DALL-E 2 and Image Generation

OpenAI's DALL-E 2, released in 2022, demonstrated the power of AI in generating highly detailed and creative images from text descriptions. This model pushed the boundaries of AI in the visual domain, showcasing its ability to combine artistic creativity with technical precision, and opening new possibilities in design, marketing, and entertainment [12].

2023: GPT-4 and Multimodal AI

In 2023, OpenAI introduced GPT-4, which expanded the capabilities of its predecessor by being multimodal—able to process and generate both text and images. GPT-4's ability to handle complex queries across different formats has made it a powerful tool for applications in education, customer service, and creative industries, further blurring the distinction between products of human and machine intelligence [13].

The last five years have seen groundbreaking AI achievements each year that have pushed the boundaries of what AI can do. From mastering strategic games and understanding protein structures to generating high-quality text and images, AI's progress continues to accelerate, bringing us closer to a future where AI plays an integral role in nearly every aspect of society. In the next section, we examine human progress.

3 Impact of AI progress across various fields

As AI continues to evolve, its influence is expected to permeate multiple sectors, driving innovation and transformation. This section analyzes the potential impact of AI across key fields such as healthcare, finance, education, entertainment, and transportation, highlighting both the opportunities and challenges these advancements may bring.

Healthcare: AI has the potential to revolutionize healthcare by improving diagnostics, personalized medicine, and patient care. Machine learning algorithms are already being used to analyze medical images with greater accuracy than human radiologists, and AI-driven predictive analytics are helping to identify at-risk patients before conditions worsen. Additionally, AI can streamline administrative processes, reducing the burden on healthcare professionals and allowing for more efficient patient management. The integration of AI in healthcare is expected to lead to better patient outcomes, lower costs, and a more proactive approach to health management [14]. The JSI team is in the last phases of donating a home doctor system to all Slovenians.

Finance: The finance industry is experiencing significant transformations due to AI, particularly in areas such as algorithmic trading, risk management, and fraud detection. AI algorithms can analyze vast amounts of financial data in real-time, enabling more informed and faster decision-making. These technologies also enhance the accuracy of credit scoring and personalized financial advice, offering tailored solutions to individual customers. However, the increased reliance on AI also raises concerns about market stability, ethical use of data, and the potential for systemic risks [15].

Education: AI is poised to transform education by providing personalized learning experiences, automating administrative tasks, and enabling new forms of interactive learning. AI-driven adaptive learning systems can tailor educational content to the needs of individual students, allowing for more effective learning outcomes. Additionally, AI can assist teachers by automating grading and providing real-time feedback, freeing up more time for personalized instruction. GPTs further offer significant improvements in education. Integrating AI in education also presents challenges, such as ensuring equitable access to AI-driven tools and addressing concerns about data privacy [16]. At JSI, we tested the quality of various GPTs on educational tasks.

Entertainment: The entertainment industry is undergoing a significant shift due to AI's capabilities in content creation, recommendation systems, and audience engagement. AI-generated music, art, and scripts are becoming increasingly sophisticated, thus differentiating between products of human and machine creativity as often impossible. Recommendation algorithms, powered by AI, personalize content delivery to users, enhancing their experience and increasing engagement. However, this rise in AI-generated content raises questions about the future of human creativity and the potential for AI to disrupt traditional content production models [17]. Recommendation algorithms were one of the central parts of the H2020 smart-city Urbanite project with most of the software developed at AI.

Transportation: AI is driving innovation in transportation through the development of autonomous vehicles, smart traffic management systems, and predictive maintenance. Self-driving cars, powered by AI, promise to reduce accidents, lower emissions, and increase the efficiency of transportation networks. AI can also optimize traffic flow and reduce congestion through real-time data analysis and adaptive traffic control systems. However, the widespread adoption of AI in transportation faces challenges related to safety, regulatory frameworks, and public acceptance [18].

In the next section, human progress and integration with AI are presented.

4 Human progress including merging with ICT and AI

4.1 Historical overview of human progress

Human progress is a story of relentless evolution and technological advancement, spanning millions of years. Beginning around six million years ago, the earliest hominins diverged from the common ancestor we share with chimpanzees, marking the start of a journey toward modern humanity. One of the earliest major milestones was the development of bipedalism, which allowed early humans to travel long distances and use their hands for tool-making. The invention of tools around 2.6 million years ago further distinguished our ancestors, enabling them to manipulate their environment in unprecedented ways.

Approximately 200,000 years ago, Homo sapiens emerged, equipped with greater cognitive abilities and complex language, facilitating social structures and cultural developments that set the stage for future innovations. The advent of agriculture around 10,000 years ago marked a fundamental shift in human society, leading to settled communities and the eventual rise of civilizations.

Fast forward to the Industrial Revolution in the 18th century, human progress accelerated dramatically. Innovations in machinery, transportation, and communication reshaped societies, laying the groundwork for the Information Age. The 20th century saw rapid technological advances, including the development of the computer, the internet, and the beginnings of artificial intelligence, all of which have profoundly impacted human life.

4.2 Recent progress: merging with ICT and AI

In the past few decades, the convergence of information and communication technologies (ICT) and artificial intelligence has fundamentally altered the trajectory of human progress. This merger has enhanced human capabilities and begun to blur the lines between human and machine intelligence, creating a symbiotic relationship reshaping society.

Mobile Phones: One of the most transformative technologies of the late 20th and early 21st centuries is the mobile phone. Introduced commercially in the 1980s, mobile telephones rapidly evolved from simple communication devices to powerful, multifunctional tools. The advent of smartphones in the 2000s, with their integration of internet access, GPS, and a multitude of applications, significantly enhanced human connectivity and access to information. Today, smartphones are essential tools for both personal and professional life, facilitating real-time communication, social networking, and a vast array of digital services [19].

The Internet and Cloud Computing: The development of the Internet in the late 20th century and the rise of cloud computing in the early 21st century have revolutionized how humans interact with information and each other. The internet has democratized access to knowledge, enabling global communication and collaboration, while cloud computing has made vast computational resources and storage available to individuals and organizations alike. These technologies have increased productivity and laid the foundation for the widespread deployment of AI systems, which rely on large datasets and significant computational power [20].

Generative Pre-trained Transformers: The recent advancements in AI, particularly with the development of GPTs, represent a significant leap in the merging of human capabilities with machine intelligence. GPT-3, introduced in 2020, demonstrated the ability to generate coherent and contextually relevant text based on minimal input, performing a wide range of tasks such as translation, summarization, and even creative writing. GPT-4, released in 2023, expanded on this by incorporating multimodal capabilities, processing both text and images, and further enhancing human-machine interaction [13]. These models are not just tools but extensions of human

cognitive abilities, enabling users to perform tasks that require complex reasoning and linguistic skills with the assistance of AI.

Wearable Technology and Augmented Reality: Wearable devices, such as smartwatches and fitness trackers, have integrated AI into daily life, monitoring health metrics and providing real-time feedback to users. These devices exemplify the merging of human biology with technology, offering new ways to enhance physical and cognitive performance. Augmented reality (AR) technologies are also becoming increasingly prevalent, overlaying digital information onto the physical world and creating immersive experiences that enhance learning, navigation, and entertainment [21].

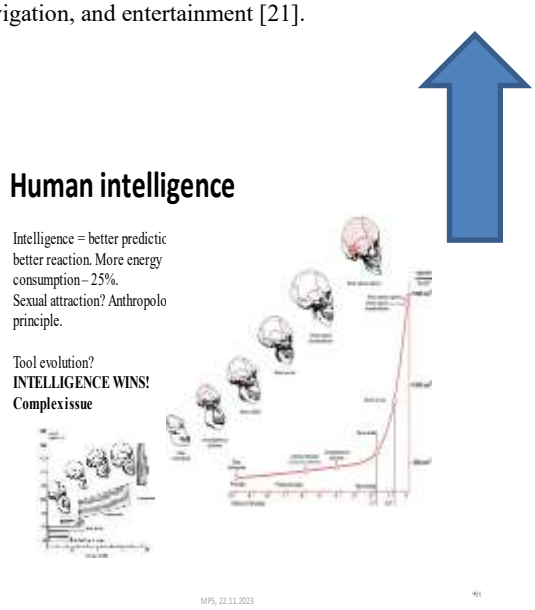

Figure 1: Progress of the human brain and intelligence. Source of the draft (modifications original): https://www.aquatic-human-ancestor.org/anatomy/brain.html

Human progress, from the earliest hominins to the modern age, has been marked by the continuous development and integration of technologies that enhance human capabilities. In recent decades, the merging of ICT and AI with human activities has accelerated this progress, creating a symbiotic relationship that extends human cognitive and physical abilities. Technologies such as mobile phones, the internet, GPT models, and wearable devices have not only transformed how we live and work but have also set the stage for future advancements that may further blur the lines between human and machine intelligence.

The key idea of this overview is that humans and user interfaces are already deeply intertwined, both through physical hardware like mobile phones and more abstract systems such as software and information networks. As these systems fast become more sophisticated, they enhance human cognitive, intellectual, and mental functions, effectively expanding our capacities. This growing interconnection between humans and technology echoes the concept of *cyborgization*, where external devices supplement and expand the functions of the human mind. The development of smartphones, wearable technology, and even future brain-computer interfaces suggests that this synergy is only deepening. Contrary to claims that our brain size is deteriorating, the measure of human intellectual capacity should now include not just our innate abilities but also the external systems that augment them [19].

The view that technology significantly enhances human cognitive ability aligns with Harari's notion of humans becoming "cyborgs" as they increasingly rely on tools that supplement mental processes. Similarly, [22] discusses the extended mind theory, which posits that external tools, such as smartphones, are integral components of the human cognitive system, challenging the notion that brain size or biological limitations strictly define mental capacity. These technological extensions of human cognitive ability have created new frameworks for evaluating our intellectual potential, making it more accurate to assess human functionality in a combined system of biological and technological entities.

The emergence of human-like properties such as consciousness [23], observed in advanced GPT models, represents a pivotal step in the evolution of artificial intelligence and human progress. These models, capable of understanding and generating natural language, are beginning to mimic forms of cognitive processes, thus contributing to what could be described as the dawn of a new "intelligent era." This era, driven by AI's ever-increasing capabilities, promises a deeper integration between human cognition and machine intelligence, potentially fostering innovations in problem-solving, creativity, and the expansion of knowledge.

Researchers like David Chalmers have explored the idea that AI systems, such as GPT models, may embody elements of extended cognition, which can extend human cognitive abilities beyond their biological limits. The more these models evolve, the more they may contribute to an era where AI complements human intelligence in unprecedented ways, leading to new forms of civilization that heavily rely on intelligent systems to solve complex global challenges [7, 22].

Figure 1 illustrates the functional growth of human problem-solving capabilities, driven by the integration of ICT and AI solutions, which serve as amplifiers of natural intelligence. Human cognitive abilities are being multiplied several times through this merger with ICT and AI, as represented by the blue arrow. While the original figure without the blue arrow shows the increase in human skull volume, and thus brain size, the blue arrow highlights the exponential growth in problem-solving capacity. A simple analogy can be drawn: consider a person walking barefoot versus using a car or plane. The speed of movement changes dramatically, even though the human's physical body remains unchanged. Similarly, while human biology (the brain) did not improve, the ability to tackle complex tasks surged drastically with the aid of ICT and AI

5 DISCUSSION

In recent years, there has been growing concern that Western civilization is experiencing a period of decline, marked by political fragmentation, cultural disintegration, and economic challenges. Scholars have pointed to a loss of social cohesion, declining institutional trust, and the rise of non-productive and conflicting ideologies [24, 25].

On the other hand, the rapid advancements in artificial intelligence are driving unprecedented changes across various

fields, fundamentally altering the landscape of industries and society. As AI technologies continue to evolve, they offer both tremendous opportunities and significant challenges that require careful consideration.

Balancing Innovation with Ethical Concerns: One of the primary discussions surrounding AI is the balance between innovation and ethical considerations. AI has the potential to revolutionize fields like healthcare, finance, education, and transportation by improving efficiency, accuracy, and personalization. However, these advancements also raise critical ethical questions, particularly regarding data privacy, algorithmic bias, and the potential for AI to perpetuate or exacerbate existing inequalities. For example, while AI-driven personalized medicine can enhance healthcare outcomes, it also risks marginalizing those without access to the necessary technology or data [14].

Moreover, the use of AI in finance, particularly in areas like algorithmic trading and credit scoring, has the potential to deepen economic disparities if not carefully regulated. The challenges of ensuring fairness, transparency, and accountability in AI systems are significant and demand robust governance frameworks to prevent misuse or unintended consequences [15].

The Human-AI Symbiosis: Another crucial aspect of the discussion is the growing symbiosis between humans and AI. As humans increasingly rely on AI technologies in daily life—through smartphones, wearables, and AI-powered applications—there is a merging of human and machine capabilities. This integration has the potential to significantly enhance human cognitive and physical abilities, leading to what some describe as an augmented human experience. However, this symbiosis also raises questions about dependency, control, and the future of human autonomy. As AI systems become more embedded in decision-making processes, it is essential to consider how these technologies may influence human behavior, decision-making, and even identity.

The development of AI models like GPT-4o has shown how closely intertwined human and machine intelligence can become. These models have not only expanded the possibilities of human-machine interaction but have also challenged our understanding of creativity, communication, and the nature of intelligence itself. As AI continues to evolve, it will be crucial to monitor and understand the long-term implications of this symbiotic relationship on human society and culture [13].

The author of this paper continuously highlights the significance of this merging, noting that the increasing integration of AI into human life first of all augments human capabilities but also to a certain degree presents complex ethical and philosophical challenges. As AI begins to mirror human-like consciousness in certain aspects [22], the line between human and machine products is becoming increasingly blurred, raising questions about the future of this relationship and the implications for human identity and autonomy [23]. The level of consciousness in large language models (LLMs), evaluated through Tononi's axioms of intelligence, was found to be significantly below that of human consciousness, but notably improved compared to earlier AI systems [23].

The Future of Work and Society: AI's impact on the workforce is another critical area of discussion. While AI can enhance productivity and create new opportunities, it also poses a significant threat to traditional job roles, particularly in industries where automation can replace human labor. This shift could lead to widespread job displacement, necessitating a rethinking of economic structures, education systems, and social safety nets to address the needs of a rapidly changing labor market [16].

The potential for AI to drive social and economic inequality is a pressing concern. Without proactive measures to ensure equitable access to AI technologies and to address the disparities that may arise from AI-driven economic shifts, society risks deepening existing divides. One of the best solutions is introducing the AI courses already in elementary schools.

Navigating the AI Revolution: As AI continues to advance, society is at a crossroads, faced with the task of navigating the complexities of the AI revolution. The potential benefits of AI are immense, but there are also certain risks. Ensuring that AI technologies are developed and deployed responsibly will require a concerted effort from governments, industry, academia, and civil society. This includes developing ethical guidelines, regulatory frameworks, and educational initiatives that can help society adapt to the changes brought about by AI. At the same time, these regulations should first of all enhance proper progress, research and development, and not pose additional bureaucratic burdens.

In cognitive terms, GPT models represent a promising approach to creating forms of artificial consciousness and cognitive information beings. These models simulate aspects of human cognition, such as language understanding and generation, by mimicking neural networks that resemble the processing of human brains. As they evolve, GPTs could potentially help us explore and understand the fundamental components of human consciousness, offering insights into both artificial and human cognition [26].

In conclusion, the discussion surrounding AI is multifaceted, touching on ethical, social, economic, and technological dimensions. As we advance, it is essential to balance harnessing AI's potential with addressing the challenges it brings, such as bias, privacy concerns, and the risk of job displacement. By proactively engaging with these issues, we can ensure that the AI revolution creates a future that is not only innovative but also promotes individual and societal human progress. Despite the ongoing debates and misunderstandings, the transition toward an information-driven era seems inevitable, as AI continues to integrate into every facet of human life, shaping our collective destiny.

Tool Usage: ChatGPT-4o and various grammar and word processing tools were applied to enhance the language quality. ChatGPT was also employed periodically to refine informal draft ideas into well-structured, formal text. The text was regardless of the language modifications finally examined and modified by the author.

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Cognitive perspective on production of third person dative and accusative clitic pronouns in Slovenian school-aged children

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Abstract

The paper investigates the production of third-person dative and accusative clitic pronouns in Slovenian school-aged children, focusing on whether cognitive factors influence their acquisition, despite the morphological similarities of these clitics in Slovenian. Previous research in Italian suggested that dative clitics in Italian are acquired earlier than the accusative due to their morphological differences, a pattern tested within the Slovenian context. Using elicited production tasks with 71 Slovenian children, the study reveals that in Slovene third person clitics are produced more frequently than third dative clitics, challenging the idea that acquisition is driven solely by morphological complexity. The research is framed within cognitive science, drawing on Universal Grammar and connectionist models to explore how cognitive processes, such as working memory and language processing demands, interact with linguistic structures.

Keywords

Language acquisition, Slovenian clitics, dative, accusative, pronouns

1 Introduction

Language acquisition is a fundamental aspect of cognitive development, providing a window into how and when the human mind processes and structures information. The acquisition of clitic pronouns, such as the third person dative (3DAT) and accusative (3ACC) clitics in Slovenian, involves complex cognitive processes that reflect both innate linguistic capacities and the influence of environmental factors. In the first part, this assignment explores these processes through the lenses of prominent cognitive science theories, including Universal Grammar and connectionist models, while also considering the role of working memory in language development. In the second part, the conducted experiment, which tested proposed research hypothesis from Italian on Slovenian school-aged children, is presented**.**

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2 Experiment

Cardinaletti et al (2021) claim that the Italian dative clitics are acquired faster than their accusative counterparts because of a morphological difference between Italian dative and accusative clitics. Since there is no comparable difference between Slovenian dative and accusative clitics, their proposal predicts that the observed difference in acquisition should be absent in Slovenian. I tested this prediction among Slovenian children. The prediction was not confirmed, since children produced 3DAT clitics significantly less often than 3ACC.

2.1 Goals and predictions of the study

This study aims to examine the production of 3DATand 3ACC clitic pronouns among Slovenian school-aged children. Acquisition of the two clitic pronouns had been studied in Italian, where it was determined that the acquisition of the 3DAT clitics precedes the acquisition of 3ACC clitics [3]. The authors argue that the difference in the time of acquisition stems from different morphological makeup of the two sets of clitics. Italian dative clitics do not differentiate between gender (*gli* is a third dative pronoun used for both feminine and masculine gender), while accusative clitics differ for the two genders and are thus morphologically more complex. They argue that gender features, or better the lack of them, must be the reason why Italian children produced more 3DAT clitics than 3ACC clitics.

In Slovenian both 3ACC (ga “him”, jo “her”) and 3DAT (mu “to.him”, ji “to.her”) clitics are comparable in their morphological complexity as they both also spell-out the gender feature. Given the analysis in [3] it is predicted that there should be no difference in the production of 3ACC and 3DAT clitics in Slovenian. The purpose of this research is to test this prediction by exploring whether there is a difference in the production of 3ACC and 3DAT clitics among Slovenian school-aged children.

2.2 Methodology

The methodology for this study is structured around two main elicited production tasks, each tailored to evaluate the production

of dative and accusative clitic pronouns in Slovenian. These tasks are adapted from those used in the study [3], ensuring consistency in approach while accommodating the unique aspects of Slovenian. Slovenian stimuli consist of translations, and where necessary, adaptations of the Italian sentences used in [3] and of mostly unmodified drawings also from [3].

2.3 Participants

71 Slovenian typically developing (TD) children took part in the study. They were divided into six age groups, as shown in the table 1. Written in- formed consent was obtained from the children's parents prior to testing. Parents provided information about the languages spoken at home, which enabled us to exclude bilingual and L2 Slovenian speakers from the study.

Table 1: Groups, age and mean age of tested children.

Groups	Age	Mean age
TD1	6.6-6.9	6.8
TD2	7.0-7.9	7.4
TD3	8.0-8.8	8.6
TD4	9.0-9.9	9.6
TD5	10.0-10.8	10.4
TD6	11.0-11.9	11.4

Elicited Production – Accusative Task

This task is designed to elicit the use of 3ACC clitic pronouns. Children were presented with a series of visual stimuli featuring one or two characters engaged in various actions. For each set of images, the initial scene was described to the child using a recorded narrative. Following this, a second image was shown, and the child was asked to describe the action occurring, specifically focusing on the interaction between the characters. The aim is to prompt responses that naturally incorporate accusative clitic pronouns, reflecting the child's understanding and use of these grammatical structures.

Example Stimulus for Accusative Task

The first drawing shows a boy (agent) destroying a sand castle (patient), (Figure 1). The narrative describes the first scene, and the child is asked, "What is the boy doing to the castle?" (Figure 2). The expected response should include the accusative clitic pronoun corresponding to the castle sand, indicating the action directed towards the patient.

Figure 1: "In this story there is a boy that wants to destroy a sand castle."

Figure 2: "Look, what is he the boy doing to the castle?"

Similar elicited production task was made for the dative.

2.4 Procedure

Each child participant was individually tested in a quiet room within their school, ensuring a comfortable and distraction-free setting. All responses were audio- recorded and subsequently transcribed for analysis, with verification by two separate reviewers to ensure accuracy.

2.5 Response coding

We have classified the answers into three categories: target, production of full noun phrases (NP), clitic/NP omission. Every answer containing a clitic pro- noun was considered as target. Children have produced a good amount of target answers. In most of the answers they produced the same verbal form they had heard in the question, present tense, or sometimes produced sentences containing past tense. The most frequent non-target answer was the production of full NPs (in both, accusative and dative tests). The answers are grammatical, though redundant and pragmatically infelicitous, since the elicitation context requires clitic pronouns. There were some instances where clitics were omitted, either in the accusative or dative tests. In the accusative test, clitic omission led to ungrammatical sentences. In the dative test, ungrammatical responses occurred with verbs like *dati* "give," *podariti* "give," and *prinesti* "bring," all of which require a goal argument. Conversely, verbs such as *brati* "read" and *metati* "throw" resulted in grammatical sentences that were, however, contextually inappropriate for elicitation.

Table 2: Percentages of target answers for all groups

Groups	Target DAT	Target ACC
TD1	28,7	57,4
TD2	57,1	83,3
TD3	37,5	62,5
TD4	71,2	85,9
TD5	64,3	76,2
TD6	81,8	82,6

3 Results and discussion

All children's responses were compared using student t-test: the difference in the amount of 3DAT and 3ACC produced between the tested children is statistically significant ($p < .001$). Table 2 gives an overview of percentages of production of clitics, full NPs and omission in both tasks. Four instances of gender agreement error were found within the youngest group TD1 and two such errors within the TD3 group. Overall, children produced a good amount of target answers. The analysis within each group shows that the difference between 3DAT and 3ACC is noteworthy in all groups, except in TD6. The youngest groups produced significantly more 3ACC clitics than 3DAT clitics, namely TD1 28,7% more, TD2 26,19% more, TD3 25,0% more. As for the analysis between groups, we found significant differences for 3ACC, where the use of a 3ACC clitic is very low in TD1 group with 57,4%, TD3 group with 62,5% and TD5 with 76,19%. The omission was always higher with the 3DAT pronoun than 3ACC, TD1 omitted 3DAT with 16,67% more, TD2 with 25% more, TD3 with 8,34% more, in group TD4 no case of 3ACC omission was noted, TD5 omitted with significantly higher percentage of 20,23% more and TD6 with 4,54% more.

In this study the production of 3ACC and 3DAT clitic pronouns on Slovenian school-age children was tested, using two elicited production tasks. Differences between 3DAT and 3ACC clitics production were found in all groups. Children produced less 3DAT than 3ACC clitics in general. Which differs from what Italian kids (as reported in [1]) were producing, and also goes against the prediction based on [1]. Surprisingly the high omission is present in all age groups. Among the non-target answers, the production of full object instead of clitics was unusually high in the accusative task for the two oldest groups, while the four youngest groups produced fuller object in the dative task, which could be age related linked to the difficulty of the task. As Slovenian 3ACC and 3DAT clitics are morphologically comparably complex, the explanation provided in [1] cannot be used to explain the observed pattern.

The findings suggest that while innate linguistic capacities, as proposed by Universal Grammar, provide a foundation for language acquisition, the role of working memory and cognitive development cannot be overlooked. The results challenge the idea that the acquisition of clitic pronouns is driven solely by morphological complexity.

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Ballot Butts: Nudging towards Pro Environmental Behaviour

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ABSTRACT

This study explores the effectiveness of a nudge-based intervention, to reduce cigarette butt littering on a student campus. Using the principles of nudge theory, particularly the EAST framework, we designed a ballot box, allowing smokers to "vote" by disposing of their cigarette butts. Observations conducted before and after the intervention revealed a statistically significant increase in proper disposal, supporting the claim that nudges can positively influence environmental behavior. However, the study also highlights several limitations, including varying participant demographics and the challenge of isolating the factors driving behavioral change.

KEYWORDS

nudging, environmental behaviour, gamification, littering

1 INTRODUCTION

1.1. Increasing Need for Innovative Solutions

With the increasingly dire consequences of climate change, the urgency to address the environmental degradation has never been greater. Among the myriad of issues contributing to this escalating problem, littering—particularly the improper disposal of cigarette butts—stands out as a significant, yet often overlooked, contributor. In 2019, of the estimated 6 trillion cigarettes, only a third were properly disposed of [1]. Cigarette butts (CBs) are composed of tightly packed microfiber bundles of cellulose acetate. Cellulose acetate is cellulose treated with acetic acid, which heavily impedes the biodegradability of CBs. During their decades-long degradation period, CBs pose a double threat. The first is plastic pollution, as cellulose acetate is classified as a 'bio-plastic' with the second being the release of toxins that build up through the process of smoking [1]. The effects typically result from leaching, causing damage to aquatic life and contaminating waterways, while the consequences in terrestrial environments range from ingestion of butts, buildup of toxic chemicals, and soil contamination [1, 2, 3]. As such, finding ways to encourage proper disposal of CBs is crucial for reducing environmental harm.

1.2. Nudge Theory

One promising line of research in reducing littering is the nudge theory, first proposed by Thaler and Sunstein in their work *Nudge: Improving Decisions About Health, Wealth, and Happiness.* In their words, a nudge is "any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives" [4]. A nudge replaced their previous idea of paternalism, which similarly influences "choices of selected parties in a way that will make them better off" [5]. Several studies have found that nudges, in their various forms, can indeed be effective in reducing littering [6, 7, 8]. For example, a study on Chinese workers found that it is possible to reduce littering on the factory floor by 20% by placing golden coins, which are culturally and religiously significant, on the factory floor, thus changing it from a place that can be littered, to a place that should not be littered [8]. There are various forms of nudges and can be roughly divided into sizing (e.g. changing portion sizes in restaurants to reduce food waste), priming (e.g. footprints leading towards a bin), proximity (e.g. having a bin close by), presentation (e.g., designing eco-friendly devices as more aesthetic), labelling and improving the functional design [7]. Due to their diversity, usefulness and cost efficiency, nudges could help mitigate the environmental impact of CBs.

1.3. Theoretical framework

Our research was inspired and partly supported by the Green Nudge project[1]. This study specifically targeted the smoking behaviours of the student population from various faculties in the area of Kardeljeva ploščad in Ljubljana, aiming to assess how the design of bins could influence proper disposal habits of the CBs.

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[1] The Green Nudge project ("UL za trajnostno družbo – ULTRA"), financed by the EU - NextGenerationEU, and Republic of Slovenia, Ministry of Higher Education, Science and Innovation.

In our pilot study we implemented the nudging principles in the context of pro-environmental behavior. During our research design and nudge implementation process we relied heavily on the ideas from The Little Book of Green Nudges [9], where we utilized their five recommended steps of nudge implementation and their EAST framework, designed to make a nudge Easy, Attractive, Social and Timely. We based our nudge on the findings of Rifkin and colleagues [10], where they found out that behavior, such as tipping in a bar, can be influenced by "dueling preferences". If a behavior is presented as a choice between two options, preference for dogs versus cats, it gives people the opportunity to self-express themselves through a behavior that is not directly connected with the preference. In a similar fashion we have designed a cigarette voting box, where people could cast a vote with their CBs. The previously mentioned study was also a basis for a pilot study by Gay and colleagues [11], where they compared the impact of different cigarette bins on polluting behavior. They found that a "dual preference" voting box, like ours, was the most efficient in reducing the pollution of the environment with CBs.

Figure 1: The ballot box for CB's
The prompts on the box are: morning shower (slo. *tuširanje zjutraj)* and evening shower (slo. *tuširanje zvečer*). The box is made from a repurposed mail box and is standing on a metal pole. Surrounding the box is a picture depicting two smokers. The bin was made by our colleagues at the Academy of Fine Arts.

Existing studies addressing cigarette butt littering through behavioural experiments indicate that 63% of such littering is driven by individual motivations, such as a lack of awareness about environmental impacts and the availability of ash receptacles [12]. Other contributing factors include convenience (e.g., the distance to bins) and habitual behaviour [13], some research highlights a correlation between an area's cleanliness and the likelihood of littering, with certain demographics, like younger individuals and men, being more prone to littering [14]. While the design of ballot bins is often consistent across studies, the specific environments, demographics, and timelines vary. Research demonstrates that these bins can be an effective, low-cost solution for reducing cigarette butt litter, particularly in more homogeneous settings like school campuses. However, their effectiveness may diminish in more diverse public spaces [14]. Given the many variables influencing these outcomes, researchers recommend further experiments to optimize these interventions in different settings [12, 13, 14].

2 METHODS

Our preliminary study into the effectiveness of cigarette disposal through the use of ballot bins was conducted on a student campus in Ljubljana, Slovenia during the spring and summer of 2024. After initially observing the campus area, we decided to target the behavior of throwing CBs on the ground. There were several 'hotspots' of discarded cigarette butts, but we were particularly intrigued by the large number of butts thrown around bins. What intrigued us was the fact that despite there being a clear area for throwing away their cigarettes, smokers still did not opt for this choice. As such, we focused on a popular smoking area of the Faculty of Social Sciences at the University of Ljubljana. During the span of six months, we conducted two sets of observations, totalling seven observations: one set of observations before our intervention and one after. The first four observations were carried out in April 2024 and observed a popular smoking spot for students and faculty next to an existing bin. With the exception of the first observation, which was done in a group by all researchers, all were done individually over the course of two hours. During these observations, we collected data on the total number of CBs thrown in the bin or improperly discarded. We also took into account other factors such as time of day, weather and any other factors we deemed important like the number of people smoking together outside, or any other factors, which might have influenced the final number. The second set of observations was done during July, this time with the nudge (the ballot box) placed next to the bin in a popular smoking spot. The ballot box can be seen in **Figure 1**.

3 RESULTS

Our descriptive results are presented in the table below (see **Table 1**), where we calculated the mean value of CBs either in the bin or on the ground before and after the implementation of our green nudge.

Table 1: Littering behaviour observations before and after intervention with CB's thrown in the bin and on the ground

Observations	Condition	CB's in bin		CB's ground	
		M	*SD*	*M*	*SD*
1	before	21	6.38	12.25	5.74
2	after	17	17.35	4.3	2.52

In order to determine if there is a statistical difference between the proportion of CBs in the bin versus on the ground based on the condition, we conducted a two-proportion Z-test. Based on

the statistical analysis we found that there was a statistically higher proportion of CBs thrown into the bin versus on the ground after the implementation of our cigarette voting box, compared with the proportions before its implementation, $z = 0.165$, $p = 0.0495$.

4 DISCUSSION

Based on our results we can confirm our hypothesis that our nudge would increase the proportion of CBs thrown into the bin versus on the ground thus reducing the pollution of the environment surrounding the student campus with CBs, which is in line with the findings by Gay and colleagues [11]. Although our results do indicate a change in the proportions, conclusions should be taken with caution, since the frequency of smokers present before and after the implementation of the nudge varied vastly and could have had a big impact on the results of our analysis.

Additionally, it is difficult to determine exactly what nudged the participants' behaviour, which opens a broader question of nudge validity. Specifically, for our nudge, there could have been a number of factors influencing their behaviour. Some of these factors include 1) proximity; simply having more available bins could have decreased the number of CBs thrown on the ground, 2) novelty; the nudge gained attention by simply being a new structure in a familiar environment, 3) presentation; the ballot box is more attractive than a conventional bin, which is why participants would decide for it. While these factors do not negate the effectiveness of the nudge, the difficulty in pinpointing the determining factor could influence the design and implementation of nudges. For example, if novelty is the determining factor, a green arrow pointing towards a bin could have the same effect as a costly ballot box. There is also a possibility that our nudge was not clear enough and thus resulted in some people not engaging with it. The communication materials were designed with a tone that was perhaps too playful and light-hearted, which may not have resonated well with the student population of smokers, who might have responded better to more straightforward and direct messages. This lack of clarity could have had an overall impact on the efficacy of our nudge as suggested by Sunstein [15].

4.1. Limitations

One key limitation of our study is the comparability of pre- and post-intervention data. Before the intervention, data was collected during the ongoing academic term with a larger, consistent student population. Post-intervention data, however, was gathered after the exam period, when fewer students were present. Moreover, the population mainly consisted of foreign students attending summer school. The study of Chinese workers by Wu and Paluck mentioned in section 1.2. urges that cultural context must be taken into account when designing a nudge. They state that nudges "must recognize motivations and subjective interpretations within a particular context" [8]. Thus, without the proper consideration of the cultural background of foreign students, it seems highly unlikely that our nudge, designed for Slovene students of the Faculty of Social Sciences, had an equal effect on foreign students attending summer school.

4.2. Future directions

While our pilot study provides valuable insights into the effectiveness of nudging towards pro-environmental behaviour, future research could address the small sample size in this study by employing a larger, more diverse population to improve the generalizability of the findings. Additionally, observing the population within a shorter timeframe would improve the validity of our results. Further studies could also include an interview before implementing a green nudge, using polling to determine the general environmental attitude, and after the green nudge, to ascertain the factors influencing their decision-making process.

In conclusion, our study has shown that nudges can be successfully employed to influence non-environmental behaviours by combining behavioural insights from nudge theory and gamification concepts (see [16] for a study combining gamification and nudging). Specifically, a ballot box could be used in short term settings, like open-air concerts and other events, where littering poses an issue. However, further research is needed to expand upon the factors underlying non-environmental decisions.

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Problem Solving as a Key for Sustainable Future*

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Abstract

Achieving sustainability in today's complex world is a challenging, long-term endeavour. This paper focuses on the critical role of education in advancing sustainability, emphasizing the urgent need for innovative, interdisciplinary approaches that prepare students for the demands of both the modern and future world. Central to this discussion is the idea of problem-solving as a key to a sustainable future, which is deeply connected to the field of cognitive science. By leveraging insights from cognitive processes, researchers can develop innovative solutions to complex challenges, promoting resilience and adaptability in society. Understanding how individuals think and make decisions informs strategies for addressing pressing issues such as climate change, resource management, and social equity, ultimately contributing to sustainable development. By integrating insights from cognitive science—particularly in problem-solving, critical thinking, and metacognitive strategies—we highlight how these cognitive tools enhance students' abilities to tackle sustainability challenges. The paper examines key issues, relevant disciplines, and outlines a framework for shaping future education to effectively contribute to global sustainability efforts.

Keywords

problem solving, education, SDG, ESG, sustainability

1 Introduction

There is a global agreement that sufficient resources should be devoted to preserving, and improving in the amount possible, our society. Having in mind the complexity of our society in total, but also of its many components, this is certainly a rather demanding endeavour. Currently, as a combination of the long-term goals and the operational prescriptions, the Sustainable Development Goals (SDG) were formulated [1]. Closely related to these Goals is the concept relating environmental issues, social issues and corporate governance – ESG [2]. One may argue that each of the three involved notions encompass rather complex and large substructures.

SDG is collection of 17 goals, spanning different aspects of our society [1]. The Goal 4 – Quality Education is specifically devoted to education. But along with it, education is important for all other goals, having in mind that generally education contributes to transferring knowledge and experience between generations. In that way, education contributes both to latency of values and good practices in our society, as well as to their evolution and gradual improvement. It is not just that the learning process is important, but awareness of it is crucial for the reflective thinking needed to address the challenges of sustainability and complex systems.

In this paper, we focus on the stated role of education. In section two, we extract aspects of society that are currently too demanding for most educational approaches and are consequently insufficiently encompassed within the optimal form of education. Cognitive science plays a crucial role by exploring how individuals perceive, think, learn, and solve problems, providing a foundation for developing educational approaches that promote sustainability.

In sections three and four, we concentrate on education. In section three, we extract starting points for the development of an optimal form of education that substantially contributes to sustainability. The ability to solve problems, a key focus of cognitive science, is critical for navigating the unpredictable dynamics of complex adaptive systems, which characterize many contemporary challenges. In section four, we additionally emphasize the education for sustainable future and relate it to systems thinking. Critical thinking, another pillar of cognitive science, enables students to analyse global challenges such as climate change and inequality, making it essential for understanding the interconnected nature of these issues. We argue that the inclusion of systems thinking significantly contributes to the education for sustainable development. Section five provides the perspective and general guidelines for the

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broader application of systems thinking in education. The last section concludes the paper.

2 Society as a complex system

Research of complexity and complex adaptive systems (CAS) broadened our understanding of characteristic dynamics in society and its parts, which includes cooperation and competition, emergence, bifurcations and deterministic chaos, to name some of the relevant notions [3, 4].

Dynamics of the CAS is characterized with nonlinear interactions, the important consequence of which is delay. That includes different aspects of dynamics, particularly the instabilities. Nonlinearity is a notion that can easily be described yet deserves significant experience to be considered properly, whether that be for predictions or for analysis of past events. CAS is modelled on the micro-level, by characteristics of entities, usually called agents, and rules of their interactions [5]. The macro-level, system behaviour is obtained by simulations. There is no direct linking between macro-level and micro-level. Instead, one modifies micro-level characteristics of agents and rules of their interactions to obtain specific macro-level system behaviour. Models differ in the level of stylization, so some reveal generic system behaviour, trends that can be related to many diverse systems [5], while others are specific and reproduce expected dynamics in detail but of a particular system. Some contributors emphasise anthropomorphic interpretation of quantities that are historically considered rather formal [6], while other develop formal approach to intrinsically human-related characteristics such as happiness [7, 8, 9], to mention few examples among a myriad of existing scientific contributions.

All stated should be taken into consideration if one wants to make reliable predictions for a society or some other CAS. That requires a critical mass of competent people, to be formed within every new generation by a well-formulated, learning outcomes oriented, profound education.

3 Education for complex systems

World Economic Forum states top 10 skills, for different periods since almost a decade ago. Consistently, critical thinking and complex problem-solving top the list of skills that employers believe will grow in prominence [10]. These have been consistently emphasized as crucial since the first report almost a decade ago. Moreover, broader application of ESG standards within organizations will also have a significant impact [10, 11]. One aspect is that investments that facilitate the green transition of businesses and the broader application of ESG standards bring about net job-creation [11].

OECD monitors education and different aspects of transition from school to work. In addition, OECD formulated and organizes world-wide testing of skills and knowledge among students, in the form of PISA testing [12, 13].

UNESCO has contributed extensively to the development of competences of children and youth [14]. It was realized some time ago that education for sustainable development is a key instrument to achieve the SDGs [14].

The UN previously proclaimed Decade of Education for Sustainable Development (2005–2014), aimed at integrating the principles and practices of sustainable development into all aspects of education and learning [14].

One of the consequences of the extensive testing of alignment of education with society's needs is that we have rather detailed and reliable insight into the fulfilment of the education potential. Yet, it is clearly stated in words by I. Bokova, General-director of UNESCO: "A fundamental change is needed in the way we think about education's role in global development, because it has a catalytic impact on the well-being of individuals and the future of our planet" [14].

All stated about the reached education level and characteristics of our society (and CAS as its models) point to the fact that an innovative, qualitatively different education is needed to include the complexity in formal curricula, so that students can grasp its fundaments in a significant portion.

As a particular aspect of education, we emphasize problem-solving. It is a set of actions aimed at solving a particular problem, no matter how complex, or interdisciplinary it is. However, that approach is not yet formulated precisely so its potential is realized only by a small part.

Along with the problem-solving skills, and critical thinking, it is crucial to embed metacognitive strategies in education. If students have learned to reflect on their own learning processes, they are better equipped to contribute meaningfully to the SDG-a and adapt to the complexity of modern society as a CAS.

4 Education for sustainable development

The ability to solve problems from the perspective of cognitive psychology is a crucial for achieving sustainability. Cognitive psychology, which studies mental processes such as perception, memory, thinking, and problem-solving, provides insights into how people make decisions and how they can be encouraged to adopt sustainable behaviours. Understanding how people process information and make decisions involves recognizing problems, generating possible solutions, evaluating those solutions, and selecting the most appropriate one. In the context of sustainability, these problem-solving skills are essential for individuals and communities to identify environmental challenges, develop innovative solutions, and implement sustainable practices [15].

Research has shown that human behaviour is a significant source of uncertainty in the use of natural resources and a critical factor in local and global sustainability challenges [16]. By integrating insights from behavioural sciences into sustainability research, we can develop policies that promote sustainable behaviour. Cognitive psychology provides tools to understand how people perceive environmental problems and how they can be motivated to change their behaviour [17].

Education plays a pivotal role in fostering these problem-solving skills. Education for sustainable development (ESD) equips learners of all ages with the knowledge, skills, values, and agency to address interconnected global challenges such as climate change, biodiversity loss, and resource depletion [18]. ESD empowers individuals to make informed decisions and take collective action to transform society and care for the planet [19].

To further enhance these educational efforts, system thinking is another critical element for achieving sustainability. System thinking allows us to see how different parts of a system interact and how changes in one part can affect the entire system [20]. By

understanding complex environmental problems through system thinking, we can develop holistic solutions that consider long-term consequences. This approach is integral to problem-solving as it helps identify the root causes of issues and their interconnections within the environmental system [21].

In addition to system thinking, STEM (Science, Technology, Engineering, and Mathematics) education is essential for sustainable development. STEM education equips individuals with critical thinking, problem-solving, and technical skills necessary to address environmental challenges. By integrating sustainability into STEM curricula, we can prepare future generations to develop innovative solutions for sustainable development [22, 23].

Moreover, a transdisciplinary approach is vital for sustainability. This approach involves collaboration between academics from different disciplines and non-academic actors to co-produce knowledge and develop actionable solutions. Transdisciplinary research addresses complex sustainability challenges by integrating multiple perspectives and promoting holistic understanding [24, 25].

The ability to solve problems from the perspective of cognitive psychology, combined with system thinking, STEM education, and a transdisciplinary approach, provides valuable tools for addressing environmental challenges and achieving sustainable development.

Before proceeding it is to be noted that any new concept or other type of change in education needs to be implemented in real time and space. Regarding time, there is a significant literature about structuration of time and about leisure time of children and youth, see e.g. [26, 27] and references therein.

5 Strategies for enhancing critical thinking and problem-solving skill's

Sometimes it is difficult for educational processes to determine which actions/methods due to the complex systems are successful, especially when we are talking about climate changes, how to integrate them into everyday life and how to receive feedback on the impacts at individual and collective levels [28]. This calls for initiatives to strengthen the link between education and science. To achieve exactly such initiatives, educational systems should use cognitive and educational strategies to foster innovative solutions, but in addition to this, implementation of gamification enhance engagement and motivation towards eco-friendly actions [29].

To be more precise, gamification can be a useful tool to teach students about sustainability in general [30], creating a gamified environment where students could be active citizens monitoring their impact on the environment and thus influence climate change and sustainability, which leads to fostering problem-solving skills, critical and analytical thinking and creating sustainable solutions.

Another strategy which can be implemented in educational system, which in its core supports the development of the individual as a critical participant of a particular system, is the metacognitive strategy. Metacognition as a concept of thinking about thinking [31], enhance critical thinking, problem-solving and finally adaptability in education [32]. Use of metacognitive strategies enables students to develop self-awareness, monitor their thinking process, and regulate their cognitive processes to be more accurate [31]. This is important when addressing complex, interdisciplinary challenges and CAS.

To be clearer, the following three dimensions of metacognitive strategies need to be implemented:

A) **Planning dimension**, students need to prepare themselves for problem-solving scenarios and thought processes, which helps clarify their understanding of the problem and outline an approach to solving it.

B) **Monitoring dimension**, students need to check and validate their comprehension of the problem-solving scenario through self-questioning, which sustains critical thinking. This step ensures continuous reflection on their knowledge, allowing them to adjust strategies based on real-time insights.

C) **Reflection dimension**, after completing the task, students need to analyse what they learned, reflect on the effectiveness of the strategies used, and consider improvements for future tasks. This helps students better understand the complexity of sustainability and develop a deeper understanding of how their learning strategies can evolve.

Therefore, sustainable education should also rely on metacognitive strategies, because in its concept it contains the skills of critical thinking, problem-solving, but also the sustainability of both the problem-solving scenario and the ecosystem that created the sustainable solution.

6 Methodology for implementing sustainable education

According to all previous stated, strategy for empowering sustainable educational system and people involved in it (students, teachers, principals, parents, local community) was created. It is based on the enrichment of school curricula with ESG principles, which ultimately strengthens the school's ecosystem and makes it sustainable, and it is built based on three dimensions.

First dimension of the program are students, which includes students in the local community as active participants and those who contribute to development and innovation through an interdisciplinary and transdisciplinary approach of teaching and learning. In this way, the education system enriches the local community with individuals who are ready to face the complex problems of the CAS, to solve them, and to improve already existing solutions. Second dimension of the program are the teachers. By strengthening their knowledge and skills, as well as by raising their awareness of problems and the possibility of active participation in solving them, teachers provide students with support in an appropriate and sustainable way.

Teachers need to collaborate with system beyond schools in the way that students can gather information, critically think about problems, give the scenario of solving specific problem and in the end implement possible solution. For this, teachers should have a support and life-long education. Third dimension of the program are parents, principals and local community, which, by raising awareness of the needs, problems and possibilities of innovation within the school's ecosystem and beyond, provide significant support to students and teachers in their development.

The ecosystem is then complete, which with its way of functioning provides sustainability because all participants are aware of learning protocols as well as improving or changing existing solutions.

7 Conclusion

The relationship between sustainable education and cognitive science is a profound and crucial one, as it merges the principles of mental processes with practical applications for addressing the complexities of our contemporary world. Cognitive science provides the foundation for understanding and developing educational strategies that foster sustainability. In this context, key cognitive concepts such as problem-solving, critical thinking, metacognition, and systems thinking play a significant role in shaping the approaches needed for sustainable development.

This paper highlights the critical role that education has both in the achieving sustainability in complex, nonlinear systems and in finding solutions to the contemporary problems. It emphasizes the urgent need for innovative and transdisciplinary educational approaches that prepare students for challenges that are expected from them to deal with. Key aspects include the importance of problem-solving skills, critical thinking, and metacognitive strategies. By integrating these elements into education, we equip future generations to address the complexities of sustainable development and complex adaptive systems.

In conclusion, the principles of cognitive science are deeply intertwined with the goals and strategies of sustainable education. Cognitive science provides a framework for understanding how students can effectively engage with the complexities of sustainable development and complex adaptive systems. The integration of these cognitive skills into educational curricula ensures that future generations are equipped with the mental tools necessary to address the pressing environmental and societal challenges of our time.

Ultimately, education for sustainable development, supported by cognitive science, fosters not only informed and capable individuals but also a more resilient and adaptable society.

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Mind, the Gap, and Other Cracks

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Abstract

With this paper we aim to outline numerous gaps and other cracks that emerge when we start researching conscious experience through first and second-person research approaches. The terms used to name various gaps were chosen for the sake of coherence (with a pinch of playfulness). The main gap is the *chasm between two consciousnesses* which we are trying to bridge by an exchange of descriptions of our lived experiences. When we begin to turn our awareness to *what it is like* to be we begin to develop the skill and way of observing in which experience is created. We call this gap between our everyday attitude and phenomenological observation the *crevice of awareness* in which lies the act of becoming aware of an experience. After becoming aware of a certain layer of experience we reach the *fissure of description*, which represents the crack between the actual experience as perceived and the constructed linguistic concepts in which we try to convey what and how we perceived the experience. When a description of an experience has been produced, the researcher interested in investigating human experience is confronted with the *cranny of comprehension*. We relate this process of conveying our experience to another conscious being to the processes of translation and remind researchers of lived experience to be careful and weary of the interpretation that inherently shadows every translation.

Keywords

Background experience, Conscious experience, First-person research, Second-person research, Experiential translation.

1 Introduction

Upon delving into topics and discussions regarding our understanding of the mind, we inevitably reach one or another gaping chasm – the most notorious is even named the hard problem of consciousness. David Chalmers [1] points out that there is nothing we know more intimately than conscious experience but there is also nothing harder to explain. In this article we are not trying to explain conscious experience, but we are interested in exploring the process of explaining and describing our conscious experience to another human being – in this paper we call this process of reporting our subjective experiences *experiential translation*. The subjective aspects of thinking, perceiving and feeling are all states of experience that have a certain way in which we experience them. As Thomas Nagel [2] puts it, there is *something it is like* to be a conscious organism, and this *what is it like* to be another organism is, most likely always, over an insurmountable chasm between one conscious organism and another.

We aim to address this chasm that extends from one experiential being to another and explore the cracks that emerge when trying to explore and extend from one ridge to another. In this analogy the ridges of *the chasm between two consciousnesses* represent different conscious organisms, each with their own *what it is like* to be, and the chasm is the impossibility of reaching the exact *what is it like* of another being. In the field of first and second-person research of lived experiences, researchers are trying to bridge this chasm by collecting detailed descriptions of experience. We will argue that in the act of producing and collecting such descriptions we stumble upon many cracks, located on both sides of what we call *the chasm between two consciousnesses*. Starting from first-person view (as one should, when going about empirical phenomenology) we stumble upon a crevice that is becoming aware of *what is it like* to be – the most intimate experience, yet often hidden behind a wall of what Edmund Husserl [3] calls our *natural attitude*.

In this paper we also touch another, an even more veiled dimension of experience that we call *background experience* (explained further in the section 3) but most importantly we state that there is a gap between what we can easily consciously perceive and what we cannot – which, for the sake of clarity, we call *the crevice of awareness*. When trying to convey one's experience to another we stumble upon the next gap in the act of translating the experience into concepts, categories and linguistic forms. We believe that there is a gap between our perceived experience and its description, which we name *the fissure of description*. When trying to fill this fissure we believe the experience conveyed is flattened and reduced. The description produced in this effort then becomes the main building block of the bridge we are building from one side of the chasm and what we can offer to the conscious being reaching out from the other side. In this paper we compare this act of describing on one side and comprehending on another as a process of translation and that practicing experiential translation is the way to more valid and richer descriptions.

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2 Experiential translation

Phenomenology, by origin a philosophical discipline, is trying to investigate concrete experiential phenomena and encourages detailed analysis of different aspects of consciousness. As such it has also been described as "a first-person description of 'what it is like' of experience" [4]. This subjective dimension 'as it is lived from the inside' is essential to consider in the field of scientific investigation of cognition and not be constrained merely to the data that can be observed and measured from the outside [5].

Claire Petitmengin [5] warns us that describing one's own subjective experience is not merely hard, but extremely difficult, mostly because turning our attention to our consciousness, and *a fortiori* describing it, requires inner effort and a specific kind of skillset. Her assumption is that a substantial proportion of our subjective experience unfolds below the threshold of consciousness. We question what her assumption presupposes - that our consciousness is something "in there" to be observed and we only need a better instrument to see further and better. We, on the other hand, are more inclined to view conscious phenomena as something co-created with and by the act of observation. In either case we believe that in the field of first-person research the two initial steps – becoming aware of our experience and then describing it - include two important gaps.

1. *The crevice of awareness* is the crack between what our "view from within" knows how to observe and what eludes our reflective thoughts. It denotes the difficulties of becoming aware of our background feelings and core dimensions of our experience.
2. *The fissure of description* is the gap between subjective observations of lived experience and descriptions of observed experience, which are most often verbal. This is perhaps at times even more frustrating, because in an instance when one has become aware of an experience, they must now try to find the right words and gestures to convey and verbalize a description that captures the nature of the subjective experience in question.

Subjective, or first-person research transfers to second-person research when we not only try to surmount *the fissure of description*, but we also convey this description to a researcher interested in exploring structures of lived experiences. Empirical or second-person research usually involves interviewing human participants about *their* experience. In the context of our paper, we call the interview method a rather wobbly bridge that tries to connect participants' lived experience with researcher's understanding *via* the participants' description of experience.

3. With this bridge we mark the third gap in the premise of empirical research of subjective experience – *the cranny of comprehension* – which spans between the second-person investigator and first-person report about the experience. It is a gap each researcher must fill and bridge when trying to comprehend and analyze the descriptive data on experience of others. We differentiate this cranny from the *chasm between two consciousnesses* because it is focused on the description and comprehension, not the entirety of another conscious experience.

We note that all three cracks are part of the greater *chasm between two consciousness*, which refers to the impossibility of experiencing as another being.

2.1 First-person translation

Jakob Boer [6] argues that the process of describing first-person experience is an act of experiential translation, with which we are inclined to very strongly agree. We believe that the act of describing subjective experience is an act of translation (latin *transfero*, "I convey", from prefix *trans-*, "across, beyond" and participle *latus* "borne, carried"). We will describe an example of a process of translating an ancient Greek text to a modern language. The underlaying assumption is that without an observer there is no meaning, and thus the nature and skill of the observer influence the source text immensely. Firstly, one must be able to see the Greek alphabet and know the symbols to perceive anything more than mere scribbles. Secondly, one must understand what a specific set of symbols denotes and relate to it a previously known meaning - one must understand the word. This step alone is complex and multidimensional, because one Greek word can have numerous possible translations and the meaning that stands out to the translator is tied to many factors, such as context and previous knowledge. Thirdly, one must understand the grammar and syntax to make sense of a sentence. With this we want to show how the meaning of a text is co-defined by the observer. The translator must then choose an accurate set of words in another language to convey his interpretation of the sentence. With this example we tried to show the complexity of our influences on what we perceive and how we leave a mark on both our perception and our description.

Experiential translation assumes that lived experience is in nature distinct from linguistic form, and that in the act of verbalizing we carry certain aspects across the gap between experience and description. In the act of translating our lived experiences into words, concepts, and categories we inherently imbue chosen meanings with our interpretation, which is perhaps inseparable from the way we become aware of our experience. We relate this intrinsic interpretation to *horizons of attending to experience*, as explained by Urban Kordeš and Ema Demšar [7], who argue that this co-defines experiential phenomena that end up being observed and reported. The *horizon* is the way in which we perceive, by which we mean co-create, our experience. This is enacted both when we try to observe and when we try to describe our experience.

2.2 Second-person translation

In the previous section we compared the process of describing one's lived experience to the process of translation. We continue with this analogy in the case of second-person research, when such translation is perchance more intuitive, because the 'input' – verbal report – comes in form of language. The researcher that receives the report proceeds with translating it in more than one way. First and foremost, the translation happens instantaneously, as it does every time we speak to another human being – we translate the words into our own known concepts and position them in our pre-existing field of knowledge.

Even more importantly, we aim to compare the subsequent process of analysing, categorizing and forming conclusions on the structure of experience to the process of translating, drawing attention once more to the notion that with translation always comes interpretation. As such we want to note and warn that becoming aware of your own *horizons of attending to experience* is a crucial step for every second-person researcher of

consciousness, which inherently makes them a first-person researcher as well.

3 Background experience

In this paper we turn our attention to a layer of experience which is, ironically, not in the focus of our attention but rather on the brink of it. William James [8] refers to this as the *fringe of consciousness.* To this fringe belong experiences that lack specific, sensory qualities, like the tip-of-the-tongue state (the intention to seek a missing word), feelings of knowing, familiarity and plausibility, intuitive judgments and numerous other conscious or quasi-conscious events that can be reported on with low sensory specificity.

What is it like aspect of those experience is hard to perceive and convey, but Petitmengin [9] describes certain internal gestures, which serve, in the language of our analogy, as bridges that enable us to become aware of the *source dimension* of our experience, which is usually *pre-reflective.* This unarticulated dimension is considered as core due to its ever-present nature, and because it is pre-conceptual and pre-discursive, it seems to be situated at the source of our thoughts. Although it constantly accompanies us, we need special circumstances to become aware of it and/or specific training in first-person observation.

In the realm of emotion, Antonio Damasio [10] calls a group of fleeting and hard-to-name feelings '*background feelings*', because they are not in the foreground of our mind, yet they help define our mental state and color our lives. We relate the foreground of our mind with the experiences on which we can easily focus our attention (such as thoughts, perceptions and loud emotions). Background feelings arise from background emotions, which are directed more internally than externally, but can nevertheless be observable to others in several ways: tone of our voice, prosody of our speech, the speed and design of our movements. According to Damasio, prominent background feelings include fatigue, energy, excitement, tension, relaxation, stability, instability, etc. The relation between background feelings and our drives and moods is intimate and close, but the relation between background feelings and consciousness is just as close, if not more. Matthew Ratcliffe [11] similarly develops the term *existential feeling* as a background which comprises the very sense of 'being' or 'reality' that attaches to world experiences. Specifically directed emotions presuppose this background, so regardless of the structure of such emotion, existential feelings are a more fundamental feature of world-experience. A few examples of such feelings are the feeling of being 'complete', 'unworthy', 'at home', 'abandoned' – all being descriptions of one's relationship with the world.

Hopefully we have now outlined the gap between our focal awareness and the experiences on the fringe of consciousness, where perhaps one of the keys to understanding our mind lies hidden. This gap was one of the points we tried to address in our recent project [12], in which we investigated the feelings of atmosphere with the presupposition that they are in the background of our mind. We will briefly present the context of our empirical investigations to use it as the reference point for our observations regarding the numerous gaps and blind spots of our methodological approach and epistemological premises.

4 Empirical context

In the aforementioned project, 'Unveiling of the Atmosphere – Etnophenomenological exploration of experiential background in relation to space', we aimed to investigate background experience which we have defined as feelings that weave the foundation on which foreground phenomena of consciousness unfold (such as emotions, thoughts and perceptions). We presupposed that experiences of atmosphere are by their nature affective, so we focused on the affective layer of experience. These feelings usually lack specific sensory attributes and are hard to pinpoint and often notice and/or name. We tried to capture and convey such background feelings with an empirical approach and a qualitative research design in which we combined approaches of first-person research such as Descriptive Experience Sampling Method (DES) [13], and ethnographical tools such as *in situ* diary entries. Our study was conducted in three phases, the first being the pilot study. We recruited three participants, previously trained in DES and first-person research, which we deemed important for a study that aims to research pre-reflective dimensions of experience.

Our participants reported about their experience in three ways: 1) through short written reports about randomly sampled moments during the day, 2) with diary entries on multiple occasions during the day of sampling, in which they situated randomly sampled moments in the context of their moods and behaviors, 3) in interview sessions in which we explored and expanded previous two types of data. The aim was to map our participants' affective experiential landscapes and to contextualize their experiences with information about their activities, environment and social interactions. We have analyzed the data according to the principles of qualitative analysis [14], which produced a list of experiential categories divided into two (vaguely distinct yet obviously separate) groups of *foreground* and *background affective experience.* In the background we situated categories such as *background mood*, *ambient atmosphere* and *deep atmosphere*.

1. *Background mood* is felt as all-encompassing and includes different ways of receiving, creating and experiencing foreground experiences (affects, thoughts and percepts), which we call different attitudes. We found three subcategories of background mood: open, closed and numb.
2. *Ambient atmosphere* includes experiences that are not clear and separate, but pervasive and ubiquitous. It represents feelings, which we feel originate from the world, and we are entangled with it either as their co-creator or merely as an observer.
3. *Deep atmosphere* includes experiences that we feel as deeply our own and private. Imprint of *deep atmosphere* marks the way of foreground affects as well as other background feelings. Phenomenologically it is harder to reach and observe, as it usually changes its character less or more slowly. When captured, we observed two distinct subcategories of feelings: *deep perturbation* and *deep unconcern*, the former connected to the feelings of danger and the latter to the feelings of safety.

5 Observational interstices

In this section we aim to address some methodological cracks and to note our observations from our research project on background feelings [12].

5.1 Becoming aware

In our study participants were prompted with a signal which conveyed to them that they should observe and report on their experience of the moment right before the signal. During the interviews they oftentimes reported that after the signal there was a brief state of feeling 'blank', as if the moment before the signal was empty and void of any experience whatsoever. But this feeling soon passed, and they started to remember and find words to describe the moment before the signal. We interpret this feeling of 'blankness' as a type of gap between being immersed in the *natural attitude* [3] and adapting the *phenomenological attitude*. To put it differently – we believe that the act of *epoché* is both and act of opening a gap and of bridging it. We argue that each time we try to bracket our trust in the objectivity of the world, we reveal and/or create a crack in the fluidity and continuity of the flow of our conscious experience. This means that when we change the nature of our awareness, we experience a moment of emptiness. To explain we will compare our awareness with the grip of our hand. When we hold on to one object, let's say a glass, we are gripping something and sensing specific qualities. When we want to switch to a different object, we must first release the glass and be (and thus feel) empty at least for a moment so that we can grip (experience) something else.

5.2 Observing experiential background

As mentioned in the section 2, we tried to observe and capture background feelings with the intention of mapping participants' experiential landscapes of affects. Based on the literature and preliminary observations we presupposed that background feelings change less frequently, which is one of the reasons they are more elusive and harder to notice, as opposed to the foreground experiences which change from moment to moment and require most of our attention.

Our findings support our claim that one way to notice the ever present is by gaps in continuity. Such a way requires regular first-person observation, optimally supported by a second-person approach (dialogue). Noting one's experience often over a longer period can bring to light changes that unravel slowly. To explain this with a more concrete and visual analogy – when a person on a diet is losing weight (if they are doing it in a healthy and sustainable way) they won't see any progress from day to day, but if they observe and measure themselves methodically throughout the whole year, they can notice a vast difference from their starting point.

5.3 Describing lived experience

Tying to the conclusion of the previous paragraph is a very concrete observation based on our research methodology. As described in section 2, we gathered reports on our participants' experience in three ways (short notes on experience of moments during the day, diary entries and interview insights). What we noticed is that often in the descriptions of a singular moment there was a lot of emphasis on the foreground experiences and less so on the background feelings. When participants weaved those moments in the experiential timeline of their whole day (and in the interviews of their whole week) more background feelings came into light – even in the moments which we had detailed descriptions of. We would like to note that minimising the effect of memory on reports is important, but that sometimes in this effort we miss something because it is 'right under our nose'.

6 Conclusion

Delving into the field of empirical phenomenology is a courageous act, because there are few, if any, clear and firm climbing holds. We understand why scientific discourse steers toward replicable and third-person tested approaches, yet we believe that exploration of lived experienced cannot (at least as of yet) be accessed any other way than through subjective observation first. And even if the act of bridging the subjective with intersubjective is full of gaps and other cracks, we stay positive that the descriptions and interpretations produced in this process lead to better understanding of how to approach empirical research of subjective experience. In the analogy of translation as the act of describing one's own experience, we aim to paint the following picture. In the gaps that lurk amid experiencing, being aware and describing, many pieces of the original experience are most likely lost in translation. Yet by persistently and methodically carrying over the remaining pieces created by this process we are building better and more reliable bridges.

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Bridging the Challenges in Experience Sampling Research

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Abstract

In this paper, we draw parallels between existing research practices and attempt to piece them together to propose a more wholesome approach in conducting experience sampling research. We consider Experience Sampling Methods (ESM) as valuable tools for studying experience, but they come with challenges, of which we address the participant burden as one of the most significant ones. We think that integrating practices from Personal Science (PS) and Citizen Science (CS), grounded in empirical phenomenology, can help address this challenge. By considering participants as co-researchers and actively engaging them in the research and community, we aim to enhance their motivation and improve the quality of the research data. We illustrate this approach through the pilot project Luna in which we explore lived experiences throughout the menstrual cycle using the ESM mobile application "Curious". This integrative method facilitates a reciprocal knowledge exchange between researchers and co-researchers, which deepens the process of self-exploration and holds a great potential to advance scientific research on experience.

Keywords

Experience sampling methods, citizen science, personal science, empirical phenomenology

1 Introduction

Scientific research into experience is a rapidly growing field. Some researchers and philosophers point out that a core problem within our current scientific worldview is the overlooked experience research [1]. New methods and tools for researching experience are being developed, among which are Experience Sampling Methods (ESM). ESM are intensive longitudinal approaches to collecting experiential and contextual data using structured diary self-report techniques [2]. Due to numerous advantages, especially ecological validity and the reduction of recall bias, ESM has spread to various research fields through the use of mass technology, mostly mobile applications [3]. Based on numerous studies [4, 5, 6] that have used ESM to investigate experiential phenomena in the past few decades, weaknesses of these methods have been identified [7].

We present ESM and the challenges inherent in ESM research, particularly participant burden. By exploring the interest in personal exploration within Personal Science and emphasising the importance of community building in Citizen Science, we attempt to tie these practices together using the concept of a methodological turn from empirical phenomenology [8]. We believe that the challenge of participant burden, which we see as under addressed but highly disruptive in ESM scientific inquiry, can be tackled through this integration of different research practices. We illustrate this approach with our pilot study, Luna.

2 Experience sampling research

We consider Experience Sampling Methods (ESM) as an umbrella term for the research in which participants gather samples of their experiences as they unfold in their life [9]. Typically, we prompt participants at random times to answer questions or to describe their experience of the moment just before they heard the beep [10]. This way we are able to minimise recall bias [7] and are able to sample dimensions of experiential states which are nearly impossible to recall later, especially in detail (e.g., the momentary content of our thoughts). These methods are also highly ecologically valid, since we are sampling experience as it unfolds naturally in people's everyday lives. Participants would receive the prompts several times per day for a longer period of time (e.g., two weeks). These repeated measures enable us to track patterns and changes in individual experiences across time and different contexts [7, 10]. Nowadays we use mobile applications on participants' personal smartphones which makes the data collection process in comparison to pen and paper much more reliable and less burdensome [11].

2.1 Challenges in ESM

ESM research is still loosely defined without a rigorous framework and we are yet to develop appropriate methodological approaches for improvements [9]. A significant challenge in ESM research is participant burden. Collecting frequent, real-time data in everyday life activities puts great demands on participants who need to albeit shortly interrupt their activity to report on their momentary experiential state [3]. These repeated measures over time might affect participants' attitudes towards the research and result in reduced compliance, careless responding and participants' attrition [12]. We should also evaluate this burden from an ethical perspective, ensuring that

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benefits outweigh the burden, especially if there is a consideration of affecting participants' well-being [13].

2.2 Existing recommendations for addressing the challenges in ESM

To mitigate this burden, researchers are working on questionnaire optimisation, making them as brief and focused as possible by prioritising essential questions and using clear and concise language [9]. The trade-off between data richness and burden on participants is also mitigated with lowering the sampling frequency [12]. By introducing the personalised scheduling for participants we avoid interrupting them in the situations in which they are unable to respond and would likely react negatively to prompts being delivered in that time [3]. Albeit we should then revise random sampling and account for the introduced bias (e.g., we could supplement the data with retrospective daily reports).

However, a key factor for successful ESM research is participants' motivation [3, 7]. It is better sustained by considering the necessary technical recommendations, but researchers should also give attention to fostering the research interest and social dynamics. Researchers should engage participants who already have interest in the research topic and therefore an intrinsic motivation to learn more on it [3]. They should also provide a sufficient training period in which participants gain the necessary knowledge and skills in order to sample the experience [7]. It is important to establish a rapport with participants and to foster a research alliance throughout the study [2]. It is suggested to provide rich feedback to participants during and at the end of the study which can also be presented as non-monetary compensation [3].

3 Personal science and interest for self-exploration

Technological advancement played a great role in a growing number of ESM studies as well as in an uptake of self-tracking practices for exploration of oneself [14, 15, 16]. The umbrella term for self-tracking practice and communities has been formed under Personal Science (PS) [17]. These individuals and groups pursue their own personal research questions using empirical methods in an iterative process of questioning, designing, observing, reasoning, and discovering which presents itself as an opportunity to scientifically expand on PS. Even though we can draw many parallels between self-tracking and scientific inquiry the question remains to what extent PS can be scientifically interesting [18]. Considering the growing interest in PS activities it seems important to address these practices, especially in new self-trackers. They often experience difficulties in making sense of their self-tracking process in interpreting their data, formulating and refining their research questions, and designing their research process [19, 20]. It would be beneficial for them to receive support that provides at least an initial establishment of their research or engaging them in a more systematic way. Lack of scientific rigour was also reported by researchers in tools used for self-tracking which can potentially mislead self-trackers and give them false ideas of phenomena they explore [21, 22]. Hence, we believe this is an excellent opportunity for the science community to engage in this already widespread phenomenon. Individuals and groups who already possess deep interest in self-exploration can potentially become great co-researchers by which they would gain support in their own exploration as well as make the scientific contribution.

4 Community in Citizen science

Citizen Science (CS) is recognized as one of the eight pillars of Open Science, playing an integral role in democratising scientific knowledge and practices [23]. It significantly bridges the gap between the scientific community and society through the idea of doing science and not merely reacting to it [24]. Due to the heterogeneity of CS projects in terms of scale, objectives, and levels of citizen scientist involvement, it is challenging to provide a universal definition [25]. However, common to all CS projects is to actively involve non-professionals in scientific research at different levels of participation [26]. In a broad sense citizen scientists perform tasks that would be otherwise done by scientists [27] or would not be possible to do without their involvement.

To achieve reciprocity between science and society in CS projects in which the bidirectional knowledge exchange facilitates benefits in both [28], significant time and resources need to be invested to establish the conditions for project activities to run [29]. Since citizen scientists are typically lay people without formal training in scientific research, appropriate training and support are essential to equip them with necessary skills and knowledge [30]. We know citizen scientists engage in the projects upon different motivation factors. We can observe the intrinsic factors, such as gaining fulfilment, enjoying the activities or being altruistic and extrinsic factors, such as building social interactions, gaining on reputation or status and expecting future returns [31]. Therefore, sustaining motivation and engagement requires more than just training. CS practitioners should establish good relationships with citizen scientists and a continuous communication as well as the conditions for citizen scientists to meet and work with each other. We argue that essential to the project's success is building a strong community. Utilising online community spaces, social media, organising workshops and training as well as local meetups, collaborative and other social activities facilitate community building. Strong community in exchange encourages participation, promotes knowledge sharing, foster collaboration and builds on sustainability of the project [32, 33].

5 Bridging ESM, PS and CS with empirical phenomenology

The key to integrating the practices of Citizen science, Personal science, and Experience Sampling research lies in the concept of a methodological turn developed in the field of empirical phenomenology [8]. In experience research, the observed is the observer, meaning that the only access to the phenomena of interest is through the observer's subjective experience. If the observer does not adopt an attitude of curious exploration and engage in epoché, meaning bracketing the natural attitude, the judgments, interpretations, and explanations of their experience, we cannot obtain data on the genuine experience as it unfolds in life. This notion is rooted in phenomenological reduction, a

method of research into experience developed by Edmund Husserl [34]. Experience Sampling has been used to study subjective experiences in real-time contexts, but integrating it with phenomenological reduction enhances the depth of data on lived experiences [35]. Therefore, it is necessary to consider our participants as co-researchers. This attitude allows us to engage them in a way that fosters their interest in the research question which facilitates the methodological turn where the research question becomes in a sense their own and they become researchers of their own experience. While providing the support and means for investigation, it is important to give co-researchers the freedom to explore the research question and their experience in a way that is meaningful to them, and to encourage critical discussion. By opening up the space for co-creation of the research design and enabling co-researchers to actively contribute their findings, we facilitate a deeper reciprocity of knowledge transfer.

6 The pilot study "Luna"

Citizen science project Luna aims to explore the lived experiences of menstrual cycles and their impact on everyday well-being. We use a diary method for daily reports and Experience Sampling Methodology (ESM) to track experiences throughout the menstrual cycle with the use of the ESM mobile application Curious (about) consciousness or Curious in short.

We adopted the iterative co-creation approach to develop our research, combining the principles of ESM research, CS projects, PS and empirical phenomenology. This makes our research process flexible in a way that the research design is being updated in an iterative collaborative manner. We engage co-researchers in the design and assessments of data collection procedure and questionnaires, data interpretation as well as analysis. By encouraging them to develop their own research questions which are relevant to their own experience we promote their personal endeavor in the research. They are also involved in other project activities, such as sharing results and designing the project visual identity. We organise different learning and sharing community activities. In the training workshops we introduced them to the principles of observing ones' own experience, how to bracket the natural attitude and report on the pristine inner experience. On our online community space as well as in the organised meetups we share feedback on the research and their participation, engage them in the conversation on the research topic related questions and encourage them to share their own feedback. They are also invited to share any findings they have along the way in the mobile application. The Curious app is designed in a way to support co-researchers in their data interpretation by providing them with simple visualisations of their gathered data which they are able to filter, compare and reflect on. Our aim in the research is two-fold. It is driven to answer the research questions on phenomenology throughout the menstrual cycle as well as to equip co-researchers with methods and tools to research their experiential landscape and gather self-knowledge. Project tries to go beyond research by also opening up the data driven discussion on possible systemic or social solutions to consider the physiological and phenomenological cyclic nature of people with menstrual cycles. This also presents a motivational factor for some co-researchers who would like to see positive (societal) changes in regard to this phenomenon.

7 Conclusion

We argue that a large number of research questions in ESM research could be better investigated if research projects adopt the CS framework with an emphasis on community building, account for the interest and practice of PS, and use the principles of experience investigation from empirical phenomenology. The challenge of participant burden in ESM research is then mitigated by creating conditions for co-researchers to be involved in personally meaningful activities, which in return provide a higher level of data validity. Even though considerable resources are needed to establish these kinds of project communities, we believe they have the potential to be more sustainable. From CS, we know that citizen scientists develop a sense of community, which encourages them to remain active in science after the initial project ends [36, 37]. This interdisciplinary integration of different research practices enhances the value of our investigations and creates more impactful and sustainable research projects that benefit both the scientific community, involved co-researchers and the society.

Acknowledgments

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Volume C

Odkrivanje znanja in podatkovna skladišča - SiKDD
Data Mining and Data Warehouses - SiKDD

Urednika / Editors

Dunja Mladenić, Marko Grobelnik

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7. oktober 2024 / 7 October 2024
Ljubljana, Slovenia

PREDGOVOR

Tehnologije, ki se ukvarjajo s podatki so močno napredovale. Iz prve faze, kjer je šlo predvsem za shranjevanje podatkov in kako do njih učinkovito dostopati, se je razvila industrija za izdelavo orodij za delo s podatkovnimi bazami in velikimi količinami podatkov, prišlo je do standardizacije procesov, povpraševalnih jezikov. Ko shranjevanje podatkov ni bil več poseben problem, se je pojavila potreba po bolj urejenih podatkovnih bazah, ki bi služile ne le transakcijskem procesiranju ampak tudi analitskim vpogledom v podatke. Pri avtomatski analizi podatkov sistem sam pove, kaj bi utegnilo biti zanimivo za uporabnika – to prinašajo tehnike odkrivanja znanja v podatkih (knowledge discovery and data mining), ki iz obstoječih podatkov skušajo pridobiti novo znanje in tako uporabniku nudijo novo razumevanje dogajanj zajetih v podatkih. Slovenska KDD konferenca SiKDD, pokriva vsebine, ki se ukvarjajo z analizo podatkov in odkrivanjem znanja v podatkih: pristope, orodja, probleme in rešitve.

Dunja Mladenić in Marko Grobelnik

FOREWORD

Data driven technologies have significantly progressed. The first phases were mainly focused on storing and efficiently accessing the data, resulted in the development of industry tools for managing large databases, related standards, supporting querying languages, etc. After the initial period, when the data storage was not a primary problem anymore, the development progressed towards analytical functionalities on how to extract added value from the data; i.e., databases started supporting not only transactions but also analytical processing of the data. In automatic data analysis, the system itself tells what might be interesting for the user - this is brought about by knowledge discovery and data mining techniques, which try to obtain new knowledge from existing data and thus provide the user with a new understanding of the events covered in the data. The Slovenian KDD conference SiKDD covers topics dealing with data analysis and discovering knowledge in data: approaches, tools, problems and solutions.

Dunja Mladenić and Marko Grobelnik

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Integrating Knowledge Graphs and Large Language Models for Querying in an Industrial Environment

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Abstract

Knowledge graphs have traditionally required the use of specific query languages, such as SPARQL, to retrieve relevant data. In this paper, we present a system capable of performing natural language queries on knowledge graphs by leveraging retrieval-augmented generation (RAG) and large language models (LLMs). Our system can ingest large knowledge graphs and answer queries using two approaches: first, by utilizing LLMs to extract information directly from subgraphs; and second, by generating SPARQL queries with LLMs and using the results to inform further inference, such as counting the number of items.

Keywords

knowledge graph, semantic inference, Industry 4.0, LLM, RAG

1 Introduction

In the context of Industry 4.0, knowledge graphs play a crucial role in mapping and describing the entire production vertical, from supply and demand dynamics to intricate details within the production process. This includes the configuration of shop floors, production lines, machines, and data setups, extending even to specific datasets generated during operations. Knowledge graphs can also include relevant information about the tools required for particular processes, as well as details about personnel, including their skills and roles.

A key standard for representing such data within the Industry 4.0 initiative is the Asset Administration Shell (AAS) [3], which provides a logical representation for a factory asset (can also be a piece of software, etc.). By adopting AAS, industries can ensure interoperability and standardization, enabling more efficient data exchange and integration across various systems, ultimately enhancing the agility and responsiveness of manufacturing processes.

Querying knowledge graphs can be a challenging task for end users, as it often requires expertise in specialized query languages such as SPARQL [8] — a skill that is not widely known among non-experts. Working with SPARQL SELECT queries remains a challenge also for LLMs, with performance varying significantly depending on the specific model and task complexity. While the leading LLMs can reliably address basic syntax errors, generating semantically accurate SPARQL SELECT queries remains difficult in many cases [10]. Similar work has been done on interaction with databases, however even with SQL query generation the results of GPT-4 are still far behind human ability (approx. 55% execution accuracy) [9].

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To overcome these challenges, we propose a system that enables users to interact with knowledge graphs through natural language queries. The system leverages LLMs' capabilities to interpret knowledge graphs while compensating for their limited ability to generate fully syntactically and semantically correct SPARQL queries. Proposed system, depicted in Figure 1, leverages large language models (LLMs) [11] to process natural language inputs and provide responses in natural language. Our approach integrates retrieval-augmented generation (RAG) techniques alongside the automatic generation of SPARQL queries based on natural language input [2].

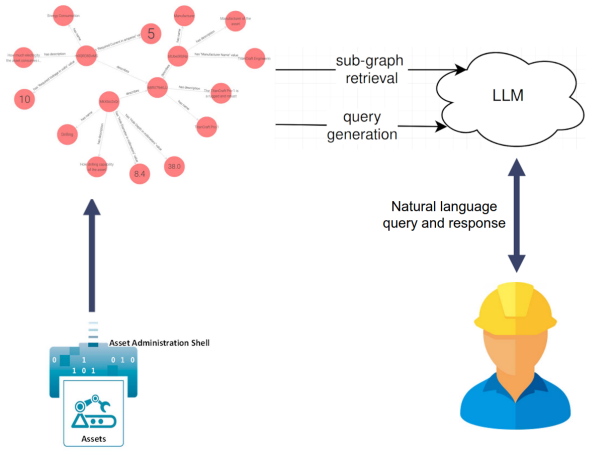

Figure 1: Intended usage of the system: AAS instances are converted into a knowledge graph, enabling natural language queries by the user.

By doing so, our system not only simplifies the querying process but also ensures that the responses are accurate and contextually relevant, making knowledge graphs more accessible and usable for a broader range of users. Additionally, the use of LLMs in combination with SPARQL querying enables the system to handle complex tasks, including those that require logical reasoning, aggregation, or interpretation of data, thus enhancing its utility in real-world applications. For example, our system is able to answer queries such as: "Give me all machines that are capable of drilling a hole with 2cm perimeter".

Finally, question answering with the help of knowledge graphs and language models has been tackled before [16], however, the development of retrieval-augmented generation (RAG) systems has seen significant growth recently. In 2024, several preprints have emerged showcasing the application of the RAG approach to knowledge graphs [12, 13, 14]. This paper contributes to this rapidly evolving field by presenting our own advancements and findings.

2 Data

This study uses a generated dataset representing a hypothetical factory with various machine models, designed to test the capabilities of the developed application. The work is part of the Smart Manufacturing pilot in the EU-funded HumAIne project [7], with the aim of eventually using real-world data from participating factories.

The mock factory includes models of "DRILLERS", "CIRCLE CUTTERS", and "CIRCULAR SAWS", each with unique names, manufacturers, and descriptions. These models are represented using AASs with relevant submodels for energy consumption, manufacturer details, and operation-specific parameters like hole diameter or depth of cut.

We created AASs for 7 drilling machine models, 7 circle cutter models, and 10 circular saw models, along with 1,000 machine instances randomly assigned to these models. Numerical values and availability were populated randomly for testing, reflecting potential real-world variations.

The initial step after acquiring AAS data is to convert it into a knowledge graph. This process involves transforming JSON-serialized AASs into RDF triples, which represent the semantic information of the data. Once the RDF triples are generated, they are stored in a GraphDB[1] repository. To enable semantic data retrieval, we employ a connector that interfaces with the ChatGPT Retrieval Plugin[2], which operates alongside the server application. When new triples are added to the GraphDB repository, the connector triggers the plugin to generate vector embeddings of the text representations of the new nodes. These embeddings are created using a language model and are stored in a separate vector database. The ChatGPT Retrieval Plugin enables interacte to a selection of different vector databases, in our case we employed the Milvus vector database. The system is also designed to maintain consistency; if any triples are removed from the GraphDB repository, the corresponding vector embeddings are automatically deleted from the vector database.

3 Methodology

The system architecture is illustrated in Figure 2. The user interacts with the system through a client application, developed using ReactJS, which serves as the graphical user interface (GUI). This client application communicates with the system's middleware, which is built on the Flask framework. Users have the capability to upload AAS data to construct and enhance the knowledge graph, as well as to issue natural language queries.

The middleware acts as the core of the system, facilitating communication between the client application, the knowledge graph stored in a GraphDB database, and OpenAI's GPT models. The AAS data uploaded by the user is first converted into RDF triples and then stored in the GraphDB repository. The Flask-based middleware also integrates with the ChatGPT Retrieval Plugin, which is responsible for generating vector embeddings of the knowledge graph nodes using OpenAI's `text-embedding-ada-002` model.

These vector embeddings are stored in the Milvus vector database [15]. The ChatGPT Retrieval Plugin allows the system to efficiently retrieve the most relevant embeddings in response to user queries, ensuring that the system can provide accurate and contextually appropriate answers. Additionally, the middleware leverages LlamaIndex[3] to manage sub-graph retrieval and query generation, which are essential for responding to complex queries by the user.

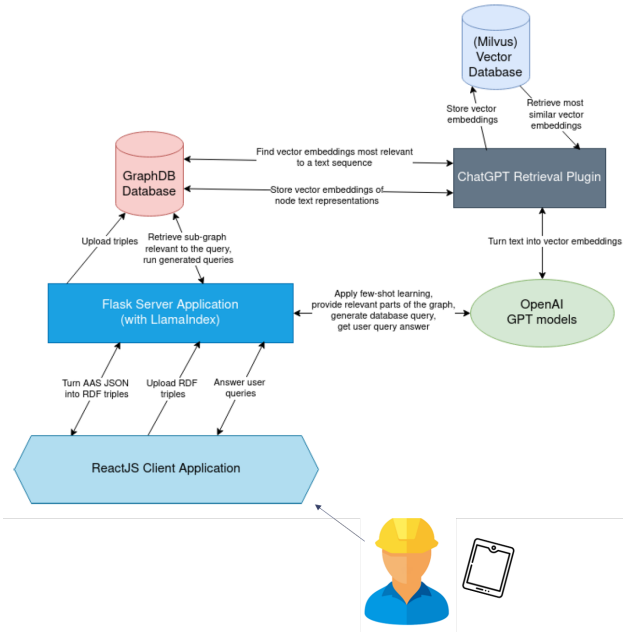

Figure 2: System architecture for retrieval augmented generation with knowledge graphs in Industry 4.0.

In summary, the architecture is designed to streamline the process of building a knowledge graph from AAS data and enables users to query this graph with retrieval-augmented generation (RAG) using natural language, with the system handling the complexities of data storage, retrieval, and natural language processing in the background.

The sequence diagram in Figure 3 illustrates the interaction between system components during query processing. Our system enables two distinct approaches to handle natural language queries, often combining both to generate a comprehensive answer for the user.

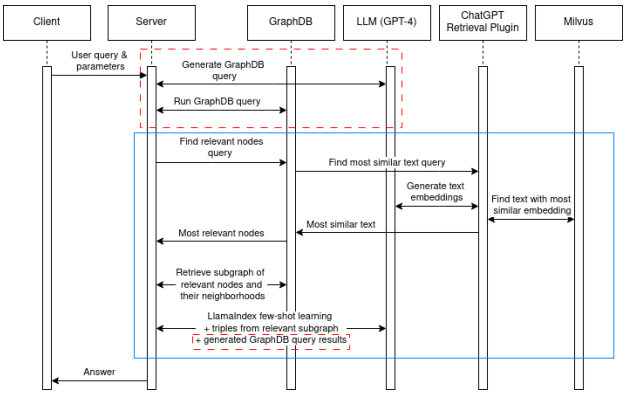

Figure 3: Sequence diagram of different approaches for data extraction. The blue box represents the RAG approach and the red box represents the SPARQL query generation approach. Note that RAG approach utilizes results from SPARQL queries on the knowledge graph.

[1] https://graphdb.ontotext.com/
[2] https://github.com/openai/chatgpt-retrieval-plugin
[3] https://www.llamaindex.ai/

The first approach utilizes a Retrieval-Augmented Generation (RAG) method. Upon receiving a query, the system analyzes the query to identify relevant concepts and generates vector embeddings for these concepts [5]. These embeddings are then matched against the knowledge graph stored in GraphDB to find the most relevant nodes. Once the relevant nodes are identified, a naive neighborhood expansion is performed, capturing additional related nodes to ensure a more complete context. The search is parameterized using parameters: scope, how many nodes from the graph to retrieve; breadth, from how many relevant nodes to start the neighborhood expansion; score weight, how many more nodes are visited from the identified relevant nodes that are deemed more relevant using embedding similarity. This subgraph, along with a few examples for context, is then fed into the Large Language Model (LLM) using a few-shot [1] learning technique to generate a response [4]. The LlamaIndex framework provides a general context query for turning triples into natural language. This method is particularly effective for queries requiring contextual understanding and extraction of complex information from the knowledge graph.

The second approach involves generating a SPARQL query based on the natural language query and the ontology used within the knowledge graph. The system attempts to execute this SPARQL query in the GraphDB database. If the query runs successfully, the resulting data is passed to the LLM to formulate the final answer. This approach is especially beneficial for tasks that involve counting instances or performing specific data aggregation operations, where LLMs alone might struggle. This approach benefits from the first approach as it can use it as backup or to enrich the SPARQL query results with additional context.

4 Results

To thoroughly evaluate the system, we employed three different evaluations: (a) assessing the accuracy of data retrieval based on query parameters (not using query generation), (b) evaluating the system's ability to correctly fetch the number of instances (testing query generation), and (c) conducting a manual assessment of most relevant user queries.

4.1 Accuracy of Data Retrieval

The first approach involved testing the system's ability to accurately retrieve data that met specific query conditions without employing SPARQL query generation. We focused on queries where the user requested a list of machines of a particular type with a voltage requirement less than or equal to a specified value. An example query would be: "Return all drilling machines that consume at most 4 volts and specify their consumption."

We conducted these tests on three types of machines: "drilling machines", "circle cutters", and "circular saws". The voltage values specified in the queries ranged from 0 to 10 volts, inclusive. The evaluation was designed to measure how accurately the system could identify and return the correct set of machines based on these voltage constraints.

For these tests, the following parameters were used (scope: 100, breadth: 1000, score weight: 100, model: `gpt-4-1106-preview`, query generation strategy: **disabled**).

The system's performance was assessed by comparing the retrieved data against the expected results, specifically checking the number of machines that met the voltage criteria and identifying any errors, such as incorrect voltage values or unnecessary machine retrievals. Results are depicted in Figures 4 and 5.

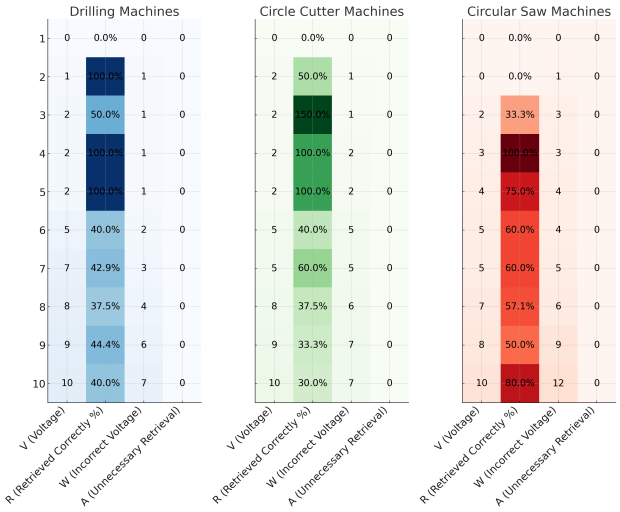

Figure 4: Performance of the system by the type of the machine and query.

In Figure 4, each table contains four columns: "V" (voltage specified in the query), "R" (percentage of correctly retrieved machines), "W" (number of machines with incorrect voltage), and "A" (number of unnecessary machine retrievals). Figure 5 summarizes the results: "Fully Correct Answers" shows the percentage of queries that returned all requested information without errors; "Share of Expected Information Found" indicates the proportion of requested information retrieved; and "Share of Incorrectly Displayed Voltages" represents the percentage of retrieved voltages that were incorrect.

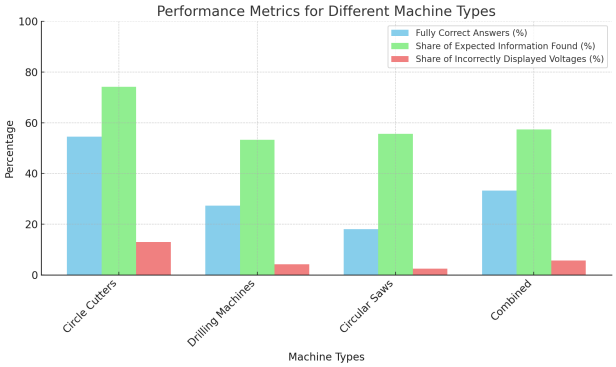

Figure 5: Combined performance.

The results show that sometimes the LLM would incorrectly generate a different voltage requirement for a machine, making it appear to satisfy the query conditions. However, the retrieved machines were always of the correct type. For example, a query like "Name all drilling machines and specify their voltage requirements" correctly retrieves all machines with the right specifications, suggesting the issue may lie with the LLM rather than the knowledge retrieval process.

To address this, users can try adjusting query parameters or rewording the query to verify the information's accuracy. If this

type of query is crucial, incorporating voltage-specific queries into the query generation strategy could improve reliability, although the LLM may struggle with large lists due to its context window limitations. As shown in Figure 5, these types of queries often do not reliably provide all requested information in one answer, so users should run multiple queries to increase the likelihood of retrieving all necessary data.

4.2 Instance Fetching Accuracy

In these tests, we tested query generation strategy. The following parameters were used (scope: 100, breadth: 1000, score weight: 100, model: `gpt-4-1106-preview`, query generation strategy: **enabled**).

The queries asked for the number of available instances for selected machine models, such as "Get the number of available [name of the machine 1], [name of the machine 2] machine instances. Specify the number for each machine type separately.". The query format was picked such that the LLM will benefit from query generation (availability property is specified in the schema supplied for query generation).

A total of 100 queries were run, with 10 queries for each number of specified machine models (ranging from 1 to 10 models). The share of fully correct answers for each query type was between 80 and 100%. The overall accuracy was 96%. This supports our hypothesis that the query generation strategy provides more accurate answers for slightly more complex queries.

4.3 Manual Evaluation of Example Queries

This evaluation was initially performed to identify several shortcomings in our methodologies as mentioned in the previous subsections. By manually evaluating specific queries relevant to end users, we were able to partially address these issues and fine-tune parameters to achieve more accurate results. For instance, while the system's initial results were often incomplete (e. g., query did not return all the machines satisfying certain criteria), increasing the breadth parameter to include a larger subgraph and allowing LLMs to traverse a broader neighborhood improved the results. Additionally, we demonstrated that subgraph retrieval and query generation can complement each other, further enhancing overall performance. All the results are commented in detail in [6].

5 Conclusions

In this paper, we presented a system that bridges the gap between natural language processing and querying knowledge graphs, specifically within the context of Industry 4.0. By leveraging large language models (LLMs) and retrieval-augmented generation (RAG), our system allows users to interact with complex knowledge graphs using natural language queries, thereby simplifying access to detailed manufacturing data.

Our evaluation demonstrated the usability of our system, however with the integration of LLMs for natural language understanding, some challenges remain. These include occasional inaccuracies in data retrieval and the LLM's limited ability to handle large datasets or specific queries. By adjusting subgraph retrieval parameters such as breadth and scope, and by combining it with SPARQL query generation, we were able to significantly enhance the system's accuracy and reliability.

This work highlights the potential of combining knowledge graphs with LLMs to create more intuitive and effective query systems in industrial environments. Future improvements could focus on refining query strategies and further optimizing the balance between subgraph retrieval and SPARQL generation to ensure even more robust and comprehensive query handling.

Acknowledgements

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Comparative Analysis of Machine Learning Models for Groundwater Level Forecasting: The Impact of Contextual Data

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Abstract

This paper presents a comparative evaluation of three distinct categories of models applied to groundwater level data: traditional batch learning methods, time series deep learning methods, and time series foundation models. By enriching the water level data with weather-related features, we significantly improved the effectiveness of simpler models. The results demonstrate that, despite their state-of-the-art performance on univariate datasets and the corresponding publicity, advanced models without contextual feature support are still surpassed by traditional methods trained on enriched datasets.

Keywords

groundwater level prediction, time series forecasting, deep learning, foundation models, contextual data

1 Introduction

Accurate water level prediction is crucial for mitigating the impacts of climate change on water resources. By forecasting water levels, we can better prepare for potential floods and droughts, and more effectively manage our water supplies. However, predicting water levels presents a significant challenge due to the dynamic nature of the data. As climate change leads to prolonged droughts and increasingly erratic precipitation patterns, the need for reliable forecasting methods becomes even more important [2].

In this paper, we aim to compare the performance of various models in forecasting groundwater levels. Specifically, we focus on the differences between traditional batch learning methods that utilize relevant contextual data and newer univariate time series deep learning and foundation models.

The main contributions of this paper are:

- A comparative analysis of the performance of traditional batch learning methods against state-of-the-art time series deep learning techniques and time series foundation models, particularly in the context of feature vectors enriched with relevant contextual data.
- The application of time series foundation models and deep learning methods to the domain of groundwater level forecasting.

The groundwater dataset used in this study has previously been employed for predictive modeling with traditional batch learning methods [9], where extensive feature engineering was also performed. Our work builds upon and extends this earlier research by incorporating a different set of models.

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2 Methods

In our experiments, we employed three categories of methods: traditional batch learning techniques, time series deep learning models, and time series foundation models.

2.1 Traditional Batch Learning Methods

In the context of data-driven modelling of environmental issues, traditional batch learning methods have historically demonstrated significant success [5]. In this study, we employed linear regression alongside two tree-based approaches: random forest and gradient boosting [7] as baselines to evaluate whether the newer, more prominent techniques, which have recently gathered a considerable amount of attention, can perform competitively in this specific setting.

All of the chosen batch learning techniques are regression-based and are valued for their simplicity, speed, and ease of use. However, they often lack the complexity necessary to fully capture intricate patterns in the data. To mitigate this limitation, we incorporated contextual features, such as weather data and forecasts (e.g., precipitation, cloud cover, temperature). While the data fusion problem is solved [8], this approach raises concerns about the availability and relevance of the contextual data.

2.2 Time Series Deep Learning Methods

Time series deep learning models are explicitly designed for forecasting time-dependent data. In our study, we employed N-BEATS [12] and PatchTST [10], both of which have architectures tailored to capture trends and seasonalities inherent in time series data. Despite their advanced capabilities, these models have drawbacks, including longer training and inference times, the necessity for extensive hyperparameter tuning to achieve optimal performance, and limited support for incorporating additional features. Although certain models support multivariate time series, they were not utilized in our experiments.

2.3 Time Series Foundation Models

While deep learning methods require separate training and prediction phases, time series foundation models aim to eliminate the training step. Inspired by large language models, these models are pretrained on extensive time series datasets, enabling zero-shot predictions on new time series without additional training. We used CHRONOS [1], an open source foundation model. The advantages of this approach include ease of use with minimal parameter adjustments and no need for training. However, similar to deep learning models, they lack support for multivariate time series.

Several studies have already evaluated the performance of various deep learning and foundation models for time series forecasting [1] [13]. However, this research extends the application of these forecasting models to groundwater level data, therefore contributing to the better understanding of their effectiveness in this domain.

3 Experiment Setting

The experiments were conducted on a dataset of groundwater levels in Slovenia. Due to the cumulative nature of water levels and to facilitate comparison with the original study [9], predictions were made on daily changes in water levels rather than on absolute values.

3.1 Dataset

The groundwater dataset is a subset of the larger dataset used in the study [9]. It consists of groundwater level measurements taken daily from multiple stations across Slovenia. To apply traditional batch learning methods, we enriched the dataset with weather data, associating each water measurement station with the nearest weather station. Due to the availability of weather data, only data from the years 2010 to 2017 was included in our study. For consistency and ease of comparison with previous study [9], we focused on data from two water measurement stations located in Ljubljana.

In traditional batch learning within the environmental domain, it is essential to not only use the raw data but also to engineer relevant features. Initially, we removed the pressure and dew point features, as they were either unrelated to the target variable or highly correlated with other features [9]. We then created additional features by shifting the data from 1 to 10 days, making historical values available, and by computing the averages of features over a 2- to 10-day window. This process resulted in approximately 2,000 features. Given the excessive number of features, which could degrade model performance, we employed a feature selection algorithm to identify the most informative subset.

We used a genetic feature selection algorithm from scikit-learn, evaluated on 365-day part of training dataset, with the maximum number of features set to 40. The algorithm was executed separately for each model, focusing on one station and a prediction horizon of three days, resulting in distinct feature vectors. Subsequently, weather forecast features with longer offsets were manually added to the selected feature set.

3.2 Evaluation Metrics

The dataset was split into a training set (approx. 2,500 days), a validation set (100 days), and a test set (365 days) for model evaluation. Model performance was evaluated using the R^2 score, averaged across all tested stations. Although alternative metrics such as root-mean-squared error (RMSE), and mean absolute percentage error (MAPE) were considered, they, for this dataset, produce results that are closely related to the R^2. This metric was selected due to its robustness against variations in data offset and amplitude, and for direct comparability with the results in the original study [9]. The R^2 score is defined as:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2},$$

where y_i is the i-th true value, $\hat{y}_i$ is the i-th predicted value and $\bar{y}$ is the average of true values.

3.3 Baseline Methods

The primary objective of our research was to compare the performance of traditional batch learning methods, enriched with relevant contextual features, against that of modern deep learning techniques and foundation models for time series forecasting. Therefore, we selected linear regression, random forest regressor, and gradient boosting regressor as our baseline methods. These models were previously applied to the groundwater dataset [9], necessitating a reproduction of the results as a benchmark.

3.4 Implementation Details

The prediction pipelines varied slightly between the different types of models:

- For **CHRONOS**, we utilized the dataset without weather features, as it only supports univariate time series. Since no hyperparameter tuning was required, the data was divided into training and test sets, omitting the validation set. The model generated the predictions directly from the water level data. We used the chronos-t5-large model from the chronos library.
- For **N-BEATS** and **PatchTST**, the same dataset was used, given the same limitation as mentioned previously. However, a validation set was required for hyperparameter tuning. After selecting appropriate hyperparameters, the models were trained on the training set and evaluated on the test set. Implementations from the NeuralForecast library were used for both models.
- For the **linear regression**, **random forest regressor**, and **gradient boosting regressor** models, we included both water level and weather data. Feature selection was conducted to reduce the number of features, resulting in 42 features for linear regression, 30 for random forest, and 36 for gradient boosting. After feature selection, hyperparameters for the random forest and gradient boosting models were tuned, and the data for linear regression was normalized. The models were then trained on the training set and evaluated on the test set using scikit-learn's implementations.

The hyperparameters used for training are listed in Appendix A, while a description of the selected features is provided in Appendix B.

4 Results

The results for all tested models across various prediction horizons are presented in Table 1. The reported R^2 scores were calculated based on the differences in water levels; if absolute water levels had been used, the R^2 scores would have been significantly higher. For example, in the case of CHRONOS with 1-day ahead predictions, the R^2 score is 0.725 for relative level differences and 0.998 for absolute water levels.

Among the models, linear regression achieved the highest performance, followed by the random forest. In contrast, the more complex methods, including deep learning models and the foundation model, showed generally lower performance, with the exception of the 1-day prediction horizon, where N-BEATS outperformed the tree-based models. Notably, the R^2 scores decrease as the prediction horizon lengthens, with a more pronounced decline observed in the deep learning and the foundation models compared to the traditional batch learning methods.

Figures 2 and 3 display the predictions from CHRONOS, PatchTST, and linear regression compared to the true data for the 1-day and 5-day prediction horizons. It is evident that the predictions from CHRONOS and PatchTST begin to exhibit a rightward shift as the horizon extends. Figure 1 visualizes the R^2 scores for all models across the different prediction horizons.

Table 1: R^2 Scores for Different Prediction Horizons and Models.

Methods	1 day ahead	2 days ahead	3 days ahead	4 days ahead	5 days ahead
Chronos-large	0,725	0,365	0,175	0,04	-0,09
GradientBoostingRegressor	0,640	0,603	0,527	0,556	0,545
RandomForestRegressor	0,726	0,697	0,701	0,706	0,691
N-BEATS	0,742	0,397	0,17	-0,03	-0,143
PatchTST	0,721	0,394	0,215	0,109	-0,02
LinearRegression	**0,792**	**0,781**	**0,785**	**0,784**	**0,780**

The best and second-best results are bolded and underlined respectively.

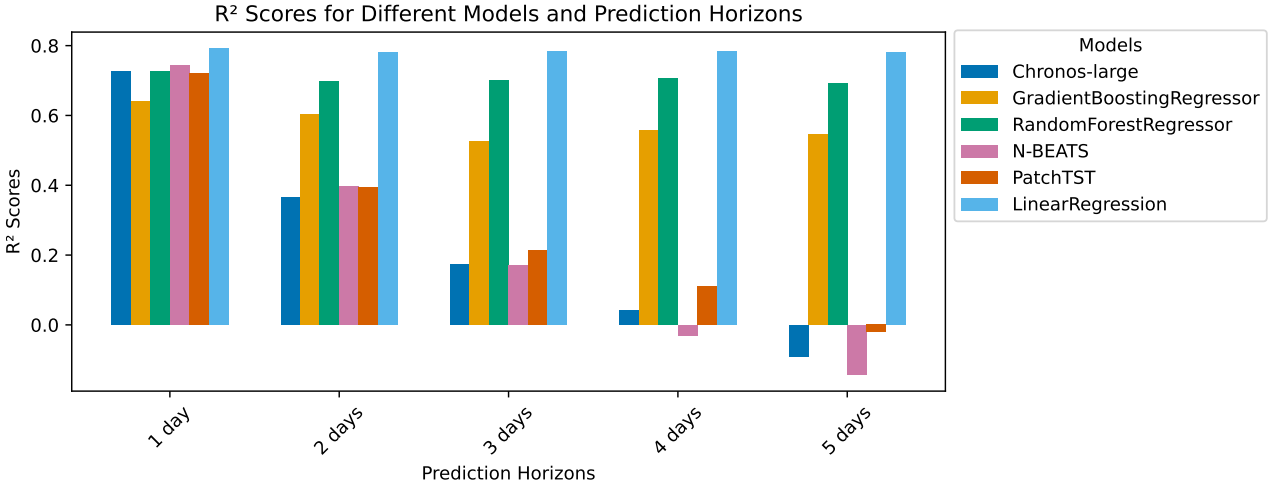

Figure 1: R^2 Scores for All of the Methods and Prediction Horizons.

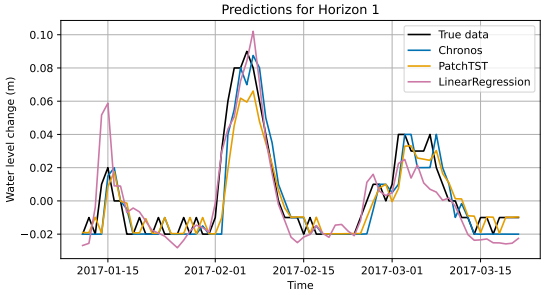

Figure 2: Example Predictions for Three Models for 1-Day Prediction Horizon.

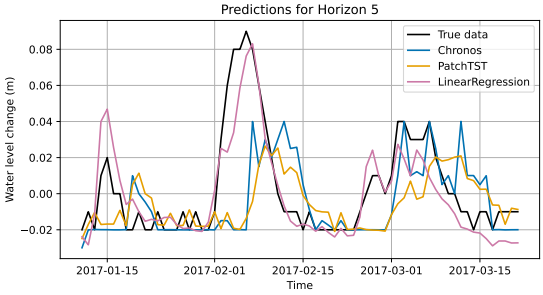

Figure 3: Example Predictions for Three Models for 5-Day Prediction Horizon.

The results indicate that traditional methods, when supplemented with relevant contextual features, outperform more complex models that do not incorporate such data. While the 1-day ahead predictions show comparable performance across all methods, as the prediction horizon extends, the accuracy of CHRONOS, PatchTST, and N-BEATS declines sharply. In contrast, the traditional models, supported by contextual features, maintain their predictive accuracy much more effectively, as shown in Figure 1.

A closer examination of the predictions in Figures 2 and 3 reveals that for 1-day ahead predictions, all models track the true data closely. However, in the 5-day ahead predictions, models lacking contextual data begin to exhibit a rightward shift in their predictions. This likely occurs due to the absence of contextual information, causing these models to lag in capturing the true trajectory of water levels. In contrast, models with access to weather data can predict further ahead by accounting for factors such as the impact of rainfall patterns on water levels.

An unexpected finding is that among the baseline models, linear regression outperforms the more sophisticated methods. For instance, in the article [9], while linear regression produced strong results, it did not surpass the performance of the other two methods.

5 Conclusion and Future Work

After evaluating all models on the groundwater level dataset, we observed that traditional methods, when equipped with relevant features, consistently outperformed newer and more sophisticated techniques, particularly as the prediction horizon lengthened. This suggests that the emphasis on developing the most powerful deep learning or foundation models for time series predictions may be overstated. With thoughtful selection of contextual features, even the simplest models can outperform modern approaches, which is a significant finding for fields with sufficient contextual data, such as data-driven environmental modelling.

To enhance the robustness of our evaluation, future work could involve testing additional methods, expanding the analysis to include more measurement stations and surface water level data, and incorporating deep learning models that support multivariate time series, such as N-BEATSx [11] and N-HiTS [3]. Further insights could be gained by exploring foundation models with multivariate support, such as TimesFM [4], as well as some more univariate models, like TimeGPT-1 [6]. Future research could also compare the inference times of various models and assess performance across different time series lengths.

Acknowledgements

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A Hyperparameters

Table 2: Hyperparameters Used for Gradient Boosting Regressor and Random Forest Regressor.

Hyperparameter	GradientBoosting	RandomForest
n_estimators	28	164
max_features	'log2'	0.5
max_depth	10	20

Table 3: Hyperparameters Used for N-BEATS and PatchTST.

Hyperparameter	N-BEATS	PatchTST
loss	HuberLoss	/
n_harmonics	5	/
n_polynomials	5	/
scaler_type	'robust'	/
n_blocks	[3, 3, 1]	/
mlp_units	[[128, 128]]	/
horizon	5	5
input_size	15	71
learning_rate	0.001	0.001
max_steps	25	1323
encoder_layers	/	12
n_heads	/	16
hidden_size	/	64
linear_hidden_size	/	512
dropout	/	0.2
fc_dropout	/	0.1
head_dropout	/	0.1
attn_dropout	/	0.2
patch_len	/	16
stride	/	8
revin	/	True

B Selected Features

Due to the large number of features selected by the feature selection algorithm, we provide a summarized description of the most frequently chosen features. The features that appeared most often include shifts and averages of precipitation, precipitation forecasts, temperature, altitude difference, cloud cover, humidity, and snow accumulation. Notably, the majority of selected features were derived features we generated, with only approximately one original feature being selected per model.

In Table 4, the most common shifts and averages for each individual model are presented. The table indicates that shifts and averages of varying lengths were selected, with a slight preference for shorter ones.

Table 4: Most Frequently Selected Shifts and Averages for Various Methods.

Method	Shifts (days)	Averages (days)
GradientBoostingRegressor	4, 10	2, 6
RandomForestRegressor	2, 6	3, 9
LinearRegression	2, 10	2, 7
Combined	**2, 10**	**2, 3**

Interactive Tool for Tracking Open-source Artificial Intelligence Progress on Hugging Face

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Abstract

Given its increasing importance in our daily lives, Artificial Intelligence has become a prominent subject that needs extensive investigation and understanding. This study presents an analysis of the open-source community in the field of Artificial Intelligence (AI). Various questions arise anytime AI is introduced. open-source AI introduces additional concerns. Should artificial intelligence (AI) be universally accessible, or should it be restricted to private use? Is it worthwhile to offer basic models to the broad user population? We chose the most important data from the primary website in the field, Hugging Face. We have developed a tool that allows for straightforward monitoring of the progress of various open-source AI models using data obtained from their leader board. The platform offers accessible and valuable information about various AI models, including their architectures and the activities of authors. Through performing a quick review with our tool, it becomes evident that the open-source community is becoming large and has an undeniable impact on the AI community.

Keywords

LLM, open-source, AI, Hugging Face

1 Introduction

Artificial intelligence, particularly large language models (LLMs), is an important topic in the computer industry today. Despite the numerous fears and dogmas around it, it is certain that AI has become an integral aspect of our lives. This research has specifically concentrated on the development of a tool for monitoring the impact of the open-source community in the area of artificial intelligence. As implied, these models are accessible to all individuals. There is considerable debate on whether this type of technology should be universally accessible. We wanted to investigate if the open-source community is actively contributing to the development of the field, regardless of one's philosophical convictions. Due to the substantial computational requirements, it was previously impossible to execute Large Language Models on personal computers. As increasingly compact versions with impressive capabilities are being produced, this scenario undergoes a significant transformation. Currently, it is feasible to execute your own model, as long as it is of a modest enough size, on a home computer's graphics processing unit (GPU), even if the GPU is a few years old [9]. The rise in accessibility also enables a larger community to test and develop new solutions and build on top of existing models. We believe that there is a big lack of tools for monitoring the impact of this movement.

Hugging Face [1] has grown into one of the primary platforms for the open-source community. Users are able to download and interact with all significant open-source models. Subsequently, users have the option to publish their models on the platform and compare their performance by adding them to the leaderboard, where all the models are benchmarked and ranked. The open-source community relies heavily on the distribution of models by large corporations, as creating a model from scratch is a hard undertaking [9]. This tool facilitates collaboration among open-source contributors, enabling them to collectively generate social media content, exchange ideas, and even publish concise articles. In addition to the models, they have the ability to generate and upload useful datasets. It represents the most advanced and innovative developments in the field of open-source AI and Machine learning.

An issue that has been observed is the absence of effective visualization tools on Hugging Face, which would enable users to easily see patterns and gain a comprehensive understanding of the open-source AI area. In order to address this issue, we have developed a sophisticated tool that offers users various viewpoints on the data.

2 Literature review

Large Language Models (LLMs) have proven essential in enhancing software engineering (SE) tasks, demonstrating their effectiveness in code comprehension Similar to conventional software engineering tools, open-source cooperation is essential for achieving superior products in this area. [8]

The article authored by Patel et al. [9] emphasizes the significance of the open-source AI community and elucidates its rapid growth in the wake of major industry leaders like Google, Microsoft, and OpenAI. An important milestone in this subject is often emphasized as the day when the LLama model was initially made available to the open-source community. The community promptly recognized the possibilities and potential involved in this release.

Due to its continuous growth, Hugging Face has emerged as the primary platform for exchanging machine learning (ML) models, resulting in an increasing level of complexity. A relational

[1] https://huggingface.co/

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database called HFCommunity was established to facilitate the analysis and resolution of this issue [1].

As previously said, open-source AI models offer an extensive range of possibilities. At the recent conference, the authors [12] demonstrated their effective use of Hugging Face. Due to the significant difficulty in developing a model with broad intelligence, researchers have merged ChatGPT capabilities with models from HuggingFace using agentic architecture to get impressive results in multiple domains. ChatGPT was tasked with creating a plan of action and assigning specific duties to each open-source model based on their own areas of expertise. This is an excellent demonstration of the influence and capabilities of the open-source community, given the familiarity with open models and their capabilities.

The article [6] examines the vulnerabilities associated with open-source AI. A much higher number of repositories with high vulnerabilities has been discovered compared to those with low vulnerabilities, particularly in root repositories. This emphasizes the significance of ensuring the security of technology in order to facilitate its utilization.

In a recent paper [10], authors have analyzed the transparency of Hugging Face pre-trained models regarding database usage and licenses. The analysis revealed that there is often a lack of transparency regarding the training datasets, inherent biases, and licensing details in pre-trained models. Additionally, this research identified numerous potential licensing conflicts involving client projects. 159,132 models were examined. It was found that merely 14% of these models explicitly identify their datasets with specific tags. Furthermore, a detailed examination of a statistically significant sample comprising 389 of the most frequently downloaded models showed that 61% documented their training data in some form.

3 Methodology

We obtained the data by extracting the Open LLM Leaderboard from Hugging Face [2] by saving the data server sent to the client. This data contains information about repositories of models that are currently on the leaderboard and the models that are waiting to be evaluated for the leaderboard. A Python pipeline was developed to clean and enrich this data available on [2]. The leaderboard data includes model architecture and precision as well as the model type and performance on the following benchmarks: ARC[3], HellaSwag[14], MMLU[5], TruthfulQA[7], Winogrande[11] and GSM8K[4]. In addition to the data provided on the leaderboard, additional information on the given models was obtained by using the HF API client. This included data about repository contributors, tags, base models, used datasets, and repo activity. It is important to note that the data is self-reported by the developers and is not enforced by HuggingFace. Additionally, the leaderboard includes duplicates due to developers being able to replace models in the repository with different models under the same name. This means the duplicates have the same repository data but distinct performances. Due to the inability to programmatically determine the current model in the repository, we chose the best-performing model under the repository name as the model representing the repository when removing duplicates. Thus, all datasets were generated for further utilization. The following analysis was conducted using the R programming language. The data was mostly studied via the perspective of time, as our focus was on identifying any obvious trends. The data was categorized using several criteria, such as model type, model architecture, and amount of parameters. The data was initially selected and aggregated to ensure that all crucial components were easily accessible. All models that were categorized as flagged have been excluded from the dataset. In addition, we have collected data on the authors' activities and conducted a study on that particular aspect. Once the data had been cleaned and prepared for visualization, we utilized the R ggplot library to create visual representations of the data. A comprehensive R Shiny app was developed by aggregating all the visuals. We chose to utilize Shiny because it is a great option for constructing interactive data analysis solutions due to several factors. Firstly, it enables the development of web applications that are capable of responding and adapting to real-time changes and user interactions. This simplifies the process of exploring and analyzing data. Shiny easily incorporates with R, utilizing its robust statistical and graphical functionalities to generate complex, interactive visualizations without the need for experience in web technologies such as HTML, CSS, or JavaScript. [13] Finally, our application was deployed to a server, making it accessible online.

4 Results

The outcome of this study is the tool we have developed. The link may be accessed via the following URL. [3]. It has six distinct viewpoints, all conveniently accessible inside its tab. The initial figure, labeled as 1, displays both the count of new models and the distribution of various model types. Hugging Face has identified five distinct categories of models: basic mergers and moerges, fine-tuned on domain-specific datasets, chat models, continuously pretrained models, and pretrained models. If the model did not belong to any of these classes, its type was classified as unknown. The user has the ability to effortlessly choose their preferred categories, along with the desired time frame and unit of aggregate (daily, weekly, or monthly). This allows the viewer to clearly observe the evolution of model types and their popularity over time. It is evident that fine-tuned models are predominantly utilized. This is logical, as users are adapting base models by training them on unique datasets to achieve specialization. Also, we can see that merged models are a relatively recent phenomenon.

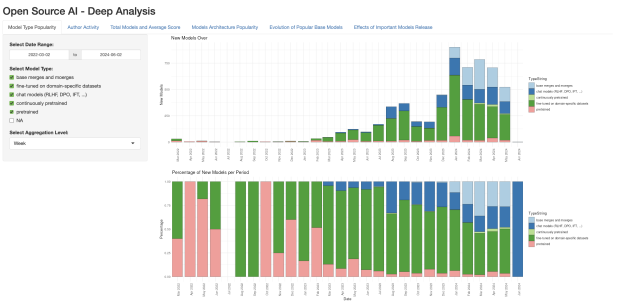

Figure 1: Popularity by model type over time

The second view, referenced as 2, has two interconnected visualizations. The upper section displays the activity of the top 10 authors within a specific range of dates. The display showcases every model they have developed, along with its corresponding type. The lower section presents the average benchmark score for

[2]https://github.com/VakeDomen/HF_analysis

[3]https://oai.dltlt.famnit.upr.si/

each model, organized by author. This visualization enables users to effortlessly monitor the most prominent authors and observe their patterns and accomplishments in model development over time. Users have the ability to effortlessly choose a certain range of dates and also narrow down the list to the top 10 authors according to their preferences. It is evident that leading authors typically do not adhere to trends and consistently provide models of similar type.

Figure 2: Top authors activity over time

The following perspective 3 illustrates two aspects. The first aspect is the alteration in the average benchmark score for each model type as time progresses. The display showcases the top-performing model for each category and time interval (daily, weekly, or monthly). In addition to the dots representing each model, we have incorporated a smooth line to aid the user in seeing the temporal changes for a particular model type. Following the first visualization, we have included a second visualization that displays the total number of models for each model type within the chosen period range. Through these visualizations, users can easily identify the model type that experienced the most improvement and the model types that were mainly produced. We can see the trend, which indicates that open-source AI models are improving, as evidenced by the improvement in average benchmark scores across most of them. The overall number of models is rapidly increasing, indicating a rise in the popularity of open-source AI models.

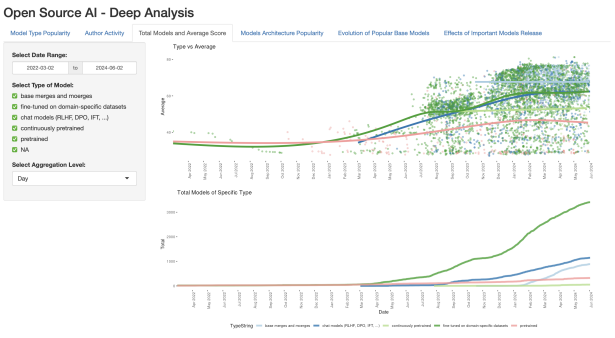

Figure 3: Change of benchmark score and total models per type over time

The fourth perspective, as seen in Figure 4, examines the changing popularity of various model architectures throughout time. The following architectures have been chosen for this specific objective: LLama, Mixtral, Mistral, Qwen2, Gemma, Phi, Opt, GPT2, and GPT2-NeoX. All architectures that did not fit into any one category were classed as "Other". This perspective has two graphics that depict popularity. The first comparison assesses the popularity of a model relative to itself, depending on the number of new models introduced before. The second one compares it to the average number of new models created, taking into account their architecture. Both are depicted by coloring the area, as it is the most convenient way to track. Users may analyze the fluctuation in popularity of well-known model architectures over time and examine how the rising popularity of a particular architecture might impact the popularity of a certain architecture of interest. The lower plot indicates that LLama and Mistral are the predominant models; nonetheless, they have experienced fluctuations throughout time, as visible on the upper plot.

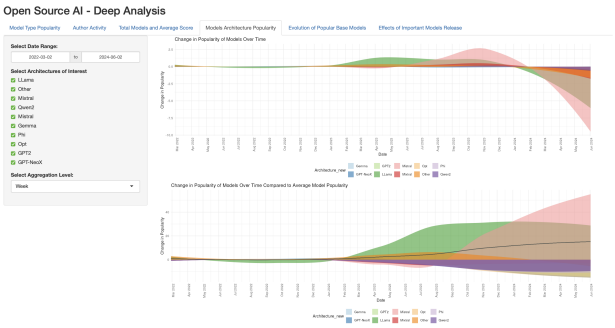

Figure 4: Change of popularity of main architectures over time

The graphic labeled as 5 illustrates the progressive improvement of the key base models developed by famous companies. This was accomplished by isolating each incremental improvement in score over time, using the base model as a reference. In order to fulfill this objective, we have chosen five distinct variations of LLama, Mistral, and Mixtral, as well as three iterations of Phi. The user may easily observe the overall improvement in benchmark scores for each base model. In addition, users have the ability to view the overall duration required for the model to achieve its maximum performance. We have included a feature that enables users to toggle the visibility of model labels, hence enhancing visibility and facilitating more in-depth examination according to their preferences. This allows the user to observe the speed at which specific models reached their peak performance and the extent of their improvement relative to the base models.

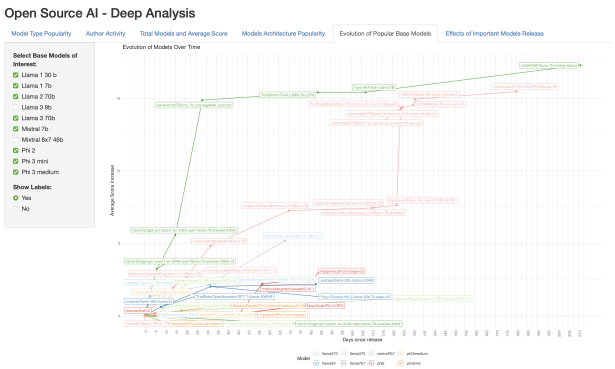

Figure 5: Evolution of famous base models

The final view, as depicted in Figure 6, illustrates the impact of significant releases on the popularity of various model designs. As we have employed identical model designs to those in view four, we have extracted and categorized all significant release dates of these models. The user has the option to choose the time unit for aggregate, which can be either day, week, or month. Users may quickly analyze the impact of significant releases and observe how they influence the popularity and mass creation of specific models. We can observe the evident impact of the recent releases of LLama and Mistral for their popularity.

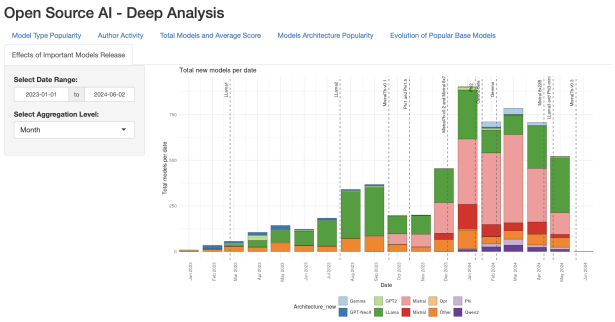

Figure 6: Effect of big releases on architecture of produced models

5 Conclusion and future work

Given the growing importance of Artificial Intelligence in modern culture, it is beneficial to explore the free solutions that are accessible rather than just depending on commercial alternatives. This paper offers valuable insights into a tool designed to simplify the examination of trends in open-source AI in a user-friendly manner. It offers various viewpoints and enables users to acquire knowledge and reach certain conclusions about the subject. Hugging Face has the capability to function as an excellent tool for finding a certain model. As time progresses, open-source AI is expected to provide a growing contribution to the AI community and provide more specific applications for models that could be ignored by big organizations.

We aim to enhance the functionality of our Shiny application by incorporating more perspectives and expanding the range of data interaction options. Our objective is to ensure that the system is as updated as possible. Besides that, we want to conduct a comprehensive analysis of the data to identify patterns and correlations inside this group. We aim to assess the potential of these models and examine their capabilities and potential uses in addressing real-world issues. We would like to analyze the sustained popularity and efficacy of these models over a longer time frame.

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Multilingual Hate Speech Modeling by Leveraging Inter-Annotator Disagreement

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Abstract

As social media usage increases, so does the volume of toxic content on these platforms, motivating the Machine Learning (ML) community to focus on automating hate speech detection. While modern ML algorithms are known to provide nearly human-like results for a variety of downstream Natural Language Processing (NLP) tasks, the classification of hate speech is still an open challenge, partially due to its subjective annotation, which often leads to disagreement between annotators. This paper adopts a perspectivist approach that embraces subjectivity, leveraging conflicting annotations to enhance model performance in real-world scenarios. A state-of-the-art multilingual language model for hate speech detection is introduced, trained, and evaluated using diamond standard data with metrics that consider disagreement. Various strategies for incorporating disagreement are compared in the process. Results demonstrate that the model performs equally or better on all evaluated languages compared to respective monolingual models and drastically outperforms on multilingual data. This highlights the effectiveness of multilingual and perspectivist methods in addressing the complexities of hate speech detection. The presented multilingual hate speech detection model is available at: https://huggingface.co/IMSyPP/hate_speech_multilingual.

Keywords

hate speech detection, inter-annotator disagreement, multilingual language modeling

1 Introduction

The phenomenon of hate speech, which is typically defined as offensive or derogatory language targeting individuals or groups based on characteristics such as race, religion, ethnic origin, sexual orientation, disability, or gender [2], has become a significant problem on social networks in recent years, with communities being increasingly exposed to toxic content as the networks grow and become more interconnected [13, 3]. Consequently, the Machine Learning (ML) and computational linguistics communities have begun developing content moderation strategies using advanced algorithms and Natural Language Processing (NLP) techniques to detect hate speech [10, 11]. However, a key challenge is the subjectivity of hate speech, as annotators often disagree due to diverse backgrounds and perspectives.

To address this challenge, researchers have proposed alternative methodologies to ground-truthing, including the incorporation of diverse perspectives into the training and evaluation pipelines of ML models [1, 14]. One such approach is introduced by [7], who train monolingual hate speech classifiers in several languages directly on datasets that include disagreement. As an alternative to gold-standard data, such data is referred to as diamond standard data, based on the assumption that more than one single truth exists. In terms of evaluation, the researchers focus on the evaluation of models from the perspective of disagreement, with the ultimate goal of estimating the agreement between the annotators themselves, as well as between models and annotators by using the appropriate metrics. Their main findings indicate that disagreement between annotators represents an intrinsic limitation to the performance that can be achieved by automated systems.

This paper aims to explore the potential of training a multilingual hate speech model, as well as further explore the ideas of incorporating inter-annotator disagreement in model training. Therefore, at the basis of this paper lie the following research questions:

- *How does the performance of multilingual hate speech classifiers trained on diamond standard data compare to the performance of monolingual models?*
- *How can inter-annotator disagreement be effectively incorporated into the classifier fine-tuning process?*

In light of these research questions, the expected outcomes are twofold: (1) multilingual classifiers trained on diamond standard data are anticipated to outperform monolingual models, and (2) incorporating inter-annotator disagreement is expected to enhance sensitivity to nuanced hate speech. These findings could benefit computational linguistics research and social media providers by informing the development of more effective content moderation algorithms.

2 Related Work

Several methods exist for incorporating disagreement into ML training pipelines [12, 5], but few focus on hate speech detection. One approach is presented in [7], where monolingual hate speech classifiers were trained for English, Italian, and Slovenian. These classifiers utilized diamond standard datasets sourced from YouTube and Twitter, employing a consistent annotation process for each language. Their main findings indicate that, according to the accuracy scores, the annotators demonstrated a high degree of agreement in approximately 80% of the cases across all three datasets. In terms of Krippendorff's ordinal alpha score, which considers both agreement by chance and the ordering of classes (from least to most severe), the agreement score is approximately

*The first author conducted the research with significant input from the second author, under the supervision and guidance of the third author. All authors contributed to writing the manuscript.

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https://doi.org/https://doi.org/10.70314/is.2024.sikdd.7

0.6 for all three languages. Furthermore, the evaluation results indicate that the performance of each model aligned with the inter-annotator agreement, both in terms of accuracy and the alpha score. This implies that the performance of models is inherently constrained by the level of agreement among annotators. Consequently, when trained on diamond standard data, it is unlikely that the performance of these models can significantly surpass human performance.

This work was built upon these findings through investigating the potential of multilingual models to enhance hate speech detection, with the aim of broadening their applicability across diverse linguistic contexts. Additionally, strategies for incorporating annotator disagreement were explored, with the goal of improving model performance to approach human-level accuracy and agreement.

3 Method

This section details the methodology for training and evaluating the multilingual hate speech classifier presented in this paper. It begins with a brief overview of the datasets used, followed by an explanation of the chosen pre-trained language model that serves as the foundation for fine-tuning. The section concludes with a description of the methods employed for evaluating the models.

3.1 Datasets

Three monolingual datasets, i.e. the English (Youtube), Italian (Youtube) and Slovenian (Twitter) datasets, introduced in [7] served as the basis for our multilingual model. Each item was annotated by two annotators independently, assigned to one of four available classes: [Appropriate], [Inappropriate], [Offensive], and [Violent]. In the case of conflicting labels, both annotating instances were kept.

To explore strategies for incorporating disagreement, three multilingual datasets were created. First, the *Duplicate All* (DA) dataset, which contains all instances by their respective two annotators from the three monolingual datasets. Second, the *Duplicate Disagreement* (DD) dataset, in which instances where annotators disagreed appear twice with their respective conflicting labels, while instances that they agreed upon appear only once, creating a more balanced training set that reflects both agreement and disagreement, potentially preventing the models from being biased towards instances where annotators agree. And third, the *Remove Disagreement* (RD) dataset, which consists only of instances where annotators agree. Thus, the first two datasets contain diamond standard data, while the third dataset can be considered a gold standard dataset in which disagreement has been explicitly removed.

All instances in these datasets have undergone the same preprocessing steps, such as replacing links and usernames with placeholders. This step was undertaken to mitigate any potential biases associated with certain names, as discussed in [6]. Table 1 presents an overview of the label distribution across the three multilingual training sets. The datasets used for monolingual evaluation are the unmodified evaluation sets presented in [7].

Table 1: Label distribution of the multilingual train sets

Dataset	Acceptable	Inappropriate	Offensive	Violent
DA	191,677	11,005	112,833	7,145
DD	111,324	8,346	72,706	4,992
RD	80,573	2,661	40,255	2,161

3.2 Model Selection and Fine-Tuning

Our proposed multilingual hate speech model builds on the pre-trained XLM-R transformer model [4], chosen for its proven effectiveness in cross-lingual understanding and its ability to handle a wide range of languages. This provides a robust foundation for fine-tuning and optimization, particularly since English, Italian, and Slovenian—the languages used for fine-tuning—were included in XLM-R's pre-training. To explore various strategies for incorporating annotator disagreement during training, three model variants were fine-tuned on the previously presented datasets, referred to in the tables as MDA, MDD, and MRD, respectively.

To address class imbalance and enhance model performance on minority classes, a custom training loop with a weighted cross-entropy loss function was implemented, as proposed in [9]. The class weights were calculated to be inversely proportional to the frequency of each hate speech class within the training data. The hyperparameters for the fine-tuning process included a learning rate of 6×10^{-6}, a batch size of 8, and 3 training epochs. During the training phase, the AdamW optimizer was employed to optimize the model parameters. The fine-tuning process was implemented using PyTorch.

3.3 Model Evaluation

In terms of evaluation, the approach introduced in [7] was replicated in order to compare the performance of the multilingual classifiers to human judgment from the perspective of disagreement. This was achieved by employing identical measures to estimate the agreement between human annotators, as well as the agreement between annotators and models. Accuracy, F1 score and, most notably, Krippendorff's ordinal alpha were used to evaluate all models in this research.

Rarely used in ML applications, Krippendorff's alpha is a robust measure for assessing inter-rater reliability, accounting for agreement beyond what might occur by chance. It is applicable across various data types (nominal, ordinal, interval, and ratio scales) and is particularly effective in dealing with missing data. The value of Krippendorff's alpha ranges from -1 to 1, where 1 indicates perfect agreement and 0 suggests agreement equivalent to chance. Generally, an alpha above 0.80 is considered a strong agreement, while in hate speech datasets, the alpha values range from 0.25 to 0.65. For a detailed discussion, see Krippendorff [8].

4 Results

This section presents the evaluation results on the multilingual model and its variants. It starts with an evaluation from the perspective of inter-annotator and model-annotator agreement. Then, the class specific evaluation results, as well as a model comparison based on the models' average scores are presented. The models are also compared to monolingual baselines fine-tuned on data for their respective languages, including the BERT model for English, AlBERTo for Italian, and CroSloEngual for Slovenian, as presented in [7].

4.1 Inter-Annotator and Model-Annotator Agreement

The inter-annotator agreement was computed on the evaluation sets for each language using Krippendorff's alpha and accuracy. The same measures were also used to compute the agreement between the annotators and the models. The results are presented in Table 2.

Table 2: Inter-Annotator Agreement compared to model-annotator agreement in terms of Krippendorff's ordinal alpha (α) and Accuracy (Acc.) for the models Multilingual Duplicate All (MDA), Multilingual Duplicate Disagreement (MDD), and Multilingual Remove Disagreement (MRD) based on the language-specific evaluation sets

Dataset	Inter-Annotator Agreement		MDA		MDD		MRD	
	α	Acc.	α	Acc.	α	Acc.	α	Acc.
English	58.19	82.91	55.89	79.97	50.18	76.47	**57.90**	**81.41**
Italian	57.00	81.79	**58.29**	82.00	56.15	80.43	57.84	**82.69**
Slovenian	56.62	79.43	55.74	78.60	52.95	76.52	**55.15**	**78.84**

First, in the case of inter-annotator agreement, annotators agree around 80% of the time in terms of accuracy, with an accuracy score between 79% and 82% across all three datasets. However, accuracy does not account for class imbalance, nor the ordering of the classes. A more appropriate estimate of the agreement is computed through Krippendorff's ordinal alpha. Here, the annotators achieve an agreement score alpha in the values between 0.56 and 0.58 across the three languages.

Second, in terms of agreement between annotators and models, the same metrics were applied. The results demonstrate a consistent level of agreement between the models and annotators across all cases. Based on accuracy scores, all models align with at least one annotator approximately 80% of the time, with alpha values comparable to inter-annotator scores. In most instances, the models achieve the upper limit of inter-annotator agreement, and in some cases, even exceed it (e.g., Italian *Multilingual Duplicate All MDA*). This suggests that the models are effectively learning consistent patterns or biases that align well with one or more annotators. Such outcomes are expected in scenarios where annotator disagreement is largely due to subjective interpretation. This should not be construed as the model being inherently superior, but rather as an indication of its efficiency in modeling the predominant patterns present in the training data.

Third, a comparison between the multilingual variants shows that the *Duplicate Disagreement (DD)* strategy consistently shows worse alpha scores, meaning that emphasizing only on disagreement might be detrimental in training. No consistent difference between *Duplicate All (DA)* and *Remove Duplicates (RD)* is evident from the experiments.

4.2 Model Comparison

To evaluate the performance of the models across the four hate speech classes, the F1 score was used. Additionally, the combined (weighted) F1 score was computed for each model to assess their overall performance. To determine the best-performing model, the weighted F1 scores were averaged across all three languages. Table 3 shows the results achieved by each of the models on the English evaluation set. In the case of the English dataset, the results show that the multilingual model outperforms the baseline monolingual English model across all classes except the [Appropriate] class, a case in which it still performs competitively. The variant which achieved the highest score on the minority classes is the *MDA* model, with an F1 score of 39.16 for the [Inappropriate] class and an F1 score of 27.82 for the [Violent] class. This is most likely due to introducing the weighted cross-entropy loss function, which was effective in improving performance on underrepresented classes, a procedure which was not performed in [7].

Similar patterns emerge on the Italian dataset (Table 4). The multilingual model is competitive to the monolingual model while outperforming the Italian baseline on the minority classes. The highest scores on the most important classes [Violent] and [Offensive] were achieved by the *MDA* variant, once again showing the superiority of the *Duplicate All (DA)* strategy.

Table 3: Model evaluation results in terms of class-specific F1 scores on the English dataset. The Total score was calculated using the weighted F1 score. The first three models represent the monolingual baselines. The subsequent models represent the multilingual models

Model	Appropriate	Inappropriate	Offensive	Violent	Total
EN	**89.38**	28.95	68.36	24.17	**83.44**
IT	85.25	13.81	0.41	0.00	63.39
SL	88.01	25.17	49.69	2.88	77.71
MDA	86.10	**39.16**	68.24	**27.82**	81.09
MDD	83.33	34.16	65.07	24.52	78.20
MRD	87.43	29.90	**69.02**	27.27	82.18

In the case of the Slovenian dataset, the observed phenomena slightly differ from the previous ones. The evaluation results are presented in Table 5. Here, two of the multilingual variants (*MDA* and *RD*) outperform the Slovenian monolingual model overall, despite predicting worse on the [Appropriate] class. Notably, the monolingual model outperforms all models on the [Violent] class, which has not been the case for the other languages. This could be due to language specifics that the multilingual model fail to capture, or to the specifics of the CroSloEngual BERT which is also heavily pre-trained on Croatian and Slovenian data. Once again, the *DA* disagreement strategy shows slight superiority over *RD*.

Finally, Table 6 shows the average scores of all models, achieved by averaging their combined (weighted) F1 scores across all three languages. Summarizing the multilingual superiority, these final results show how monolingual models drastically falter on unseen languages, while the multilingual models have the capacity to reach the inter-annotator agreement ceiling for all languages.

While overall results show that the *Remove Disagreement (RD)* gold standard strategy for incorporating disagreement is best, one should be cautious when making such conclusions. Class-specific results show that the Duplicate All (DA) strategy outperforms in all the classes most relevant to hate speech detection, except for [Appropriate], which is the least relevant class. Another difference is that the *MDA* model involved training longer on the same data which might have resulted in improvement on minority classes and saturation on the majority class. For a future fairer comparison, the fine-tuning process on gold standard data should be adjusted accordingly. The *MDA* variant of the model is available at: https://huggingface.co/IMSyPP/hate_speech_multilingual.

5 Discussion

In recent years, automated hate speech detection has become crucial for moderating online content and mitigating the negative impact on social dynamics within online communities. This

Table 4: Model evaluation results in terms of class-specific F1 scores on the Italian dataset

Model	Appropriate	Inappropriate	Offensive	Violent	Total
EN	86.27	1.28	1.05	0.00	67.42
IT	**91.32**	**58.46**	59.02	40.34	**83.22**
SL	86.23	0.76	3.25	0.00	65.95
MDA	89.77	58.45	**60.42**	**44.97**	82.38
MDD	88.95	56.04	58.31	39.85	81.19
MRD	90.41	55.46	59.49	38.78	82.50

Table 5: Model evaluation in terms of class-specific F1 scores on the Slovenian dataset

Model	Appropriate	Inappropriate	Offensive	Violent	Total
EN	79.93	3.98	2.34	0.00	53.84
IT	79.84	3.80	1.24	0.00	53.43
SL	**85.70**	43.69	65.26	**29.12**	78.39
MDA	84.30	**45.22**	**69.69**	24.79	**78.88**
MDD	82.33	43.39	68.59	23.84	77.19
MRD	84.98	38.47	68.40	15.50	78.80

Table 6: Average performance of models based on class-weighted F1 scores across three languages

Model	Avg. Weighted F1 Score (all languages)
EN	68.23
IT	66.68
SL	74.02
MDA	80.78
MDD	78.86
MRD	**81.16**

research proposes a novel multilingual hate speech model to address these challenges on a broader scale. The following discusses the main findings.

First, the inter-annotator agreement and the agreement between annotators and models suggest that inter-annotator agreement sets an intrinsic limit on model performance. Models are limited by the quality and consistency of the annotated data, which directly affects their ability to accurately predict unseen data. However, incorporating areas of disagreement into model development can lead to more robust models capable of handling ambiguous cases by employing one of the several available strategies for incorporating disagreement.

Second, the multilingual model consistently surpassed the monolingual baselines, achieving the inter-annotator agreement ceiling across all languages. This success can be attributed partly to the ability to leverage patterns learned from multiple languages, partly to vast amounts of data incorporated into state-of-the-art pre-trained multilingual models, and partially to the class weighting scheme employed in the fine-tuning. These findings support the first research question, demonstrating that a multilingual hate speech classifier trained on diamond standard data outperforms its monolingual counterparts.

Finally, this research contributes substantially to hate speech classification in a multilingual context by introducing a novel multilingual hate speech detection model and making it available on the Hugging Face platform. Our model underscores the importance of incorporating inter-annotator disagreement into model development, challenging the reliance on gold standard data in subjective tasks, such as hate speech detection.

6 Conclusions

This paper advances automatic hate speech detection by introducing a novel multilingual model fine-tuned on the state-of-the-art XLM-R transformer. By leveraging multilinguality, the model significantly outperforms monolingual baselines, demonstrating its effectiveness across diverse linguistic contexts. This highlights the potential of multilingual approaches in improving hate speech detection, especially in scenarios where content spans multiple languages.

Additionally, this research incorporates inter-annotator disagreement into the fine-tuning process using diamond standard data, offering a valuable alternative to traditional gold-standard models. By embracing rather than ignoring annotator disagreement, the model better reflects the nuances of subjective annotations, enhancing its real-world applicability. However, while this approach shows promise, annotator disagreement continues to present challenges, indicating that further work is needed to fully address its impact on model performance.

Future research could extend this work by evaluating the models on additional languages, exploring alternative baseline models, refining strategies for incorporating annotator disagreement and handling minority classes. As online hate speech extends its impact, developing robust, multilingual content moderation systems is crucial to maintaining safe and inclusive digital environments.

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Predicting Pronunciation Types in the Sloleks Morphological Lexicon of Slovene

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Abstract

We present an experiment dealing with the automatic prediction of pronunciation types for lemmas in the *Sloleks Morphological Lexicon of Slovene*. We perform a statistical analysis on a number of mostly *n*-gram-based features and use a set of statistically significant features to train and test several machine learning models to discriminate between lemmas for which a phonetic transcription can be generated automatically using Slovene grapheme-to-phoneme (G2P) conversion rules (e.g. *Novak*), and lemmas with pronunciation that follows other G2P rules (e.g. *Shakespeare*).

Keywords

grapheme-to-phoneme conversion, pronunciation types, morphological lexicon, proper nouns, Slovene

1 Introduction

The *Sloleks Morphological Lexicon of Slovene* [2] is the largest open-access database containing machine-readable information on the morphological properties of Slovene lemmas (e.g. *miza* 'table', noun, common, feminine) and their inflected forms (e.g. *mize*, singular, genitive; *mizo*, singular, accusative). Since version 2.0 [3], each lemma and inflected form also contains accentuated forms (e.g. *míza*) and phonetic transcriptions in the International Phonetic Alphabet (IPA) and its equivalent X-SAMPA (e.g. IPA: /ˈmiːza/, X-SAMPA: /"mi:za/). Both transcriptions were generated automatically from accentuated forms, first in version 2.0 using a rudimentary rule-based system, then again in 3.0 with a greatly improved and linguistically informed rule-based grapheme-to-phoneme (G2P) conversion tool for Slovene.[1]

Rule-based G2P conversion for Slovene (particularly from accentuated forms) yields very good results and leaves only a minority of issues to be resolved manually because in terms of its orthographic depth, Slovene features a shallow orthography ([9]) in which each grapheme in the alphabet generally corresponds to one phoneme (see e.g. [4]) and the spelling-sound correspondence is relatively direct ([1]; [11]): the pronunciation rules allow for words to be pronounced correctly based on their graphemic representation, with some exceptions and several predictable phoneme assimiliations (such as the assimilation of voiceless consonant phonemes to their voiced equivalents *glasba* 'music', IPA: /ˈglaːzba/, or vice-versa, voiced-to-voiceless, *podpreti* 'to support', IPA: /pɔtˈpreːti/).

However, not all entries in Sloleks follow Slovene G2P principles. For a number of words, particularly proper nouns denoting people (*Shakespeare*, *Sharon*), locations (*Sydney*, *Birmingham*), inhabitants (*Newyorčan* 'New Yorker'), etc.; as well as adjectives derived from proper nouns (*aachenski* 'pertaining to Aachen', *Acronijev* 'belonging to Acroni'), the phonetic transcription cannot be generated using Slovene G2P rules. In such cases with foreign orthographic elements that indicate relations between graphemes and phonemes that are unusual for Slovene, Slovene linguistic and lexicographic practice (see e.g. [5]) first requires a transliteration into the closest equivalent using Slovene graphemes, which can then be used to generate the phonetic transcription using Slovene G2P rules (e.g. *Newyorčan* → *njújórčan* → IPA: /ˈnjuːˈjoːrtʃan/).

Because of this, it is necessary to discriminate between different *pronunciation types*: categories of words that follow Slovene G2P rules (*Slovene G2P*) and those that do not (e.g. *Other G2P*; more on this in Section 2). Pronunciation types denote the manner in which the phonetic transcription of the word can be generated. In some cases, assigning the pronunciation type to a lemma is trivial – if the lemma contains a grapheme that is not part of the Slovene alphabet[2] (e.g. *x*, *y*, *w*, *q*), it belongs into the *Other G2P* category (e.g. *Byron*, *Oxford*). There are, however, many exceptions that belong in the *Other G2P* category despite being comprised entirely of Slovene graphemes (e.g. *Matt*, *Sharon*).

In Sloleks 3.0, the first cca. 100,000 lemmas that had been part of version 2.0 were manually annotated with pronunciation types, whereas the 264,000 new entries (added automatically from the *Gigafida 2.0 Corpus of Modern Standard Slovene* [6]) still lack this information. Because manual annotation from scratch is time-consuming, we performed an experiment to determine to what degree the pronunciation type can be predicted automatically by relying on the scarce linguistic and morphosyntactic information that can be extracted from an individual lemma.

The paper is structured as follows: we describe the dataset that was used for the statistical analysis and machine learning experiment (Section 2), as well as the process of feature selection (Section 3). We train several machine-learning models and evaluate their performance using 10-fold cross-validation (Section 4). Finally, we manually evaluate a sample of automatically annotated entries (Section 5) and conclude the paper with our plans for future work (Section 6).

[1]The Slovene G2P tool is part of *Pregibalnik*, a piece of software used for the automatic expansion of the *Sloleks Morphological Lexicon of Slovene*: https://github.com/clarinsi/SloInflector It was developed within the *Development of Slovene in the Digital Environment* project. The Slovene G2P converter is also available as an API-service: https://orodja.cjvt.si/pregibalnik/g2p/docs

[2]Although *ć* and *đ* are not part of the Slovene alphabet, they are phonemically transparent and frequently occur in names of Slovene citizens, so they are not counted as foreign characters for the purposes of this task.

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Table 1: Lemmas in Sloleks 3.0 by Pronunciation Type

Pronunciation Type	Frequency	%
-	264,538	72.41%
Slovene G2P	94,750	25.93%
Other G2P	3,066	0.84%
Numeral	1,840	0.50%
Acronym	845	0.23%
Slovene G2P with minor deviation	113	0.03%
Abbreviation	70	0.02%
Ambiguous G2P	69	0.02%
Symbol	49	0.01%
Total	**365,340**	**100.00%**

Table 2: Lemmas in Sloleks 3.0 with *Other G2P* pronunciation type by Morphosyntactic Properties

Morphosyntactic Properties	Frequency	%
Adjective, possessive	1,092	35.62%
Noun, proper, masculine	958	31.25%
Noun, proper, feminine	713	23.26%
Adjective, general	142	4.63%
Noun, common, masculine	127	4.14%
Noun, common, feminine	20	0.65%
Adverb, general	10	0.33%
Noun, common, neuter	2	0.07%
Verb, main, imperfective	2	0.07%
Total	**3,066**	**100.00%**

2 Dataset

Sloleks 3.0 contains a total of 365,340 entries, but only approximately 28% have been manually assigned one of 8 pronunciation types[3] (as shown in Table 1). For the classification task, we focus only on the two most frequent pronunciation types (*Other G2P* and *Slovene G2P*). [4]

In terms of their morphosyntactic features, the *Other G2P* lemmas mostly consist of possessive adjectives and proper nouns, collectively accounting for cca. 90% of the category (as shown in Table 2), but only 15% of the portion of Sloleks annotated with pronunciation types.

The final dataset for statistical analysis and machine learning consisted of 94,863 *Slovene G2P* lemmas (e.g. *dekadentnost*, *Košak*, *prefiltriran*) and 3,066 *Other G2P* lemmas (e.g. *Elizabeth*, *Presley*, *Sinclaire*).

3 Statistical Analysis and Feature Selection

From each lemma, we extracted a series of features that could help discriminate between the two classes: (a) percentage of *Slovene G2P* graphemes within the lemma (i.e. graphemes of the Slovene alphabet as well as *ć* and *đ*); (b) morphosyntactic features (e.g. *noun*, *proper*, *masculine*); (c) relative frequencies[5] of character-level uni-, bi-, and trigrams within the lower-cased lemma (e.g. *Matt* $\rightarrow f_r(m)$, $f_r(a)$, ..., $f_r(ma)$, $f_r(at)$, ..., $f_r(mat)$, ...); (d) relative frequencies of character-level uni-, bi-, and trigrams from a robust CVC-conversion of the lemma, substituting consonant graphemes with *C* and vowel graphemes with *V* (e.g. *Matt* $\rightarrow$ *CVCC* $\rightarrow f_r(C)$, $f_r(V)$, ..., $f_r(CV)$, $f_r(VC)$, ..., $f_r(CVC)$, ...); (e) relative frequencies of character-level uni-, bi-, and trigrams from a finegrained CVC-conversion of the lemma[6] (e.g. *Matt* $\rightarrow$ *ZVKK* $\rightarrow f_r(Z)$, $f_r(V)$, ..., $f_r(ZV)$, $f_r(VK)$, ..., $f_r(ZVK)$, ...)

For (c), (d), and (e), the initial and final uni-, bi-, and trigrams of the lemma were extracted separately as well, as in some cases the position of the *n*-gram in the word can be indicative of one class over another.

For general character-level *n*-grams, the first 1,498 with a frequency of at least 500 across all Sloleks 3.0 lemmas were analyzed; these cover cca. 88.34% of all *n*-gram occurrences. For robust CVC and finegrained CVC *n*-grams, all were analyzed. We performed the Kruskal–Wallis H test [7] (k=2, n=97,056) on a total of 6,148 features, out of which 2,490 (40%) were statistically significant.[7] Statistically significant features by categories are shown in Table 3. 1,146 features are more indicative of *Slovene G2P* and 1,344 are more indicative of *Other G2P*. As shown in Table 4, only three of the top 10 general *n*-grams indicative of *Other G2P* actually contain non-*Slovene G2P* characters, confirming that detecting lemmas from the *Other G2P* category is more complex and requires more than simply taking into account non-*Slovene G2P* graphemes.

Table 3: Statistically Significant Features by Category

Feature Category	Number
Percentage of *Slovene G2P* characters	1
Morphosyntactic features	3
General character-level *n*-grams	1,119
Initial character-level *n*-grams	398
Final character-level *n*-grams	468
General robust CVC *n*-grams	66
Initial robust CVC *n*-grams	44
Final robust CVC *n*-grams	39
General finegrained CVC *n*-grams	157
Initial finegrained CVC *n*-grams	102
Final finegrained CVC *n*-grams	93
Total	**2,490**

4 Pronunciation Type Prediction

The identified features (along with several placeholder *n*-grams to take into account any graphemes not covered in the initial dataset) were taken into account to develop a custom vectorizer that converts a given lemma and its lexical features based on the MulText-East v6 (MTE-6) Morphosyntactic Specifications for

[3]It should be noted that all the inflected forms within the entry effectively inherit the pronunciation type.

[4]Symbols in Sloleks are rare, along with entries within the *Ambiguous G2P* category (where an entry can either follow Slovene G2P rules or not, depending on the context – e.g. *Amanda* as a Slovene name: /amˈaːnda/; or as an English name with a pronunciation adjusted to the Slovene set of phonemes: /əmˈɛːnda/). Abbreviations and numerals are easily identifiable, and while acronyms have a separate manner of generating phonetic transcriptions which also depends on their morphological patterns, they are also mostly identifiable with rules. Because of its rarity and similarity to *Slovene G2P*, the *Slovene G2P with minor deviation* category was merged into *Slovene G2P* for the classification task.

[5]Relative frequencies were calculated as $f_r(x_n) = f_a(x_n)/\sum f_a(y_n)$, e.g. the absolute frequency of *n*-gram *x* of length *n* within the lemma divided by the sum of absolute frequencies of each *n*-gram *y* of length *n* within the lemma.

[6]In the finegrained CVC-conversion, consonant graphemes were generalized into more finegrained categories, e.g. graphemes denoting Slovene sonorants (M), voiced (G) and voiceless obstruents (K), foreign consonants (X), etc.

[7]Effect size was calculated as $\eta^2 = (H - k + 1)/(n - k)$, as reported in [10].

Table 4: Top 10 Statistically Significant General Character-Level *n*-Grams by Effect Size (η^2)

n-Gram	H	p	η^2	Means
y	11509.36	$p \leq 0.0001$	0.1186	$\mu_S < \mu_O$
w	9595.25	$p \leq 0.0001$	0.0989	$\mu_S < \mu_O$
ch	7558.60	$p \leq 0.0001$	0.0778	$\mu_S < \mu_O$
ll	6295.96	$p \leq 0.0001$	0.0649	$\mu_S < \mu_O$
ss	3804.26	$p \leq 0.0001$	0.0392	$\mu_S < \mu_O$
nn	3220.65	$p \leq 0.0001$	0.0332	$\mu_S < \mu_O$
th	2973.89	$p \leq 0.0001$	0.0306	$\mu_S < \mu_O$
wa	2761.53	$p \leq 0.0001$	0.0284	$\mu_S < \mu_O$
tt	2745.10	$p \leq 0.0001$	0.0283	$\mu_S < \mu_O$
co	2571.20	$p \leq 0.0001$	0.0265	$\mu_S < \mu_O$

Table 5: Model Performance Based on 10-Fold Cross-Validation

Model	A	BA	P	R	F1	ROC AUC
LinearSVC	**99.08**	**87.87**	**96.36**	**87.87**	**91.64**	**98.89**
Multin. NB	97.38	79.17	78.12	79.17	78.62	96.55
kNN (k=5)	98.25	75.17	93.67	75.17	81.74	91.63
Majority	96.87	-	-	-	-	-

Slovene[8] into a 2,500-dimensional numerical vector. The entire dataset was converted into vectors and split into a training set (80%) and a test set (20%), both stratified by class. Three models[9] (Linear Support Vector Classifier (LinearSVC), Multinomial Naive Bayes Classifier (Multin. NB), and k Nearest Neighbors Classifier (kNN)) were trained and evaluated with 10-fold cross-validation. The results are listed in Table 5[10] and show that LinearSVC outperforms the other two models. All three exhibit above-baseline accuracy compared to the majority classifier, but Multinomial NB and kNN perform much worse in terms of balanced accuracy as well as precision and, in case of kNN, recall. Recall is also somewhat lower with LinearSVC, which is to be expected – some *Other G2P* lemmas might contain no indicative *n*-grams and are thus hard to detect; on the other hand, once identified, the model is very precise in its prediction.

Table 6 shows the confusion matrix for the LinearSVC model tested on the 20% stratified test dataset. The model very rarely misclassifies *Slovene G2P* lemmas, and more frequently errs with *Other G2P* lemmas. A closer inspection of the misclassified *Slovene G2P* examples reveals several errors in the original dataset: *Beethoven*, *Ratzinger*, *Rotterdam*, *Franco*, *Oberstdorf*, and *Keller* were in fact correctly classified as *Other G2P*, but they are miscategorized as *Slovene G2P* in the original dataset. Other misclassifications include examples of foreign proper nouns and possessive adjectives that contain unusual grapheme combinations for Slovene (e.g. *Andreas*, *Aurelio*, *Hilton*, *Simpsonov*), but their pronunciation can still be derived from their graphemic representation (e.g. *Andreas* → IPA: /and'reːas/).

On the other hand, *Other G2P* lemmas misclassified as *Slovene G2P* include *Andersonov*, *Atkinsov*, *Batmanov*, in which the grapheme

[8]MTE-6: https://nl.ijs.si/ME/V6/msd/html/msd-sl.html The vectorizer uses Slovene morphosyntactic tags, e.g. *Slz* (S – noun, l – proper, z – feminine).
[9]All models were trained using the Python library *scikit-learn*. [8]
[10]A, BA, P, R, and F1 refer to accuracy, balanced accuracy, macro-precision, macro-recall and macro-F1, respectively.

Table 6: Confusion Matrix for Linear Support Vector Classifier

True → ↓ Predicted	Slovene G2P	Other G2P	∑
Slovene G2P	**18,939**	140	19,079
Other G2P	34	**473**	507
∑	18,973	613	-

Table 7: Confusion Matrix for Manual Evaluation

True → ↓ Predicted	Slovene G2P	Other G2P	∑
Slovene G2P	**86**	9	95
Other G2P	14	**91**	105
∑	100	100	-

'a' is pronounced as /ɛ/, but this cannot be discerned from the graphemic representation itself. Other misclassified examples are more obviously pertaining to *Other G2P*, e.g. *Dorfmeister*, *Faulknerjev*, *Flaubertov*, *Heisenbergov*, *Balfourjev*. This might indicate that not all indicative *n*-grams have been included as features (e.g. 'ei', 'ou'), possibly for lack of evidence in the original dataset or because they are less frequent and have not been included in the initial batch of statistical tests. As the lexicon expands with new entries, the model will be updated with new examples and new features to potentially improve performance.

5 Manual Evaluation

We trained a new instance of the LinearSVC model on the entire dataset and used it to annotate the remaining cca. 264,000 lemmas from Sloleks 3.0 with no pronunciation type, resulting in 86,730 lemmas with *Other G2P* and 177,808 lemmas with *Slovene G2P*.

We performed a preliminary manual evaluation consisting of a random sample of 100 examples from each class. The results are shown in the confusion matrix in Table 7. Although the sample is too small to be representative of the whole, it indicates that the model performs well even on unseen data, achieving an accuracy of 88.50% (P=0.91, R=0.87, F1=0.89) over a majority baseline accuracy of 50.00%.

The misclassifications of *Other G2P* as *Slovene G2P* include examples such as *Mukhamedov*, *Beatli*, *Livenza*, and *Preidler*, with limited indicators that the words belong to the *Other G2P* category. Most graphemes in these examples are pronounced according to *Slovene G2P* criteria, with the exception of individual *n*-grams ('nz', 'ei', 'kh'), some of which have not been included in the set of features. In other examples, only one or two vowel graphemes are indicative of *Other G2P* pronunciation (e.g. *Trendlina*, which is also a lemmatization error; the correct lemma is *Trendline*; and *Sanberg*), and the pronunciation of single vowel graphemes appears harder to predict than consonant graphemes or combinations thereof.

Similarly, the misclassifications of *Slovene G2P* lemmas as *Other G2P* lemmas include examples such as *Doneck*, *Barson*, *Bronson*, *Piersanti*, and *Faustini*. While these are proper nouns of foreign origin, their Slovene pronunciation can either be fully discerned from their graphemic representation (e.g. *Doneck* → IPA: /dɔ'neːtsk/), or it only differs slightly from what Slovene

grapheme-to-phoneme conversion would produce (e.g. *Faustini* → automatically converted IPA: /faus'ti:ni/; correct IPA: /fa͡us'ti:ni/).

6 Conclusion

In the paper, we presented the results of an attempt to automatize the assignment of pronunciation types to lemmas in the *Sloleks Morphological Lexicon of Slovene*. The results show that a model based on a series of mostly *n*-gram features can provide good results when discriminating between *Slovene G2P* and *Other G2P* categories, with the best performance achieved by the Linear Support Vector Classifier. However, there is still room for improvement, particularly in terms of recall – a number of *Other G2P* lemmas from the test set were misclassified as *Slovene G2P*, while those classified correctly were classified with a relatively high precision score. *n*-grams that are statistically significant as indicative of one class have proven to be useful features for model development, but because they are not evenly distributed and occur sporadically in different lemmas, it would make sense to further improve the model by performing the same statistical analysis (as described in Section 3) on the long tail of less frequent *n*-grams to prepare a more comprehensive list of indicative *n*-grams. The current version of the model is very light-weight and additional features should not cause the model to become overencumbered.

There are several possibilities for further development of the model. Firstly, instead of using relative frequencies of *n*-grams as features, it would be useful to test how different measures such as TF–IDF, absolute frequencies, or even Boolean values influence the performance of the model, and potentially also test several other machine learning algorithms (e.g. Random Forest Classifier). Secondly, while the other pronunciation types from Sloleks 3.0 (acronyms, abbreviations, etc.) are relatively easily identifiable (but much less frequent), in the next step, it would be informative to include them in the training set and test out the model's performance on the full set of categories. Thirdly, a statistical analysis should be performed on the probabilities with which the model makes decisions and to what degree they correlate with the percentage of graphemes that differ from the shallow orthographical Slovene G2P rules (e.g. *Anderson*, with arguably only 'a' not following Slovene G2P rules; vs. *Châteaux*, where the majority of graphemes are pronounced completely differently compared to Slovene G2P rules). This would require the preparation of a separate dataset in which graphemes are manually aligned to either the graphemes of their transliterated Slovene graphemic forms (*Newyorčan* → *njújórčan*) or their Slovene IPA transcriptions. By assigning scores that reflect the degree of orthography depth for the individual lemma, it would be possible to use the dataset to train a regression model.

Similarly, *Other G2P* lemmas from Sloleks 3.0 can be manually annotated with their language of origin and transliterated according to the recently published transliteration rules of *Pravopis 8.0*,[11] the new orthographic manual of Slovene, which at the time of writing this paper is still in development. Such a dataset would enable the development of a model for language identification for individual lemmas, and, ultimately, a model for automatizing transliteration of lemmas of foreign origin into their Slovene equivalents. As of now, no such tool yet exists for Slovene, and even the new orthographic manual anticipates that all transliteration should be done manually, which begs the question whether at least part of the work can be automatized. This would be an important step in the development of a modern, digital infrastructure for Slovene orthography, and would facilitate the automatic expansion of modern digital dictionary databases and datasets for automatic speech recognition.

In addition, although our preliminary experiments with LLMs (ChatGPT 3.5 and 4.0) classifying *Slovene G2P* and *Other G2P* lemmas have yielded much worse results than the best performing LinearSVC model, more systematic experiments are warranted.

As part of our future work, we intend to implement the model into *Pregibalnik*,[12] which is used for automatically extending the lexicon and currently assigns no pronunciation type. The model itself is available under the Apache 2.0 license on Github[13], while the pronunciation type annotations will be included in future versions of Sloleks and, eventually, manually validated.

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Higher-Order Bibliographic Services based on bibliographic networks

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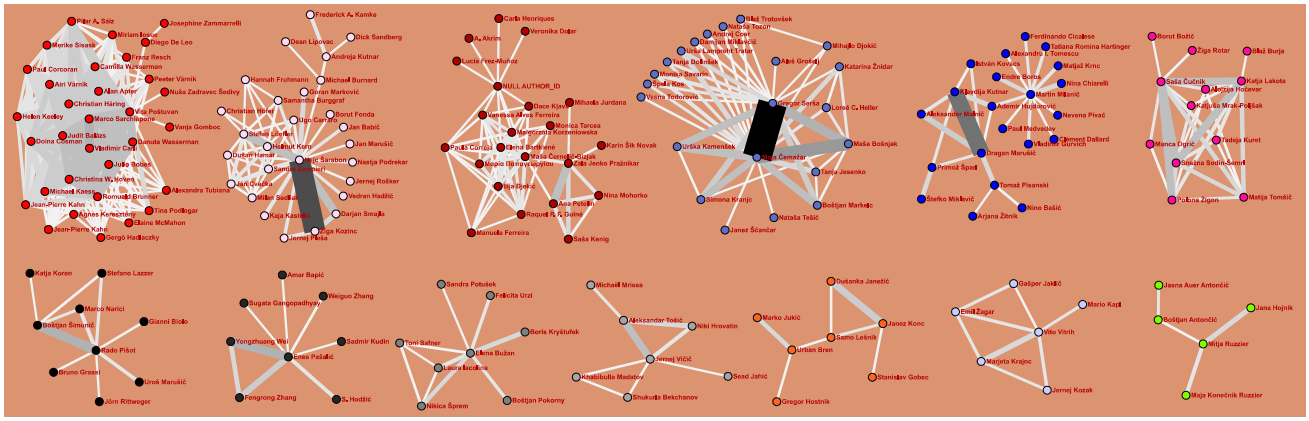

Figure 1: The largest co-author groups at level 10 at the University of Primorska until 2024.

Abstract

Bibliographic databases only provide basic services to users, but they could provide much richer information for specific user needs. The main reason for the delay in developing such higher-order bibliographic services is the limited access to data in proprietary databases. We expect the new open bibliographic databases like OpenAlex will encourage faster development of these services. We describe an approach based on a collection of bibliographic networks as a foundation to support the development of higher-order bibliographic services.

Keywords

bibliographic database, open access, network analysis, higher-order bibliographic service, prototype, OpenAlex

1 Introduction

From special bibliographies (BibTEX, EndNote) and bibliographic databases, it is possible to obtain data about works (papers, books, reports, etc.) on selected topics. A typical work description contains the following data: authors; title; publisher/journal; publication year and pages. In some sources, additional data are available including languages, classification of documents, keywords, authors' institution/country affiliation, lists of references, and the abstract. This data can be transformed into a collection of compatible two-mode networks on selected topics [5]: works × authors; works × keywords; works × countries, and other pairs of characteristics describing works. Besides these networks, we can also get the partition of works by their publication years, the partition of works by journals or publishers, the vector of the number of pages, and, in some cases, the (one-mode works × works) citation network.

When constructing any of these networks, the first task is to specify the nodes and which relations are linking them. In short, the network boundary problem [16] has to be solved. This includes deciding whether a network is one-mode or two-mode and which node properties are important for the intended analyses. For specifying links, this amounts to answering a series of questions:

(1) Are the links directed?
(2) Are there different types of links (relations) to include?
(3) Can a pair of nodes be linked with multiple links?
(4) What are the weights on the links?
(5) Is the network static, or is it changing through time?

Another problem that often occurs when defining the set of nodes is the identification of nodes. The unit corresponding to a node can have different names (synonymy), or the same name can denote different units (homonymy or ambiguity). For example in the BibTEX bibliography from the Computational Geometry Database [14] the same author appears under 7 different names: R.S. Drysdale, Robert L. Drysdale, Robert L. Scot Drysdale, R.L. Drysdale, S. Drysdale, R. Drysdale, and R.L.S. Drysdale. Insider information is needed to decide that Otfried Schwarzkopf and Otfried Cheong are the same person. At the other extreme, there are at least 57 different mathematicians with the name Wang, and Li in the MathSciNet Database [20]. Its editors have tried hard, from 1985, to resolve the identification of the author's problem during the data-entry phase. The significant growth of contributions by Chinese scientists and their full name similarity in

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https://doi.org/10.70314/is.2024.sikdd.12

Roman transcriptions adds additional complexity to the problem. In the future, the problem could be eliminated by implementing initiatives such as using ORCID or resolving the identification problem in bibliographic databases (Scopus, OpenAlex).

2 Higher-Order Bibliographic Services

The data collected in different bibliographic databases can be used to provide higher-order bibliographic and bibliometric services such as what to read (contact/visit)? – a list of relevant articles/books (authors, institutions) on selected topic; where to publish? – a list of journals suitable for the publication of an article, automatic suggestion of keywords; reviewer selection – a list of reviewers suitable for a submitted article; possible partners for research collaboration; a career application – a candidate's activity report draft; etc.) for different types of users (students, researchers, teachers, decision-makers, funding agencies, research institutions, database managers, etc. . To support this goal we have to use high-quality data often obtained by combining data from different databases.

For the development of higher-order bibliographic and bibliometric services, open bibliographic databases such as OpenAlex are particularly welcome, as the developed services can remain open.

3 OpenAlex

The basic type of unit in a bibliographic database is the work. A user searching the database gets a list of works satisfying the query. Usually, some operations with such lists (inspection, filtering, merging, intersection, statistics, etc.) are supported. Only basic services are provided to users.

Some web services also supporting some other types of units (authors, institutions, research fields, conferences, etc.) were developed such as Google Scholar [19], Scholar GPS [12], and DBLP – computer science bibliography [10].

Our approach is based on OpenAlex [18, 9] but this information can be obtained from most bibliographic databases [13, 11]. OpenAlex indexes more than twice as many scholarly works as the leading proprietary products and the entirety of the knowledge graph and its source code are openly licensed and freely available through data snapshots, an easy-to-use API, and a nascent user interface.

OpenAlex is based on 7 types of units (entities): **W**(ork), **A**(uthor), **S**(ource), **I**(nstitution), **C**(oncept), **P**(ublisher), or **F**(under) (and some additional ones such as topics, keywords, countries, continents, languages, etc.). Each unit gets its OpenAlex ID – we assume that the identification problem is solved by the database.

The simplest use of OpenAlex is through its web interface (service) https://openalex.org/ or using a direct URL request in the browser URL line. For example

- Author's name: search the OpenAlex web service
- Known author ID: URL https://openalex.org/A5001676164
- Work with DOI: URL https://api.openalex.org/works/https://doi.org/10.1007/s11192-012-0940-1
- Known work ID: URL https://openalex.org/W2083084326
- Name of the institution: search the Openalex Web service
- Known institution ID: URL https://openalex.org/institutions/I4210106342

This way, the OpenAlex web interface provides basic inspections of the selected unit. For example, by including a link with our OpenAlex author ID on our web page we get a report on our publications. Similarly, we get the report on the publication activity of the selected institution.

3.1 API

An application programming interface (API) is a way for two or more computer programs or components to communicate with each other. It is a type of software interface, offering a service to other pieces of software [21]. In our case, API enables us to use the database data from our programs. An R package supporting the use of OpenAlex is `openalexR` [1].

The OpenAlex API is available at https://api.openalex.org. Its response is returned in JSON format. Here is an R code using the OpenAlex API for the IMFM institution search

```
setwd(wdir <- "C:/work/OpenAlex/API")
library(httr); library(jsonlite)
res <- GET("https://api.openalex.org/institutions",
    query = list(search="imfm"))
str(res)
cont <- fromJSON(rawToChar(res$content))
names(cont); str(cont)
```

The response data are available in the variable `cont`. Similarly, the API can be used also from other programming languages.

The OpenAlex query can be composed of different components. Using **search** we can search for a given search text across titles, abstracts, and full-text. Using a **filter** we can limit our search to units satisfying given conditions. Using **select** we can select data fields that will appear in results. The query can be further controlled by some parameters. For example

```
wd <- GET("https://api.openalex.org/works",
  query = list(
    search="handball",
    filter="publication_year:2015",
    select="id,title",
    page="2", per_page="200"))
names(wd)
wc <- fromJSON(rawToChar(wd$content)); names(wc)
names(wc$meta); wc$meta$count; str(wc$results)
```

returns the second page (with up to 200 entries) on works on handball published in the year 2015. Only information about works ID and title is returned.

The OpenAlex API uses paging – the list data are provided by pages. The **basic paging** (up to 10 000 units) is based on two parameters `page` and `per_page`). The **cursor paging** is a bit more complicated than basic paging, but it allows us to access as many records as we like.

4 A collection of bibliographic networks

We developed an R package `OpenAlex2Pajek` to support the creation of bibliographic networks from OpenAlex [4]. We get a collection of bibliographic networks (citation network **Cite**, authorship network **WA**, sources network **WJ**, keywords network **WK**, countries network **WC**), some partitions and vectors (properties of nodes) (publication year, type of publication, language of publication, cited by count, countries distinct count, referenced works, and additionally two files containing names of works `xyzW.nam` and names of authors `xyzA.nam`. Most acquired networks are 2-mode – they link units of two different types; an ordinary or 1-mode network links units of the same type.

Currently, `OpenAlex2Pajek` contains three main functions `OpenAlex2PajekCite`, `OpenAlex2PajekAll`, and `coAuthorship`.

We split the process of creating the collection of bibliographic networks into two parts:

- determining the set W of relevant works using the **saturation approach** [7, page 506],
- creation of the network collection for the works from W.

The set W is determined iteratively using the function `OpenAlex-2PajekCite` and the collection is finally created using the function `OpenAlex2PajekAll`.

The function `coAuthorship` creates a weighted temporal network describing the co-authorship between world countries in selected time intervals. The weight of an edge is the number of works co-authored by authors from the linked countries.

In an analysis of weighted networks, the 1-neighbor skeleton is often used to get an overall insight into the network's basic structure. In the 1-neighbor skeleton, only its strongest link is kept for each node. The resulting directed network is forest-like. Non-trivial connected components in 1-neighbor skeletons are (usually) directed trees with a pair of nodes linked in both directions with the largest weight in the tree – these two arcs are usually replaced by an edge (undirected link). In Figure 2 the 1-neighbor skeletons for years 1990, 1995, 2000, 2010, 2015, and 2020 are presented. We see that the number of isolated nodes (countries not collaborating with other countries) is decreasing. In all analyzed years the US has a leading (hub) position. In the years 1990, 1995, 2000, and 2010 the edge in the main component links US and GB but in the years 2015 and 2020 GB is replaced by CN. In 1990, stronger secondary hubs were GB, FR, RU, JP, and DE. In the following years, some other countries SE, ES, AU, CN, BR, ZA, and IN (BRICS) became secondary hubs attracting previously non collaborating countries or geographically or linguistically close countries.

Most of the ingredients of basic reports are counters, sorted lists, (weighted) degrees and their distributions obtained from an adequate network. Sometimes also the time is considered producing time series.

An important property of a collection of bibliographic networks is that some of them are compatible – they share a common set (most often the set of works W). This allows us to use network multiplication (defined by the product of network matrices) to compute the corresponding derived network connecting the remaining two sets [5]. For example, in the derived network $\mathbf{AK} = \mathbf{WA}^T \cdot \mathbf{WK}$ its entry $AK[a,k]$ tells us in how many works the author a used the keyword k. Similarly, in the derived network $\mathbf{ACiK} = \mathbf{WA}^T \cdot \mathbf{Cite} \cdot \mathbf{WK}$ its entry $ACiK[a,k]$ tells us how many times the author a cited works described by the keyword k.

A 2-mode network is always compatible with its transpose (on both sets). The corresponding derived networks are called projections – the row projection $\mathrm{row}(\mathbf{WA}) = \mathbf{WA} \cdot \mathbf{WA}^T$ and the column projection $\mathrm{col}(\mathbf{WA}) = \mathbf{WA}^T \cdot \mathbf{WA}$. Both projections are ordinary weighted 1-mode networks that can be analyzed using standard network analysis methods.

For the authorship network **WA** its column projection $\mathbf{Co} = \mathbf{WA}^T \cdot \mathbf{WA}$ is the co-authorship network. Its entry $Co[a,b]$ counts the number of works that authors a and b co-authored. It turns out that a work with k co-authors contributes k^2 links to the co-authorship network – works with a large number of co-authors are overrepresented in it. To treat all authors equally the fractional approach is used [3]. In Figure 1 the largest co-authorship groups at level 10 at the University of Primorska are presented – connected components of the link cut at level 10 in the network **Co**. Each pair of linked authors co-authored at least 10 works

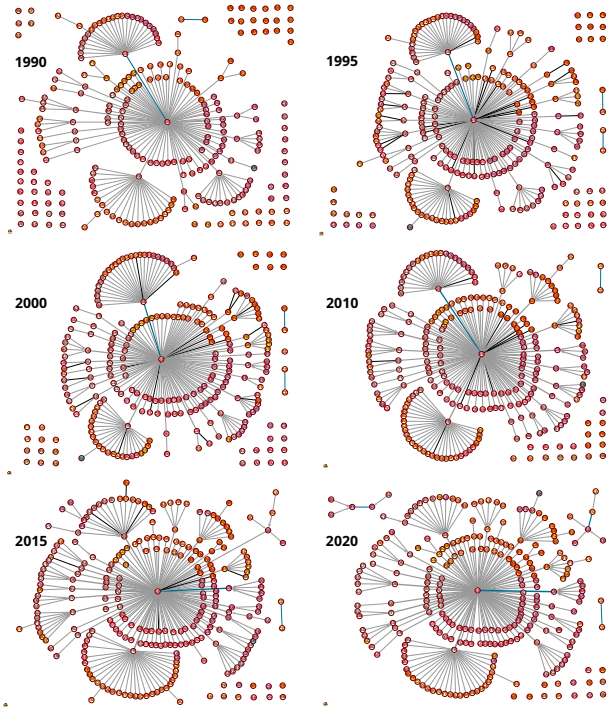

Figure 2: 1-neighbors skeletons of world co-authorship for selected years.

in the bibliography of works with at least one co-author from University of Primorska.

In bibliometric analysis, the citation network **Cite** has a very important role. It collects "votes" about the relevance of previous works for a given work. It is often used for solving the network boundary problem, and also for identifying the most relevant works in the collected bibliography [2, 6]. The derived network $\mathbf{ACiA} = \mathbf{WA}^T \cdot \mathbf{Cite} \cdot \mathbf{WA}$ describes the citations between authors – its entry $ACiA[a,b]$ counts the number of times author a cited author b. The co-citation network is defined as the column projection of the citation network $\mathbf{coCi} = \mathrm{col}(\mathbf{Ci}) = \mathbf{Ci}^T \cdot \mathbf{Ci}$ and the bibliographic coupling network is defined as the row projection of the citation network $\mathbf{biCo} = \mathrm{row}(\mathbf{Ci}) = \mathbf{Ci} \cdot \mathbf{Ci}^T$.

The idea of derived networks can be extended to temporal bibliographic networks [8]. Using derived networks we enlarge the source for different statistics. Additional insight can be gained by analyzing the structure of networks and identifying important subnetworks in them [6].

In the following, we present an overview of typical report ingredients [7, 15]. Because of limited available space, we decided to put examples on Github/bavla.

5 Report ingredients

5.1 Statistics

Because the analyzed networks are often large a complete presentation is not an option. To describe them we use different statistical descriptors.

- sizes of sets (number of nodes, number of links); structural network properties (number of components, size of the largest component, etc.)
- top units – ordered lists of units with the largest values of selected property (degre, weighted degree, link weight,

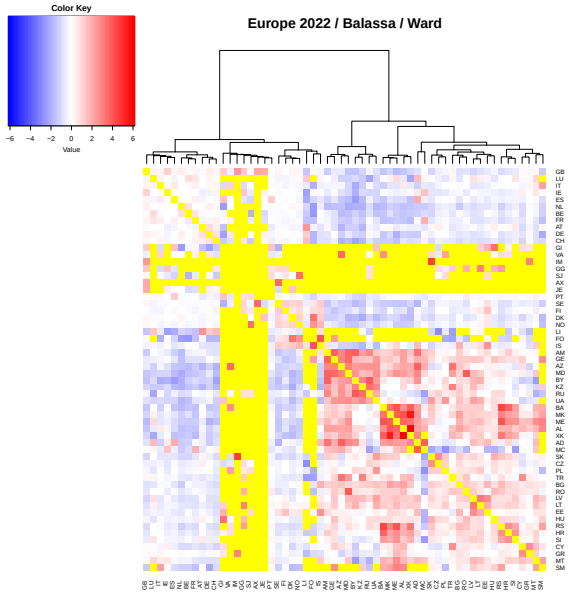

Figure 3: Balassa EU co-authorship for the year 2022.

- distribution of selected property
- time series describing temporal changes of selected properties
- scatter plots showing a possible relationship between two selected properties

Often bibliometric properties of units follow laws such as Zipf (or power) law, Bradford law, Lotka law, lognormal distribution, Hirsch index, etc.

5.2 Network analysis

Derived networks are weighted. To get readable results of reasonable size we usually search for important subnetworks, often a kind of skeleton – from a given network less important elements are removed. There are different types of skeletons (spanning forest, k closest neighbors, cuts, cores, islands, etc. [6]).

A traditional graph-based visualization is used if the obtained result network is not dense. For denser networks, the matrix display is much more readable. In a matrix display, the permutation of nodes (usually obtained by clustering) can create patterns that reveal the network's internal structure.

Figure 3 presents a matrix display of Balassa co-authorship indices between European countries in 2022 (yellow cell – no link, red/blue cell – above/below expectation) [17].

5.3 Special algorithms

Some properties can require special computational procedures and direct access to the bibliographic data. In such cases, open access to the bibliographic database is of crucial importance.

5.4 Reports

The results of analyses can be combined and presented to users in different forms:

- Booklet report (in PDF).
- (Service generated) web pages.
- Dashboards.
- Dataset (JSON, CSV, etc.).

6 Conclusions

We have presented an approach to support higher-order bibliographic services based on networks. Open access to high-quality bibliographic data is crucial for the faster development of such services. The new bibliographic database OpenAlex seems to be a step in the right direction. It needs the support of science policy and also of individual scientists (checking the correctness of their data).

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The computational work reported in this paper was performed using a collection of R functions OpenAlex2Pajek and the program Pajek for analysis of large networks. Code, data, and figures are available on Github/Bavla/OpenAlex.

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Are papers all that counts? A bibliometric analysis of the Slovenian scientific community

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Abstract

We conduct a bibliometric analysis of the Slovenian science by scraping the data from Slovenian current research information system (SICRIS) and using it to build a knowledge graph, representing a network of all Slovenian scientific fields and a large majority of Slovenian researchers. By analyzing this network using different graph measures, we obtain valuable insights into the connections between different scientific fields and researchers in Slovenian science. Additionally, we show the importance of graph measures as measures of scientific excellence, since they measure very different aspects of scientific success than the traditional citation metrics.

Keywords

bibliometrics, Slovenian scientific community, knowledge graphs

1 Introduction

With the growth and diversification of the scientific enterprise, obtaining empirical evidence on the research process is crucial for enhancing its efficiency and reliability. Meta-research and bibliometrics are developing scientific disciplines, seeking to analyse, evaluate and refine research practices, and several studies have focused on the analysis of the global scientific endeavour, e.g., identifying most prominent scientists and fields [7]. These studies also focus on the problem of how to properly rank scientific excellence and scientific outputs in general, warning that one should not rely on just a few metrics to obtain a comprehensive picture of the actual impact a specific scientist has [8].

Until now, very few studies have tackled the analysis of scientific ventures at national level, and to our knowledge, there has been no study covering the Slovenian scientific landscape specifically. This kind of research is nevertheless important and could potentially influence policies that would improve scientific production and enable effective distribution of research funds and resources.

In this study, we try to address the identified research gaps by 1.) drawing the map of Slovenian scientific research that would enable proper decision making and policy formulation, and 2.) proposing new metrics of scientific excellence that would allow us to obtain a more complete view of the impact a scientist or a discipline as a whole has. More specifically, our contributions are the following:

- Using the collected data about the Slovenian scientists and their projects, covering different scientific fields and a large majority of researchers working in Slovenian science, we conduct a graph analysis of connections between different fields and researchers. By drawing a comprehensive map of connections between actors and fields, we identify the most important researchers and scientific fields that connect others and play a vital role in the Slovenian scientific ecosystem.
- We created a new ranked list of Slovenian scientists according to graph based metrics, which were not available in any of the previous analyses or databases. We argue that these metrics measure the importance of a role that a specific scientist has in a research community, i.e., their influence which allows them to act as a bridge or a hub connecting scientists from different fields.

2 Related work

Studies in bibliometrics (see [4] for a comprehensive survey of techniques used for measuring scientific excellence) have recently gained traction in parallel with the success of the scientific enterprise, which has grown in both size and diversity, and with the availability of data. According to Ioannidis et al. [7], research on research is becoming important due to the mounting evidence suggesting an alarming drop in reproducibility of research findings, the growing inefficiency of the scientific process, and the fact that the number of false positives in the literature is exceedingly high. To address these problems, they propose a meta-research divided into five main categories that should be studied: methods, reporting, reproducibility, evaluation, and incentives. Studying these five areas would correspondingly allow for five distinct insights into how to perform, communicate, verify, evaluate, and reward research.

Recently, several studies also tackled the problem of how to properly rank scientist and scientific outputs in general. For example, Ioannidis et al. [8] addressed the increasing prevalence of multiauthorship observed in several fields and how this phenomenon affects the effectiveness of the informativeness of citation metrics. They also explored how sensitive the indicators are to self-citation and alphabetic ordering of authors. They concluded that multiple indicators should be used for ranking, as a composite of different metrics gives a more comprehensive picture of the actual impact that a specific scientist has. They also acknowledged that no single or composite citation indicator can be expected to select all the best scientists.

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Several studies employed graph-based metrics to enrich the assessment of bibliometric analysis [4, 1]. Network metrics such as degree of centrality, betweenness centrality, eigenvector centrality, closeness centrality, and PageRank were used to pinpoint the relative importance of research constituents (i.e., researchers and institution), which may not necessarily be reflected just through publications. In a large majority of cases, these metrics were calculated on co-authorship graphs.

The studies that would cover Slovenian scientific environment are very scarce. In fact, we are aware of just one, the study by [2], where they claim that research performance is highly dependent on the conditions of (national) research environments. They focus on analyzing research activity in six eastern European countries, namely Croatia, Estonia, Hungary, Latvia, Lithuania, and Slovenia, and try to determine and compare the effectiveness of research in a specific country by obtaining the number of articles belonging to the most cited 10% and the most cited 1% articles in the corresponding subject area and publication year for each country. Their empirical analysis addresses three levels: cross-country, cross-institution, and cross-researcher comparison. The study concludes that Hungary is the country with the highest output, followed by Croatia and then Slovenia, when it comes to the number of influential articles published.

3 Methodology

In this section, we describe our methodology, namely 1.) how we gather the data and 2.) how we analyze these data to obtain a map of the Slovenian scientific community.

3.1 Data Retrieval

Data were retrieved from the Slovenian Current Research Information System (SICRIS) website[1], which lists more than 35,000 researchers working in Slovenian research institutions. Data collection from the SICRIS website proved challenging, as information about a specific researcher can only be obtained by scraping his/her Web page on SICRIS. This required finding a solution to quickly retrieve data from more than 35,000 different pages, and to achieve this, we used the Python Asyncio[2] and BeautifulSoup[3] libraries, which allow the asynchronous connection to several dozen pages simultaneously and extraction of the required data.

Since the script sometimes took several seconds to connect to a specific page, which could quickly accumulate, resulting in considerable overall slowdowns, we optimized the procedure and identified potential slowdowns. Our proposed solution was to implement a strategy that involved canceling the connection and adding the URL to a list whenever a page failed to connect within a 0.5-second time frame. This timeframe was chosen after several trials and was found to be the best compromise. Once all pages had been visited, we repeatedly tried to reconnect to the URLs on this list until it was empty. This change significantly reduced the time required to retrieve all our data. Once all the data was retrieved, we used the Pandas library[2] for data manipulation, which allowed us to export the results into Excel spreadsheets, appropriate for further processing.

From SICRIS, we extracted research areas for each scientist and various bibliometric indicators of their impact, namely A", A', A1/2, citation metrics based on a quantitative assessment of publications in exceptional, high quality and important venues, respectively. We also extracted the A1 metric, which represents a weighted sum of these three metrics, a CI10 metric measuring the number of pure citations of scientific work in the last 10 years, the CImax metric measuring the number of citations in the most cited work, and the h10 metric representing the h-index in the last ten years. Furthermore, we extracted the SICRIS points, a conglomerate metric combing several distinct metrics mentioned above, and the A3 metric, which measures the amount of funds a specific researcher received for his research activity outside of the Slovenian National Research Agency (ARIS).

Finally, the SICRIS database also contains information on projects financed by the Slovenian national research agency in which a specific researcher participated. Scraping this information provided us with an important insight into collaborations between different scientists and fields, allowing us to build collaboration graphs, calculate several graph-based ranking criteria and draw the map of the Slovenian scientific community.

3.2 Methods

Once the data was obtained, we conduct two distinct analysis steps, namely 1.) graph construction and analysis, and 2.) correlation analysis

3.2.1 Graph construction and analysis. To construct the necessary graphs, we used the Python NetworkX library [6]. Using the data from SICRIS, which contain information about project collaboration, we created an undirected graph as follows: all researchers who participated in at least one project are represented by a node, and nodes of researchers who worked together on a project are connected by weighted edges, in which the weights represent the number of shared projects. By removing the isolated nodes, we ended up with a graph with a total of 20,012 nodes and 618,871 edges.

In the next step, we apply several graph statistics and measures in order to obtain several node rankings, each of them measuring a different aspect of the importance a specific node (i.e., a researcher) has in the graph. More specifically, we calculate PageRank (PR), Betweenness centrality (BC), and Eigenvector centrality (EC) measures.

In the context of our graph, the **PageRank** [3] algorithm is applied to evaluate the influence of researchers within the collaboration network. Thus, researchers who are strongly connected to other researchers, who also have many connections (i.e, the so-called hubs in the graph), will have a higher PR score, reflecting their importance and influence in the Slovenian research community. On the other hand, the **Betweenness Centrality** [5] measure evaluates the role of each researcher as an intermediary or a bridge between other researchers. This measure is based on the idea that researchers who are on many collaboration paths between other researchers are considered central and influential in the network. In our contexts, it helps to better understand the structure of the collaboration network among researchers. Researchers with high BC are those who play a crucial role in creating links between different subgroups of researchers and interdisciplinary connections. In practical terms, BC evaluates the number of times a researcher is traversed by the shortest paths connecting other researchers in the network. Thus, researchers who are frequently used as pathways for collaboration among their peers obtain higher BC scores.

[1] https://cris.cobiss.net/ecris/si/en
[2] https://docs.python.org/3/library/asyncio.html
[3] https://www.crummy.com/software/BeautifulSoup
[2] https://pandas.pydata.org/

[1] https://networkx.org/

Another graph centrality measure that we applied to the created graph is the **Eigenvector centrality** [9]. This measure evaluates the influence of a researcher taking into account both the quality and the quantity of connections. EC assigns more weight to connections that include influential researchers. Thus, a researcher connected to influential researchers will be assigned a high score, reflecting potentially greater influence within the network. This measure helps to detect researchers who, even with fewer direct connections, occupy strategic positions in the collaboration network. While this may seem similar to the PR algorithm, there are some differences. Unlike PR, which primarily focuses on the popularity of links, Eigenvector centrality also takes into account the quality of connections. This means that even if a researcher does not have a large number of direct connections, if they are connected to influential researchers, their Eigenvector centrality score can be high. In summary, while both measures aim to evaluate the influence of researchers in a network, they do so through slightly different approaches, thus offering complementary perspectives for analyzing the structure and importance of actors within the collaboration network.

Our second important area of focus in our research is the collaboration between different fields. To build a graph that would represent interdisciplinary collaboration between fields, we grouped all researchers from the same field into a single node, representing an entire field, i.e., we obtain a node for each scientific field found on SICRIS. Similar to the previous graph, edges and their weights represent collaborations on a project between researchers in the linked fields.

3.2.2 Correlation analysis. In order to better understand the metrics from SICRIS and to evaluate the relevance of our scores, we deemed it pertinent to explore the correlation between all our data. This analysis has two main purposes. First, we aim to test the **hypothesis 1** that the new graph ranking we presented, measure different aspects of scientific excellence than the more established measures based on number of citations or publications available on the SICRIS web page. This hypothesis would be deemed correct if one-on-one correlations scores between the newly proposed graph measures and other measures would be low, and incorrect if correlations would be high.

Additionally, we wish to explore the correlation between the established measures available on the SICRIS web page. More specifically, we wish to test the **hypothesis 2** that these measures are strongly correlated, which would indicate that they essentially all measure a very similar aspect of scientific excellence, which is problematic. In order to obtain one-on-one correlations between all measures, we calculate the Spearman correlation coefficient among all of them and then display it through a heatmap.

4 Results

In Table 1, we present some of the results of the graph analysis conducted on the graph of nodes representing researchers, connected by edges representing project collaborations. More specifically, we present 10 best ranked researchers in the SICRIS dataset according to the average between ranks of the three newly proposed graph-based measures, their declared scientific fields, and their ranking (i.e., lower is better) according to the SICRIS points, BC, EC and PR measures.

Note that while the table does contain some highly ranked researchers according to the SICRIS points (e.g., Dr. Sašo Džeroski is ranked as 33rd out of roughly 20K researchers according to this criteria), several researchers in the table are ranked relatively low according to SICRIS points (e.g., the best ranked researcher according to our novel three measures, Dr. Branimir Leskošek, is ranked as 5731th according to the SICRIS points). This finding supports **hypothesis 1** that the proposed new measures measure different aspects of scientific excellence than the more established citation measures. Another important observation is that 7 out of 10 best ranked scientists appear to be active in two fields. This might suggest that they are (or have been) involved in several interdisciplinary projects, which could have a positive influence on the newly proposed graph-based metrics.

In Figure 1, we present the heatmap of the correlations between the different metrics extracted from SICRIS website and the newly proposed graph-based metrics. We observe a strong correlation between PR and BC, 0.7, which might suggest that researchers who collaborate with a wide range of colleagues from different fields are more likely to work with the most important ones.

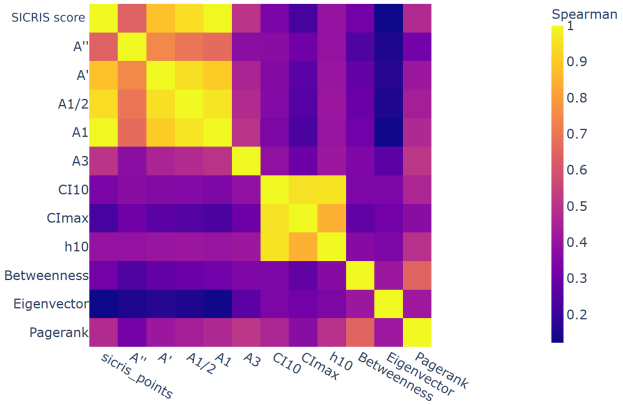

Figure 1: Heatmap of the Spearman correlation among metrics.

We also observe very strong correlations in the top left corner of the heatmap. While a strong correlation was expected, as A", A', A1/2 and A1 are all scores based on the number of publications (in venues of different qualities), the almost perfec correlation between the SICRIS points and A1 (which suggest they measure exactly the same aspect of the scientific impact) is surprising. This finding supports **hypothesis 2** that the current SICRIS measures all measure a very similar aspect of scientific excellence. On the other hand, there is no strong correlation between any of the newly proposed graph-based metrics and metrics extracted from the SICRIS website.

In Table 2, we present the results of our study of interdisciplinary collaboration between different scientific fields. The graph metrics were obtained from a graph of nodes representing fields and edges representing interdisciplinary project collaborations. Note that the field of Computer science and informatics ranks first according to all the criteria. On the other hand, most interdisciplinary collaborations are conducted by the researchers from the field of Chemistry, which ranked as third according to the average (AVG) between the ranks of three graph-based metrics, PG, BC and EV.

5 Conclusions

The graph based bibliometric analysis of the Slovenian scientific community shows that current citations based metrics do not cover some aspects of scientific excellence, such as researcher's

Table 1: 10 best ranked researchers in the SICRIS dataset according to the average between ranks of the three newly proposed measures, BC, EC and PR. We do not show metric scores, but ranks according to scores (i.e., lower value is better).

Researcher	Field 1	Field 2	SICRIS points	BC	EC	PR	AVG
15355 PhD Branimir Leskosek	Public health (occupational safety)	Computer science and informatics	5731	8	4	31	14
06013 PhD Damjana Rozman	Biochemistry and molecular biology	Metabolic and hormonal disorders	704	21	2	33	18
11279 PhD Nives Ogrinc	Control and care of the environment	Animal production	182	7	50	3	20
27733 PhD Tina Kosjek	Control and care of the environment	Pharmacy	809	2	73	9	28
22459 PhD Tadeja Rezen	Neurobiology	Microbiology and immunology	1837	61	3	49	37
22621 PhD Polonca Ferk	Metabolic and hormonal disorders	Pharmacy	5059	13	8	103	41
12688 PhD Kristina Gruden	Biotechnology	/	219	44	139	6	63
08800 PhD Gregor Sersa	Oncology	/	71	3	185	1	63
12315 PhD Ester Heath	Control and care of the environment	Chemistry	208	62	115	23	66
11130 PhD Šašo Dzeroski	Computer science and informatics	/	33	1	195	20	72

Table 2: Scientific fields as defined in the SICRIS database, sorted according to the average (AVG) between the ranks (lower score is better) of three graph-based metrics, PG, BC and EV.

Rank	Field	Collaborations	PR	EC	BC	AVG	Rank	Field	Collaborations	PR	EC	BC	AVG
1	Computer science and informatics	81248	1	1	1	1.0	36	Textile and leather	21080	27	41	39	35.67
2	Materials science and technology	88934	4	3	4	3.67	37	Animal production	34982	29	29	50	36.0
3	Chemistry	101139	2	2	12	5.33	38	Political science	13598	46	37	27	36.67
4	Control and care of the environment	52648	5	8	9	7.33	39	Anthropology	9860	53	36	24	37.67
5	Physics	50010	3	9	14	8.67	40	Ethnology	6698	65	39	11	38.33
6	Plant production	74535	6	6	16	9.33	41	Cardiovascular system	20793	28	43	45	38.67
7	Systems and cybernetics	45584	7	10	23	13.33	42	Telecommunications	14068	41	45	31	39.0
8	Biology	58879	12	7	21	13.33	43	Veterinarian medicine	30954	32	34	60	42.0
9	Civil engineering	36466	22	13	6	13.67	44	Metabolic and hormonal disorders	18518	30	46	55	43.67
10	Biochemistry and molecular biology	79725	11	5	25	13.67	45	Metrology	12978	34	52	47	44.33
11	Neurobiology	45680	14	12	19	15.0	46	Law	7480	54	49	32	45.0
12	Biotechnology	87261	8	4	33	15.0	47	Psychology	8583	51	55	29	45.0
13	Interdisciplinary research	22946	9	33	5	15.67	48	Human reproduction	21535	35	42	58	45.0
14	Public health (occupational safety)	30400	10	25	13	16.0	49	Process engineering	15340	36	47	53	45.33
15	Educational studies	23518	33	15	3	17.0	50	Hydrology	12396	40	53	44	45.67
16	Mathematics	30680	17	20	20	19.0	51	Architecture and Design	4242	58	57	22	45.67
17	Manufacturing technologies and systems	38874	18	14	26	19.33	52	Philosophy	7380	57	44	43	48.0
18	Forestry, wood and paper technology	30620	19	28	15	20.67	53	Sport	10013	43	54	49	48.67
19	Geography	18555	39	23	2	21.33	54	Geodesy	7760	45	56	51	50.67
20	Economics	26891	31	16	18	21.67	55	Electric devices	13633	42	51	59	50.67
21	Microbiology and immunology	54175	16	11	42	23.0	56	Literary sciences	6399	61	50	48	53.0
22	Sociology	19922	44	17	10	23.67	57	Traffic systems	4448	48	60	52	53.33
23	Pharmacy	41125	15	18	41	24.67	58	Culturology	7240	60	48	54	54.0
24	Linguistics	18176	49	19	7	25.0	59	Technology driven physics	6876	47	59	64	56.67
25	Chemical engineering	33753	13	27	38	26.0	60	Communications technology	4388	52	63	56	57.0
26	Energy engineering	32762	23	21	40	28.0	61	Psychiatry	2481	55	65	61	60.33
27	Computer intensive methods and applications	26942	20	32	34	28.67	62	Criminology and social work	2324	66	62	62	63.33
28	Mechanics	26444	24	31	36	30.33	63	Mining and geotechnology	2342	59	68	63	63.33
29	Oncology	37101	21	24	46	30.33	64	Theology	2941	67	58	66	63.67
30	Geology	26961	37	26	28	30.33	65	Ethnic studies	2398	63	61	67	63.67
31	Electronic components and technologies	28858	26	30	37	31.0	66	Art history	1408	70	64	57	63.67
32	Historiography	12390	56	22	17	31.67	67	Archaeology	1177	68	66	65	66.33
33	Urbanism	8669	50	40	8	32.67	68	Information science and librarianship	792	62	70	70	67.33
34	Mechanical design	22352	25	38	35	32.67	69	Stomatology	391	64	71	68	67.67
35	Administrative and organisational sciences	18563	38	35	30	34.33	70	Landscape design	1046	69	67	71	69.0
							71	Musicology	748	71	69	69	69.67

role of connecting a wider research community. Our correlation analysis indicates that existing measures of scientific excellence extracted from the SICRIS web page are strongly correlated. In the future, we plan to expand this analysis to also measure the impact of Slovenian scientists on the global scientific enterprise and conduct additional research to try to find certain patterns across disciplines, or institutions.

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Empowering Open Education Methodologies with AI-based Strategies for the Customization of Education

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ABSTRACT

The amount and heterogeneity of data generated in the context of education allied to the rapid progress of scientific research and technological development have created vast amounts of data, much of it open data, but significant challenges to gathering, filtering and making sense of this information. In this paper, we discuss the research outcomes of complementary Artificial Intelligence (AI)-based strategies monitoring and enhancing Open Education, mining online forum interaction student-educator, and empowering mentorship of educators. Firstly, the initial results obtained from the construction of an Observatory focusing Open Education Resources (OERs), contribute to implement 2019 UNESCO OER Recommendation and advance the Education-focused Sustainable Development Goal (SDG) 4. It is acting on five verticals, enriching and treating multilingual data, it displays meaningful information on a dashboard focused on AI and OERs and serving as a collaboration platform focused on existing partnerships within the international research centre on AI under the auspices of UNESCO (IRCAI), the UNESCO Chair in Distance Education and the UNESCO Chair on Open Technologies for Open Educational Resources and Open Learning, mobilizing research collaboration on key AI research challenges relating to generating knowledge about OER. Secondly, we will discuss the recent development of an Educational Recommender System (ERS) that integrates Conversational Analysis (CA) to assess and enhance collaborative learning (CL) in Virtual Learning Environments (VLEs). This novel system was designed to identify collaboration among students and provide tailored recommendations to promote participation and interaction within discussion forums. Finally, we will discuss the development and implementation of AI and OERs in alignment with SDGs, addressing topics of significant social impact over an international online mentoring initiative.

KEYWORDS

Open Education, Machine Learning, Educational Recommender System, Conversational Analysis, Virtual Learning Environment

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1 Introduction

The centralizing piece of the discussions in this paper is an AI-based observatory that allows to explore OER-related topics, particularly those mentioned in the OER Recommendation: promoting OER and acknowledging it's contribution to advancing quality education while providing information on advances focused on the equity and inclusion qualities of OER, as well as on research, activities, projects and news related to OER development, including new initiatives and projects while also promoting public infrastructures for education. The OER Observatory builds on the content made available in UNESCO's OER Dynamic Coalition Portal (oerdynamiccoalition.org) providing the user with access to any of the four proposed views: media; science; policies and training. In each of the views, the user can access interactive data visualisation summarising the sourced data configured to observe the UNESCO OER recommendations. As it is fully based on open data, it allows the user to click on the resources collected and summarized, being taken directly to the source in media, journal, policy or training.

Embracing the intersection of AI and education, which has led to the development of various tools that personalize and enhance learning experiences, we discuss a complementary research based on CA much aligned with the objective of empowering Community interaction at the SDG 4 (Education) Observatory [6]. AI applications in education often focus on providing adaptive feedback, facilitating personalized learning paths, and analyzing student data to improve outcomes. CA is a method that examines the understanding generated through interactions, offering a framework for analyzing how students collaboratively build knowledge. By combining CA with AI, this research aims to develop a system that not only assesses but also actively promotes collaboration in VLEs [10]. The ERS discussed later in this paper, is an example of how IRCAI's SDG4 Observatory gains a complex capability towards the engagement with communities such as in Education. This discussion then expands towards the appropriate mentorship of the professionals that will change the domain's landscape. While initiatives in this context are diverse and disperse, the authors are not aware of existing similar approaches [5].

2 AI-based strategies for the moderation of online forums on education

Entering the age of Big Data, AI is feeding the data-driven digital transformation across industries including Education. CL emphasizes the importance of group tasks and joint participation, wherein students learn by actively engaging in dialogues that facilitate the sharing of ideas and information. Even in remote settings, CL enables students to learn together through virtual platforms. AI offers new opportunities as a pedagogical tool, providing adaptive and personalized environments that can support CL. This research explores the integration of AI into educational contexts, particularly through the development of an Educational Recommender System (ERS) that uses CA to identify and promote collaboration among students in VLEs [1] (see Figure 1).

Figure 1: The ERS forum analysis screen

The research methodology is divided into three key stages: *Conversational Analysis*, applying CA to monitor discussion forums within the Moodle platform, focusing on interactions among students, identifying collaborative behaviors and interaction patterns; *Collaboration Assessment***,** evaluating the level of collaboration among students based on identified interaction patterns; and *Development of ERS*, building a mechanism that provides recommendations to students, teachers, and tutors. These recommendations are aimed at enhancing collaboration and are based on the analysis of forum interactions [15]. The initial dataset comprises 20,976 messages of Moodle discussion forums, with 15,703 posted by students from a vocational education school. The analysis focuses on these messages to develop and validate the ERS's recommendations. The quality of collaboration is measured through various indicators, which are extracted during different stages of CA. *Preprocessing* applies techniques of Natural Language Processing (NLP) to ensure the accuracy of the analysis, preparing data for the *Resource Processing* stage using Social Network Analysis (SNA) to characterize social dynamics and interactions among students. Moreover, the *Message Attribute Identification* is the CA stage that allows identifying characteristics of students' messages, , specifically their questions, and then *Topic Modeling* is employed to identify key terms discussed in the forums [12], using Tomotopy library (bab2min.github.io/tomotopy) The ERS was tested across five experimental cycles in different classes at two Brazilian Federal Institutes , in a Portuguese language context. The results indicated a positive impact on student learning, with 82% of participants acknowledging the relevance of the recommendations. The system motivated increased participation and collaboration, with a notable trend of students writing more and systematically organizing their ideas in forum posts. Additionally, 90% of students engaged in other activities proposed by their teachers, demonstrating the effectiveness of the recommendations. The results also demonstrate the system's effectiveness in fostering collaboration, with positive feedback from students and educators. A dashboard was developed for teachers, containing graphs including one that shows the main terms discussed in the forum by analysis, in which each edge represents a message from the student with two of these terms, and the nodes in blue highlight the new terms that emerged in relation to the previous analysis (see Figure 2).

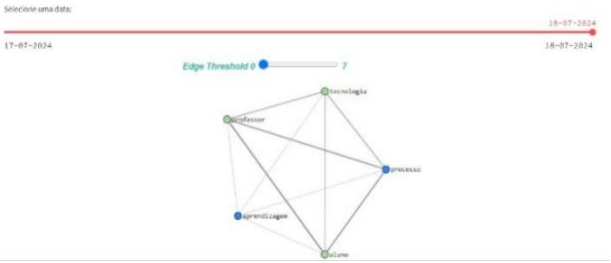

Figure 2: Visual analysis of students' collaboration in a discussion forum where nodes represent actors in the discussion (students/educators) and edges represent interactions.

The development of the ERS represents a significant advancement in promoting collaborative learning in educational settings [6,7]. By integrating CA into the system, the ERS effectively identifies and enhances collaboration among students. The current implementation of this ERS aims to provide personalized recommendations to students, teachers, and tutors, fostering a more interactive and collaborative learning environment [6]. Future work will explore the integration of additional features, such as *wikification* and visualization tools, to further enhance the system's capabilities. Furthermore, the research will benefit from the semi-automatic categorization of educational resources of a range of formats, including videos as in [3].

3 An AI-based Observatory to Assess the Impact of OER Worldwide

Although the abundance of information available online, some of which is labeled as education-related, it is harder and harder to find the appropriate resources that can serve education either at an undergraduate or a professional training level. IRCAI's Open Education Observatory is an initiative dedicated to monitoring, analyzing, and promoting the use of OERs globally. It serves as a hub for research insight and fomenting collaboration, providing valuable insights and data on the

adoption, impact, and trends of OER in education systems worldwide. The observatory supports educators, policymakers, and institutions in leveraging open resources to enhance teaching and learning. It is designed to support government and institutional decision-makers dedicated to promoting the goals of the 2019 UNESCO OER Recommendation, which is centred on OER but generally promotes the ideals of Open Education (see Figure 3).

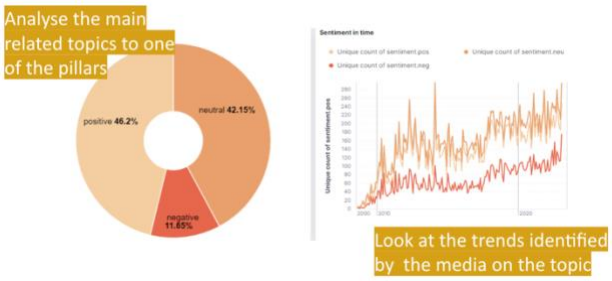

Figure 3: Dashboard of visual modules to analyse the most relevant topics under a certain domain or SDG, and the trends that can direct the education actors preparedness

The Open Education Observatory ingests a range of different data sources with heterogeneous nature and different frequency: (i) worldwide news in almost real-time providing information from a vast catalogue of multilingual world news, captured in more than 60 languages and based on a variety of *wikidata* concepts; (ii) published scientific articles, including journal and conference papers, mostly peer-reviewed, covering over more than 126 million articles with yearly updates; (iii) OER policies from the OER Policy Hub (www.oepolicyhub.org) that needs to be input into the OER DC Portal; subsequent extraction and enrichment of metadata; preparation of dashboard related to dashboard based on filters over the metadata, as well as OECD policies data and metadata on AI and Education with yearly updates; (iv) lectures and videos selected and filtered on content from Videolectures.net [10] resources related to OER; (v) a snippet of worldwide public and private initiatives related to AI and SDG 4 captured by IRCAI's Top100 and related actions; and (iv) a range of worldwide indices with yearly updates on Education-related topics such as the percentage of children out of school, or the literacy rate in youth and adults (see Figure 4).

To ensure that content is readily available for each focus area, materials from the mentioned sources are categorized by relevant keywords and concepts closely associated with the five key areas of the Recommendation. This organization allows users to easily filter and access content based on their specific interests within these areas. By doing so, users can tailor their exploration of resources to match their focus, whether it's capacity building, supportive policy development, leveraging equitable access provided by OER, sustainability models, or international cooperation.

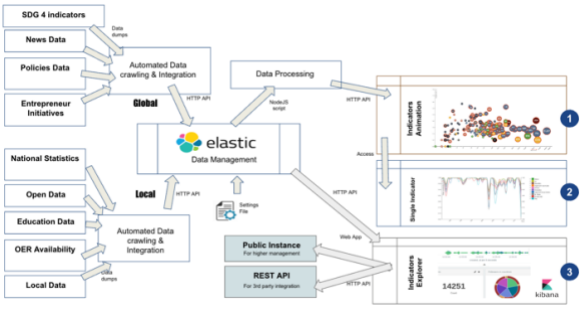

Figure 4: The architecture of the OER Observatory as an Elasticsearch-based system that enables the visualization of heterogeneous data on OERs

For each area, users can filter and find content specific to their domain of interest: up-to-date news and research on OER developments, academic studies related to professional development, and relevant lectures for capacity building; information on OER policy development; resources and research focused on effective, inclusive, and equitable access to quality OER; strategies for developing sustainable OER models; and opportunities for fostering international cooperation through potential new partnerships and shared goals. This organized approach enhances the ability to pinpoint and utilize the most relevant information in each domain. Information generated by the Observatory can be used to aid in the resolution of problems related to the promotion of OER, by identifying trends and major areas of discussion, and to explore successful scenarios through similar challenges and cases. The Observatory provide benefits to a range of stakeholders including: national governments, providing access to a variety of perspectives on OER trends for decision-making; educational and research institutions, facilitating the access to resources and data; civil society, allowing access to information and training materials that explore the knowledge available towards the implementation of the UNESCO recommendations; and the general population, empowering open education.

4 Open Education for a Better World

The Open Education for a Better World (OE4BW) program is an international online mentoring initiative aimed at advancing the development and implementation of open educational resources (OER) that address topics of significant social impact, in alignment with the United Nations Sustainable Development Goals (SDG) [2,14]. As part of the Slo2Svet project, the program received 70 project applications and 87 mentor applications from six continents and 25 different countries (see Figure 5). The program's activities are structured into thematic clusters, focusing on areas such as Artificial Intelligence, Displaced

Persons, Sustainability, Health and Well-being, Renewable Energy, Education, and Youth (specifically targeting developers aged 12-24). Throughout the project development process, progress was closely monitored by a network of mentors and hub coordinators, providing essential guidance and support to OER developers. Additionally, within the scope of the Slo2Svet project, evaluation rubrics for the OER projects were developed and will be utilized during the final conference, where developers will present their completed work.

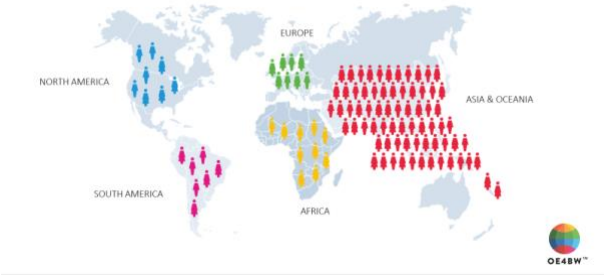

Figure 5: Participants of the OE4BW mentorship in 2023/24.

5 Conclusions and further work

In this paper we discussed the research results and opportunities in Open Education, building on an overall perspective over the OER landscape, the AI-enhanced student-educator interaction, and the mentorship for further progress.

We will be exploring further the potential of the OER observatory, particularly in what regards the appropriate use of LLMs in analyzing the compliance to AI policies in Education. In what regards the future developments of the EduColab, in alignment with IRCAI's *SDG 4 Observatory* and the *Videolectures.net* research agenda and the potential for institutional collaboration, we will focus on: (i) the appropriate *wikification*, incorporating suggestions of *Wikipedia* concepts identified by *Wikifier* and related to the main discussion topics; (ii) integration of interactive data visualization presenting graphical representations of collaboration trajectories, topic evolution, and other key indicators; (iii) extending the system, applying the ERS to other datasets, including public and private message exchange logs, to validate and enhance its applicability; and (iv) personalized recommendations**,** developing a user-based collaborative filtering technique to tailor recommendations more specifically to individual student groups. Moreover, we will explore together the pathways of AI-based citizen science in the context of Open Education and how it can be integrated in the wider scope of the SDG4 Observatory. In the context of the Slo2Svet project, we are conducting a comprehensive analysis of the Open Education for a Better World (OE4BW) mentoring program since its inception, examining outcomes and connections to other initiatives [see for example, 12]. Additionally, we will develop an evaluation framework to assess the impact of the projects produced through the program, mapping project outputs to the five action areas of the 2019 UNESCO OER Recommendation, using insights provided by automatic text analysis and other AI tools. This will allow us to connect the projects produced by OE4BW to the concrete objectives of the Recommendation, providing examples of practice that can be leveraged to advance its goals.

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Addressing Water Sustainability Challenges in North Africa with Artificial Intelligence

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ABSTRACT

The topic of water sustainability has been leading the priorities worldwide where Artificial Intelligence (AI) can position research institutions, public & private companies and governments towards evidence-based decision-making in regards to water resources. In this particular domain, the amount and heterogeneity of data generated allied to the rapid progress of scientific research and technological development have created vast amounts of data, but significant challenges to gathering, filtering, and making sense of this information. This paper presents the research outcomes of collaborative effort engaging a total 51 students mentored by 15 professors across 11 research institutions in North Africa, distributed by 14 selected projects focusing the appropriate application of machine learning methods to local and national water sustainability problems. These outcomes were motivated by a youth challenge co-organized during May 2024 between AI Africa and IRCAI with the support of GITEX.

KEYWORDS

Machine learning, text mining, large language models, community engagement, water sustainability, competition

1 Introduction

Building upon common interests, exciting initiatives and existing projects developed by IRCAI and AI in Africa (aiinafrica.org), focused on AI and Sustainability, this activity aimed to build capacity within African youth to advance the Sustainable Development Goals (SDGs) though AI on challenges within their own communities and in the region. The AI Youth Challenge originated in the context of discussions started in GITEX Dubai in 2023 and forwarded to a concrete event in the AI Everything section of the GITEX Africa in the end of May 2024. It was mostly directed to PhD/MsC students and young entrepreneurs working on AI to solve problems for the good of their communities, exploring a wide range of machine learning methodologies (from image recognition on satellite imagery, to text mining on social media, gamification strategies optimizing water consumption, and application of LLM frameworks for RAG and AI Agents in the context of water sustainability), engaging experts from global agencies like, e.g., UNESCO, AI Movement, and UNESCO's Water Education Institute, as well as national companies, research institutions and government. The global challenge of this action, "Water, AI and Sustainability" is one of the MENA priorities, takes into consideration the UN Water Program for 2024-25 [12], and follows the work done by IRCAI with the European Commission (EC) on the NAIADES Water Observatory [9], as well as the recently opened new IRCAI Committee on AI and Water Resource Management [4] focusing on the impact of AI in SDG 6 [11]. This work aligns with UNESCO's interests in taking action to capacitate the Youth towards AI, with focus on the recent activities based from Morocco but with a global scope, including the opening of the new UNESCO AI Centre, the AI Movement (aim.um6p.ma).

Figure 1: Winner of the AI4Water challenge, designed and developed by UM6P students, exposing a water map that pinpoints remote villages with assigned water scores based on satellite imagery and crowdsourced data.

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2 Finalist innovative ideas on water sustainability

Attracting the participation of more than 50 PhD and MsC students across 20 teams based in research institutions in Morocco, this initiative was designed to encourage a conversation between the communities, corporate thought leaders, the education visionaries, and the ecosystems builders to have constructive conversations around the shifts and needs of the changing future landscape. The discussions included researchers, start-up communities, technologists, and government representatives to unite and define the future of water sustainability as they see it. The selected AI technologies and methodologies ranged from the use of satellite imagery to the analysis of news and social media, or the input from water-related sensors and the application of Large Language Models (LLMs) to describe good practices. We shall proceed with describing the problems addressed by the finalists of the AI4Water challenge, their prototypes and the value of the innovation they brought with them.

AquaScore. The Rural communities in Morocco's High Atlas Mountains struggle with water management due to limited resources and visibility. Despite needing modest funds, these villages face significant hurdles in accessing support. The challenge lies in objectively quantifying water issues and connecting these communities with potential supporters. AquaScore creates a water map that pinpoints remote villages and assigns them water scores based on satellite imagery and crowdsourced data. This enables ranking villages by water criticality, helping funders and supporters identify where to direct their assistance effectively. The prototype (described in Figure 1) also offers a platform for discussing water solutions, fostering community engagement through gamification features. By increasing the visibility of rural Moroccan villages and providing objective water criticality assessments, AquaScore facilitates efficient resource allocation for donors and experts. This AI-driven approach ensures fair and unbiased assistance to communities in need, promoting water sustainability and improved water management in constrained environments.

AquaScore employs a hybrid approach combining Computer Vision (CV) and Natural Language Processing (NLP). CV algorithms segment satellite images to generate automated baseline water scores, while NLP algorithms extract insights from textual data to enhance score accuracy. This combination allows for objective assessment and continuous improvement of water criticality rankings. The team has already aggregated data on 1,322 High Atlas villages, extracted satellite images, and segmented them using Facebook's Segment Anything model. This process was completed on UM6P servers using 500GB of storage and 80 CPU cores. The system will incorporate user-submitted reports and internet-scraped data to further refine water scores. The uniqueness of AquaScore lies in its data generation and refinement approach. It creates datasets in areas with data scarcity, starting with an automated baseline from satellite imagery and then enriching it through user-generated content. This closed-loop system employs active learning, progressively enhancing accuracy and relevance of water scores.

AquaSense. Water management is a critical issue in many countries, including Morocco. Severe droughts, poor water distribution, and recent natural disasters raise the urgent need for better solutions to manage water resources effectively. AquaSense's prototype (see Figure 2) offers a smart way to handle water resources by predicting future water situations, visualizing key data, and engaging citizens and communities. This helps decision-makers plan better, save resources, and respond quickly to local water issues. AquaSense provides accurate forecasting of water parameters for informed management and answers water-related questions with detailed analysis using the latest data and news. It offers transparent data visualization through interactive charts, allowing users to view and upload data easily. The community & citizens' space features real-time news updates, a water levels map to locate and help regions in need of water, and a tool to easily report local water issues.

Figure 2: Screenshot of the prototype of Aquasense defining parameters, visualizing data and monitoring engagement.

AquaSense combines two distinct parts of AI: DL (LSTM) and Generative AI (RAG and AI Agents). AquaSense uses Multivariate and multistep LSTMs to accurately predict water parameters' levels for the coming years, and Retrieval-Augmented Generation and AI Agents to answer water-related queries with detailed analysis, using the latest data, news, predicted parameters, and documents from sources like UN, UNCCD, and EPA. AquaSense uses Tensorflow and Keras (LSTM model), Pandas and Numpy (data preparation & mgmt.), Langchain (LLM framework for RAG and AI Agents), Chroma (Vector DB), Nomic Embeddings (Open-Source embeddings), GPT3.5-TURBO (LLM model), Streamlit (Web app). Aquasense improves water management by helping stakeholders make informed decisions, enhancing resource allocation, and promoting sustainable practices. Through its innovative features, it bridges the gap between citizens and authorities, which fosters collaboration and reduces water crises over time. Also, AquaSense aligns with several UN Sustainable Development Goals (SDGs) such as SDG 6 (Clean Water and

Sanitation), SDG 13 (Climate Action), and SDG 11 (Sustainable Cities and Communities).

Water Consumption Tracker. This prototype is addressing the global problem of water optimization in the light of the already visible consequences of climate change. That is, the large amount of wasted water due to irresponsible water use by the households. The added value lies in the behavioral approach: the application is designed to make users more aware of their attitude toward water consumption, and to make water conservation a pleasure rather than a responsibility. Introducing a gamification approach as a new strategy should help make water conservation more appealing. It is based on an app that tracks real-time water usage, provides personalized recommendations, and motivates users over a gamification environment, fostering a community focused on sustainable water use.
The use of Machine Learning models such as Random Forest Regressor to find patterns between the households characteristics and their water usage behavior. We plan to add GenAI using LLM model as a chatbot to support our vision by providing custom tips to optimize water usage. The approach was fundamentally based on: (1) collecting data about the households using our application UI; (2) providing optimum water consumption level by the ML model based on the data collected; and (3) monitoring water usage through IoT sensors and the notification system of our App. The data collected is used to optimize the ML model performance. Our approach can potentially reduce household water waste by 20-50% by educating users about their consumption habits through notifications, ranking systems, and feedback mechanisms.

Figure 3: The pitch of one of the top 3 teams – Ghayt – presenting the Water Consumption Tracker at the AI stage of GITEX Africa.

Aquatic Biodiversity. The introduction of non-native species into marine ecosystems presents a significant threat to the fragile equilibrium of these vital environments. Invasive species, often aggressive, can outcompete native organisms, leading to disrupted food chains, altered habitats, and potentially irreversible ecological harm. From coastal areas to the open sea, the swift proliferation of invasive plants, animals, and microorganisms endangers the biodiversity, productivity, and resilience of our marine life. Addressing this escalating global issue requires immediate and decisive action. AI-powered early detection algorithms were prepared to constantly monitor for signs of invasive species, triggering immediate alerts to enable rapid response. Based on species-specific data, the system can precisely deploy the most effective eradication methods, from underwater drones to selective biocides. As invasive species evolve, the AI-driven platform continuously adapts strategies, ensuring that the interventions remain effective and environmentally responsible.

YAZ. High unemployment rates in North Africa often translate into many individuals employed in low-wage jobs, particularly youth from low-income households. Severe water scarcity leading is decreasing exports and rising prices of vegetables and fruits. Challenges meeting the needs of Morocco's population while being a major exporter of produce to global markets. This AI-based agricultural solution is based on Smart Hydroponic Towers designed to efficiently grow crops vertically indoors and outdoors, offering optimal use of available spaces. The adoption of hydroponics in Africa has the potential to create millions of new jobs in the coming years. Integrated with GPT architecture, the technology allows real-time monitoring, pest detection, and yield estimation. YAZ hydroponics are a shift towards a resilient and sustainable Moroccan agriculture.

The tools and technologies presented in this paper that are open source, are available at IRCAI's SDG Observatory GitHub repository (github.com/IRCAI-SDGobservatory).

3 From concept to prototype in a month

AI in Africa in collaboration with IRCAI conducted a gathering of minds which culminated in a 1-day summit around technologies and shifts of the future, hosted by GITEX in the AI Everything section of the GITEX Africa 2024. Between 26th April and 31st May, 55 PhD and MSc students from 11 research institutions took part of a complete program including expert sessions kicked-off at the AI movement, UNESCO's new center for AI in Africa, and engaging experts in water-related topics such as Matjaž Mikoš, UNESCO chair for landslide risk reduction, droughts and floods, discussing our recent research on news mining for extreme weather events [5, 6]; Gerald Corzo Perez, senior researcher at the UN Water Education IHE Delft, discussing our ongoing research on Water, AI and Twitter [7]; and Ignacio Casals, R&D Manager in Aguas de Alicante Spain, providing a industrial perspective on the use of AI to tackle the challenges of wastewater management [8].
The students were followed across 8 stages including: conceptualization; data collection, analysis and visualization; methodology and implementation, prototype building and pitch (see Figure 3). In order to maximize the impact of the programme, the content from the abovementioned opportunities will be organized across UNESCO's most related to the five areas: (1) capacity building; (2) developing

supportive policy; (3) effective, inclusive and equitable access to quality Education; (4) nurturing and creating sustainability models for Water Sustainability; and fostering and facilitating international cooperation.

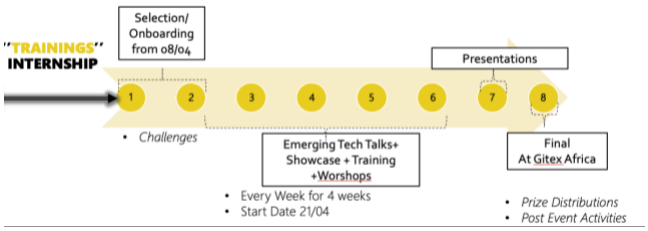

Figure 4: The phases of the training curriculum across 5 weeks.

The training curriculum included weekly seminars open to public, training workshop for participants, showcases and mentoring sessions (see Figure 4). The discussions forming the bae concepts of the participant projects were held in the light of IRCAI's research and research achievements (see Figure 5), aiming at building research collaboration bridges.

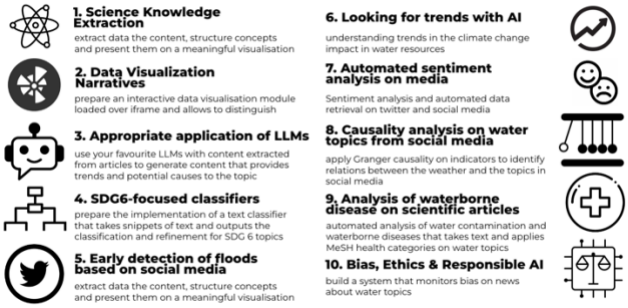

Figure 5: Selected topics from IRCAI's research to motivate challengers in AI and Water research

The data and methods generated by the participants programme can be used by companies, government and research institutions to aid in the resolution of problems related to Water Sustainability, by identifying trends and major areas of discussion, and to explore successful scenarios through similar challenges and cases. IRCAI's SDG 6 Observatory [10] is being built to properly address the challenges of decision makers, using AI. It is benefitting: (i) national governments providing access to a variety of perspectives (including trend and comparative) on a data driven dashboard with information on Water Sustainability trends for decision-making; access to local (e.g. country-level) progress on SDG 6; (ii) educational institutions, offering access to information on current trends on Water Sustainability research and development; (iii) research institutions, sourcing open data over interactive visualisation and research; (iv) the NGO community, easing access to information directly linked to community priorities including citizen science activities; and (v) general population, empowering water education for all.

4 Conclusions and further work

The capacity building to enhance opportunities can benefit from the engagement of the Youth in AI-driven challenges that start in research problems deriving from issues to address in their communities. Problems they know well and data that they often have privilege access to, with promising impact that can ensure the sustainability of the innovation offered. The initiative served us also to collaboratively discuss sustainable solutions that help large scale recovery and define a better and more hopeful inclusive Africa. The winning outcomes of this challenge will integrate a vibrant worldwide Community of researchers and entrepreneurs focusing on AI and SDGs, starting with SDG 6, and supported by initiatives such as IRCAI's Top 100 or the SDG Observatory. Ethical considerations are being addressed in the context of the EC project AI4GOV.

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Predicting poverty using regression

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Abstract

Poverty reduction is the first Sustainable Development Goal set by the United Nations to be achieved by 2030, but current data indicates that the progress is insufficient. The diverse factors influencing poverty across different nations pose a challenge in developing effective predictive models. This paper evaluates the use of various regression models to predict poverty rates using a comprehensive dataset of 111 variables from sources such as the UN and the World Bank. The data, spanning multiple domains like political stability, education, and economic conditions, was preprocessed and transformed to create auxiliary features and interactions. Among the models, Ridge regression yielded the best results, achieving a Root Mean Square Error (RMSE) of 3.6, indicating high predictive accuracy on a global scale. This study highlights the importance of addressing multicollinearity and incorporating a wide range of features to improve the generalizability of poverty prediction models. Future research should explore more complex methods, such as neural networks, and refine model hyperparameters for enhanced performance.

Keywords

poverty, linear regression, lasso regression, ridge regression, elastic net regression, sustainable development goals

1 Introduction

The need to eradicate poverty has been a long standing issue, which was globally recognized numerous times, most importantly in the United Nations (UN) Sustainable Development Goals (SDGs), being given the number one spot of SDG1: "End poverty in all its forms everywhere", which should be achieved by 2030. The latest UN report on the progress made in achieving SDG1 indicates Poverty has returned to pre-pandemic levels in middle- and high-income countries, with poverty in low income countries still a fraction above those reported in 2019. While the trends seem to be going in the right direction, the UN warns that the current pace of improvement is insufficient to reach the agreed goals before 2030. This raises the question of what impacts poverty rates the most and how countries can most effectively reduce poverty levels.

To fully understand and address the issue of poverty, one must navigate several definitions, which can often lead to confusion. The baseline definition used in this paper is the poverty line as is defined by each country individually, recognizing that different countries have different measures of, e.g., what life conditions and how much income makes an individual reach a "poor" status, as well as how we can normalise this to better compare these relative indicators between countries. We are still missing a clear theory in poverty research, despite the issue existing for a number of decades [2]. With that being said, some authors have already explored the causes of poverty. For instance, corruption, political instability, ineffective local governance, government polices, gender inequality and short-term wage replacement policies, such as maternity leave benefits and sickness pay, impact relative poverty [6, 7]. When assessing what people believe causes poverty some geographical differences emerge. For example, the United States are mostly of the thought that an individuals traits are responsible for poverty, while countries in Europe have a blend of individualistic, fatalistic and structural beliefs such as lack of will, bad luck and social injustice respectively [4].

Machine learning (ML) has also been used in academic research to identify trends and analyze data in most fields, including poverty research. Although a number of papers have already been published on the use of ML to predict poverty [1, 10, 12, 5, 3, 8] (for more see [11]) including combining satellite images and neural networks to help predict poverty in five African countries [5], most take a limited number of variables. Usmanova's literature review found 22 papers published between 2016 and March 2022, with a total of 57 AI methods applied, the most popular being random forest, used in more than half of all papers reviewed. It also found most papers focus only on African and South Asian countries, a finding consistent with our own [11].

In this paper we focus on the following research questions: (i) can regression be useful to identify the most influential features, from a large amount of global indicators; and (ii) can direct and indirect causality relations be identified that signal new indicators relevant to the Poverty-related issues?

2 Data

To address the research questions, we utilized 111 primary variables from sources such as the UN and the World Bank, aggregated through the Our World in Data portal. These variables span diverse domains, including political stability, policies, education, healthcare, economic conditions, and inequality. We prioritized features that prior research has identified as significant, while also incorporating some factors that are less intuitively linked to poverty. The dataset was then used to train various models aimed at predicting poverty rates across countries. This task is particularly challenging because countries respond differently to the same variables. For instance, GDP growth tends to have a more significant impact on poverty reduction in developing nations compared to developed ones. Additionally, many variables

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are strongly correlated, making it difficult for linear regression models to capture their relationships accurately.

As previously mentioned, most of the data used in this paper was sourced from *ourworldindata.com* (OWiD), with some additional data coming from *fao.org*—including variables such as foreign direct investment inflows and outflows, and the added value of agriculture, among others. Data on the transatlantic slave trade and colonial rule was obtained from *www.slavevoyages.org*. All datasets were preprocessed before being merged, following a series of steps.

The first preprocessing step involved light modifications, such as removing irrelevant columns, renaming columns, and excluding data from before 1987 and after 2023 due to gaps and incomplete data. Despite increased reporting in recent years, many countries still omit certain indicators, complicating model training. To address this, missing features with more than n data points for a given country were interpolated, with the edges filled using backward fill (bfill) and forward fill (ffill). Those with less than n data points used the mean of the country's income group for the given year as a filler value. The number n was intuitively chosen to be five and the methods bfill and ffill were chosen to prevent the use of unrealistic data. The World Bank classifies countries into income groups: low (less than 1,045 USD), lower-middle (1,046 USD to 4,095 USD), upper-middle (4,096 USD to 12,695 USD), and high income (12,696 USD or more). However, it is important to note that the data generated using the aforementioned methods somewhat reduces overall robustness.

The next step involved generating auxiliary columns, specifically lagged columns and changes in value for relevant parameters. For instance, the row corresponding to Niger in 2013 would also include the GDP per capita for 2012, 2011, and earlier years, in addition to the value for 2013. This approach reflects the fact that poverty trends often manifest in response to changes over time, rather than immediately. The default number of years for lagged data was set to five. Similarly, we incorporated changes in value over the same five-year period to capture more explicit data on unusual events, such as the onset of wars or significant political changes.

Next each primary parameter was also used as an argument for a number of mathematical functions in an effort to see if any correlations aren't linear but perhaps squared, cubed or another elementary function. The functions used were: x^2, x^3, $\ln x$, $\sin x$, $\cos x$, $\tan x$, $\arcsin x$, $\arccos x$, $\arctan x$ to try and capture any elementary nonlinear dependence within the model.

The last step was to create all possible products with the available primary parameters, as creating all possible products with all auxiliary parameters included would have been computationally inefficient. After all these steps were made, the individual columns were fused together. This method of preprocessing increases the possible variables included, making the model even more general and retaining as many rows of data as possible.

The function responsible for preprocessing, generating and merging the data has a few parameters: *basic_parameters_only*, *combinations* and *math*. *basic_parameters_only* determines, if the model will only contain data obtained from various online databases, or if the model should include generated data: the change in value and values for previous years. *combinations* determines, if the model should create all possible combinations with the primary parameters and *math* determines if mathematical columns are included in an attempt to gain a deeper insight into the features' relationships. The parameters are marked with B, C and M. For instance, B+M would mean the file contains the basic parameters in addition to the mathematically derived columns.

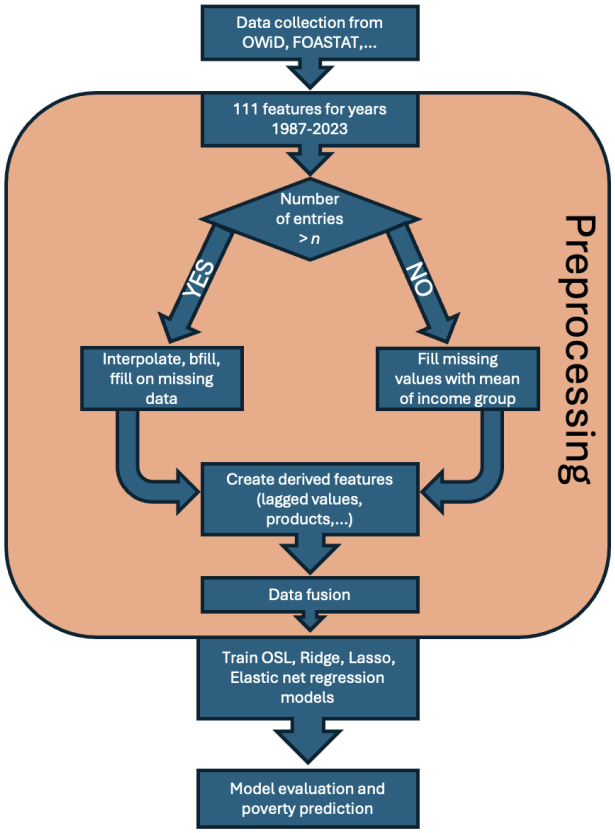

Figure 1: Scheme of adopted methodology

3 Methodology

In order to predict worldwide poverty levels, we have used different linear regression models and compared their accuracies. With this we aimed to ease the interpretability of the models, which is harder to obtain with more complex methods such a neural networks. To perform the research work that is the base of this paper, we have selected ordinary linear regression, lasso regression, ridge regression and elastic net regression as the models to compare. OLS regression struggles with multicollinearity, where predictor variables are highly correlated, leading to unstable estimates of the coefficients. Ridge regression addresses this by adding an L2 regularization term, which penalizes large coefficients and helps to stabilize the estimates in the presence of multicollinearity. By shrinking the coefficients, ridge regression reduces the sensitivity of the model to colinear predictors, ensuring more reliable and generalizable results. Unlike lasso, ridge retains all predictors, making it particularly useful when multicollinearity is a key concern but feature selection is not the goal. We use the implementation of these linear regression algorithms in scikit-learn [9].

The datasets were split into training and test sets using the sklearn function `train_test_split`, with 80% for training and 20% for testing. The training set was used to train four regression variants (`LinearRegression, Lasso, Ridge, ElasticNet`), all with a random state seed of 42. while the test set was used to

determine the mean squared error (MSE) and R^2 value using the functions `mean_squared_error` and `r2_score` from [9], both common metrics used to assess models accuracy. All models except OLS regression also had the data standardized before training. The hyperparameter α for the models was sensibly chosen as 0,1. The results, seen in Table 1 are color coded: red for poor performance, yellow for intermediate, and green for the best. The variation in the number of rows is due to the exclusion of rows with insufficient yearly data, which were dropped when calculating differences from previous years.

After identifying the most successful model, we proceeded to compare its performance between high-income and low-income countries. This comparison aimed to assess how the accuracy and frequency of reported data influence the model's performance. These two income groups were chosen because low-income countries typically report less data with lower accuracy, while high-income countries provide more precise reports. We selected all high- and low-income countries from the dataset that were not used during the model's training. From the 20% of data reserved for evaluation, 444 rows (30%) belonged to high-income countries, and 368 rows (24%) belonged to low-income countries.

We used the trained model to predict poverty levels for these groups and evaluated its performance using the MSE metric to analyze differences between income groups. Additionally, we calculated the maximum error to determine if the average performance was skewed by outliers. A similar evaluation was conducted on the data from Slovenia and Somalia, which were part of the split. Slovenia had 8 rows of data, and Somalia had 6, allowing us to explore how missing data impacts the model's performance, as Somalia had significantly fewer data points overall.

4 Main Results

The file configuration plays a critical role in the model's performance. The results show that C+M, C, and B+C are the best configurations. The C+M file includes all basic features, lagged values, changes in value, mathematical columns, and all possible combinations of basic parameters, totaling 8,236 parameters. Configuration C contains all basic features, combinations, and lagged and difference columns. Lastly, B+C includes only the basic parameters and their combinations. All top-performing models were trained on these datasets.

The results in Table 1 show considerable variation. Models trained with ordinary least squares regression performed poorly, with the best model reaching an RMSE just under 10.15 and an R^2 of 0.50. In contrast, lasso and elastic net regression achieved better results, with RMSEs around 7 and R^2 values close to 0.80. Ridge regression also struggled, except for configuration B+C, which provided the best results with an RMSE of 3.6 and an R^2 of 0.94. However, caution is advised when interpreting models using configuration C+M or C, due to the high number of features relative to the dataset size, which could affect their real-world reliability.

The model weights reveal that only products are present among the top ten most important factors. These products include data on population, population density, agriculture, equality, healthcare, and education. The largest weights show the biggest differences, gradually decreasing in magnitude. The top ten weights range from just over 10 to 7, with the highest weights involving combinations such as population and population density, meadows and pastures with the global peace index, and

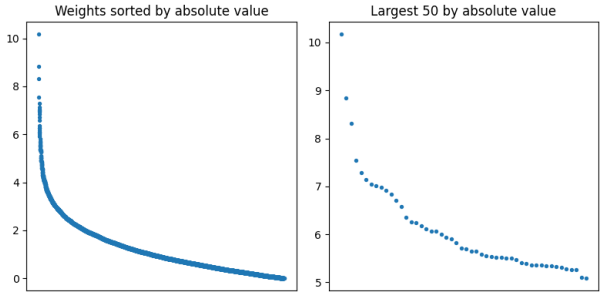

Figure 2: Visual representation of model weights

population with urban and rural population share. Other notable combinations include secondary school completion with women's civil liberties, internet usage with sanitation access, and military spending with wealth distribution. The weights also reflect factors like infant mortality, years colonized, and agricultural employment. Figure 2 further illustrates the decline in the absolute value of these weights.

The model performed better on high-income countries, with an MSE of 6.60, significantly below the overall MSE. In contrast, the MSE for low-income countries was 20.68. The maximum error was also lower for high-income countries (22.1) compared to low-income ones (34.4).

The difference in the model's performance on Slovenia and Somalia was notable. For Slovenia, the MSE was 0.78 with a maximum error of 1.54, far below the overall metrics. Somalia, however, had a much higher MSE of 95.7 and a maximum error of 18.7, likely due to less reliable and extreme poverty data, which skews the model's performance on extreme cases.

5 Discussion

Firstly, the fact that ordinary least squares linear regression couldn't produce an accurate model confirms the fact that the parameters are indeed correlated. This is probably also the reason why the ridge regression model performed the best: ridge regression is used to address the issue of multicollinearity and the features included are mostly strongly correlated, as stated in the introduction. Furthermore, the correlation between parameters is obviously drastically increased by generating all possible products of basic parameters.

Secondly, the impact of mathematical columns needs to be considered. Of the first four models, two have mathematical columns and two don't. Of the eight models generated, three of them perform worse if mathematical data is present, while 5 performed better with mathematical data included. This might indicate some deeper connection, which would be interesting to try and understand. Furthermore, lasso regression handles mathematical columns much better compared to the other models used due to its ability to exclude features.

The impact of product combinations of basic features stands out, with all better-performing models having the *combinations* parameter set to `True`, suggesting deeper relationships between variables. Exploring these connections further, perhaps by training a neural network on the basic parameters and comparing it to linear regression models, could be insightful. If the neural network performs better, further investigation into these correlations would be needed.

Structure	Linear MSE	Linear R^2	Lasso MSE	Lasso R^2	Ridge MSE	Ridge R^2	Elastic net MSE	Elastic net R^2	Shape of X
M	203	0.031	74	0.65	-	-	-	-	(7653, 2131)
None	-	-	109	0.48	163	0.22	108	0.49	(7653, 1221)
C+M	198	0.054	45	0.78	-	-	40	0.81	(7653, 8236)
C	-	-	50	0.76	-	-	45	0.79	(7653, 7326)
B	103	0.50	110	0.47	103	0.50	111	0.46	(7661, 111)
B+C	-	-	48	0.77	13.3	0.94	43	0.79	(7661, 6216)

Table 1: MSE and R-squared values for different regression models and dataset configurations. The presence of B, C or M signals the presence of basic basic parameters only (B), combinations (C) and mathematically (M) derived columns in the dataset. A dash is used to label non-converging models with a negative R-squared value.

The dataset used spans from 1987 to 2023, which is relatively short, given that poverty often has deep historical roots. Although data becomes scarcer in earlier years, those points could still be crucial for improving model accuracy. Moreover, most hyper parameters in this paper were chosen sensibly due to time and computational constraints. Different values for the number of lagged years, years of differences, hyperparameters in the training of models and the minimum number of data points required to interpolate missing data could all lead to interesting discoveries and improvements of the generated models. Our result here shows it is possible to achieve this degree of accuracy, but it doesn't limit what the best model could be. The elastic net, especially, should benefit from such a tuning.

As stated in [11], the recent literature mostly uses the random forest model and, in fact, ordinary linear regression wasn't even in the top ten most common methods. An interesting thing to explore would also be the performance of random forest using the best configuration, B+C. The models may struggle to capture correlations between variables due to differing impacts across countries, as mentioned in the introduction. A potential solution is to split the countries into k groups and train separate models for each group. While this could improve predictions, it raises two challenges: how to split countries without bias and how to ensure enough data for training.

The weights in the model further emphasize the issue of multicollinearity among the parameters, with only product terms emerging as the most influential. However, this does not reveal the true importance of individual parameters, as they may enhance the impact of another factor within the product term. Additional research is needed to better determine the true significance of these parameters and gain a clearer understanding of what drives poverty rates up or down. It can be seen in Figure 2, the models weights occupy a wide range. It is clear that some features are more important, based on their weights and further work is being done to understand which features stand out and why.

The model also performed better in predicting poverty levels in high-income countries compared to low-income countries. This discrepancy can likely be attributed to the fact that high-income countries report more data with greater accuracy, allowing the model to identify underlying patterns more effectively. In contrast, much of the data for low-income countries had to be interpolated, which reduced variability between countries and negatively impacted the model's performance.

6 Conclusion

In this paper, we have shown that a general model exists, based on linear regression methodologies, which can predict poverty with a relatively high accuracy (RMSE of 3.6). This was achieved through testing of numerous linear regression models using open data, with the best model being created by using ridge linear regression trained on data which also included all possible combinations of the basic features included in the dataset. The basic parameters included consist of 111 different parameters describing countries across 36 years. Better models could possibly be generated using more complex methods such as neural nets or random forest, gaining in accuracy but compromising the explainability of the model. The models could also benefit from hyperparameter tuning during the whole process to improve results and find the optimal values. We will be addressing this in further research.

7 Acknowledgements

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Fact Manipulation in News: LLM-Driven Synthesis and Evaluation of Fake News Annotation

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Abstract

Advancements in artificial intelligence and increased internet accessibility have made it simpler to create and disseminate fake news with customized content. However, they also improved the ability to analyze and identify such misinformation. To effectively train high-performance models, we require high-quality, up-to-date training datasets. This article delves into the potential for generating fake news through factual modifications of articles. This is facilitated by prompt-based content generated by large language models (LLMs), which can identify and manipulate facts. We intend to outline our methodology, highlighting both the capabilities and limitations of this approach. Additionally, this effort has resulted in new quality synthetic data that can be incorporated into the standard FAK-ES dataset.

Keywords

fake news, synthetic data, fact extraction, fact verification, large language models

1 Introduction

Synthetic data refers to artificially generated data that is not obtained by direct measurement or observation of real-world events. Instead, it is created using algorithms and simulations. The primary purpose of synthetic data is to provide a realistic alternative to real data for various use cases, such as training machine learning models, testing systems, ensuring data privacy, and more.

We will generate synthetic data from news articles. By making sure, that the information in the news is changed we can safely call it fake news. In our article, fake news will denote articles that are *intentionally* and *verifiably* false [4]. Synthetic data enhances model training by providing additional examples to supplement scarce labeled datasets and allows for privacy-conscious testing without real content manipulation. It enables adaptability to evolving fake news tactics by simulating diverse scenarios from the newest data, thereby improving the robustness and resilience of detection algorithms [3].

Large language models (LLMs) made a huge difference in the world of news. Fake news is now much easier and cheaper to construct, but we also have additional methods to help us tackle its spread. Numerous articles appeared trying to partake in this effort. The following are the main scientific contributions of this paper:

(1) A methodology to create synthetic data for fake news using LLMs.
(2) We then use this methodology, to adapt the FA-KES dataset with 100 additional synthetic fake news [1].

In Section 2, we discuss work that is closely related to our task. Section 3 then outlines the methodology for generating synthetic fake news, culminating in Section 4, where we present the results and introduce some modifications to the methodology. Finally, in Chapter 5, challenges, capabilities, and potential improvements are considered.

2 Related Work

A wide range of approaches to generate fake synthetic news with LLM has been developed. In [8] authors generated huge amounts of fake news and categorized them into multiple categories. LLMs can generate fake news by altering the style to mimic credible sources or using sensationalism to influence perception. They can subtly manipulate content to be perceived as true, blend real and fabricated information to exploit cognitive biases, or create convincing fictional narratives.

In general, when making a dataset we want a diverse distribution of fake datasets. In our case, we will focus on one way of data change, which comes under the umbrella of *Content Manipulation*. Similar news manipulations can be seen in [7] where the authors use two main techniques. The first one extracts the summary from the original text, which preserves the main content, which is then changed to produce a fake article. The second one asks a question about the article and changes the content of its answer, to construct a new article. Our approach is in nature similar to the Question-Answer framework.

Many articles provide fake news detection models made using synthetic data. Most popular are deep neural networks such as BERT [1]. But there are other fact-based approaches for fake news labeling as in [3]. In [2] they used GPT4-turbo for prompt-driven fake news detection.

3 Methodology

The methodology is divided into four conceptual steps: Data collection, Characterization of facts, Fact extraction, and Fact manipulation as presented in Table 1.

3.1 Data Collection

The publicly available FA-KES dataset [5], focused on the Syrian war, addresses the deficiency of manually labeled datasets in this domain of news data. It comprises 804 articles sourced from various media outlets. We used 426 articles that were manually labeled as authentic news, but we could just as well use the other (fake) articles.

[1] https://github.com/golobluka/Fake-news-generation-from-FA-KES-dataset

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https://doi.org/10.70314/is.2024.sikdd.13

1. Data collection	2. Characterization of facts
• Should have textual and statistical facts	1.Name of casualty 2.Gender or age group 3.Cause of death 4.Type 5.Actor 6.Place of death 7.Date of death
3. Fact Extraction	**4. Fact manipulation**
Name of casualty: Civilians **Gender or age group**: e.g., child, adult, senior **Cause of death:** shooting, shelling, weapons, etc. **Type:** military personnel **Actor:** rebels, forces **Place of death:** Airbase **Date of death:** April 7, 2017	**Name of casualty**: Manipulated fact **Gender or age group**: Manipulated fact **Cause of death:** Manipulated fact **Type:** Manipulated fact **Actor:** Manipulated fact **Place of death:** Manipulated fact **Date of death:** Manipulated fact

Figure 1: A methodology to generate synthetic data for fake news detection

3.2 Characterization of Facts

While making the FA-KES dataset, its authors created seven factual categories:

(1) `Name of casualty or group`,
(2) `Gender or age group`,
(3) `Cause of death`,
(4) `Type`,
(5) `Actor`,
(6) `Place of death`,
(7) `Date of death`.

It is crucial to note that all articles have a similar structure, describing war incidents. This allows us to establish a consistent framework of facts, such as actor and casualty details. We stick to those facts, but generate them differently, employing LLMs capabilities with faster and cheaper execution, albeit with a slight reduction in reliability.

3.3 Fact Extraction

We extract facts by constructing prompts for LLMs. First approach was a few-shot prompt, which gives some examples of output. Later we constructed an additional approach: Say we are extracting the fact `Place of death` with this second technique. We give a detailed description of what should be extracted and then LLM reads the article and performs the task solely on this basis. This description is usually longer and contains more context. The issues with fact extraction in general are:

- Some articles lack certain facts or merely imply them. LLMs can identify this, outputting responses such as "No information."
- Longer articles may contain multiple events, each with distinct data such as dates or casualties. This can be managed by creating separate tables for each event or consolidating all events into a single table with various facts.

3.4 Fact Manipulation and Synthetic News Generation

The objective is to modify relevant information without altering the writing style or topic of the article. For this transformation, we used a chain of thought prompt, which for a given fact: 1) changes the fact to another with a different meaning, 2) generates a new article based on the altered facts. By changing one fact at a time, quality is improved compared to altering multiple facts simultaneously, as one fact creates a clearer chain of instructions. LLMs such as `Llama3.1:8B` often struggle with precise changes in the article, such as modifying implicit references or incorporating new facts. Quality can be improved by carefully adjusting the prompt content.

LLMs are also exceptional in summarization and paraphrasing. Both are used simultaneously with changing the facts. The problem is that we aim to maintain the extracted facts when summarizing. But this is not crucial, as it usually has better results as article generation.

3.5 Fake News Annotation and Fact verification

After we have generated the fake articles, we can label that data as "fake" or "non-fake", based on comparison with extracted facts. We performed this labeling with various models and compared the performance of labeling,to get the best model. In this experiment we decided for `Llama3.1`. To do the labeling, we are performing fact verification [4]. The fact verification task in general is making a decision as to whether a claim is correct, based on the explicitly-available evidence, such as Wikipedia articles or research papers. We have the extracted fact, which will be compared to the article content. The question thus becomes: Do these facts appear in the given article? This approach emphasizes factual content rather than the overall sentiment of the article.

There are two primary types of prompts: 1) Direct prompts that present the article and a table of facts, asking if the facts relate to the article, 2) Structured prompts that inquire about the correspondence of one fact at a time with the article. The question is: Does this fact correspond to the content of the article? This method combines individual results into an aggregated score. Say the `Place of death` is characterized as `Idlib and Daraa provinces`. Then the question posed to LLM is of the form: `Read the article and understand its places of death. Do Idlib and Daraa provinces "really correspond" to places of death in the article?`

We are not as interested in labeling, as we are interested in the quality of produced synthetic fake news. For this purpose, we will also use fact verification in a slightly different way. We are asking the LLM: Were the factual changes in fake news really made, as they were supposed to? A similar method is used in the article [7].

4 Experimentation and Results

4.1 Experimental settings

We selected 426 articles labeled as authentic news from FA-KES dataset. Then facts were extracted and transformed, as described in the previous section. At first two basic approaches were used to randomly choose 70 news articles and transform them. Afterward, we used the labeling procedure to compare performance, resulting in the table 1. Based on the results we then composed the final algorithm, which would be manually evaluated.

4.2 Evaluation

For every experiment, we first manually checked a minimum 10 percent of random examples to get an overview of how well the LLM was able to do the job. It is quite useful to print text that represents the procedure of decision-making that LLM undertakes, when challenged with the task. It was even helpful to see LLMs generated thinking procedure, as this gives valuable insight, into what is going on "under the hood". We believe that manual fact-checking is the first and most crucial step in generating good prompts. Based on fallacies one can then adjust prompts content. To shed some light on this procedure we have made the following overview.

4.3 Fact Extraction Results

Name of casualty or group:	Members of Nusra Front
Gender or age group:	Adults (no specific age mentioned)
Cause of death:	Explosion at a mosque
Type:	Non-civilian (militants)
Actor:	Unknown (no group claimed responsibility, but supporters blamed ISIS)
Place of death:	Ariha, Idlib province, Syria
Date of death:	Not specified in the article

Figure 2: Example of fact extraction.

LLMs are capable of recognizing different topics and extracting words that correspond to this topic, and also noting if the fact is not mentioned. At first, we extracted short words as represented in Figure 2.

The issue begins with nuances. For example, in many articles the `Actor` is only suspected but not known. In some cases, actor and causality are not precisely distinguished. This usually leaves LLM to some kind of arbitrariness. For this purpose, We also added a longer description that better captures the nuanced subtleties related to facts. This can also be captured in Table 1. There we see the results for short (normal) or detailed extracted facts. The recall is far worse in the case of short prompts. This likely means that there is an abundance of false negatives, which result from the fact, that labeling does not manage to match true articles and their corresponding short facts.

The shorter extracted facts are often not comprehensive. For example, under the label `Type` (which classifies civilian or non-civilian) it writes only civilians, even though, contextual understanding also includes some non-civilian casualties.

Overall the most important insight remains: fact extraction has better quality than article generation.

4.4 Quality and coherence of synthetically generated fake news

The LLM can detect (for example) the `Actor` of some attack in the news, and then it is mostly able to change every occurrence of this `Actor` with another `Actor`. But if we would like to preserve all the coherence of the article much more would need to be done.

News usually contains background information, that provides context for the accident. Our algorithms failed to properly adjust this context, leaving it unchanged in most cases. Our fake news fails to preserve enough coherence to be trusted by a skeptical reader, who tries to connect background material to the event in the article.

Table 1: Comparison of fake synthetic data.

Type of data	Number of facts manipulated	Precision	Recall	F1	Accuracy
Summarization	2/7	0.74	0.63	0.68	0.71
Detailed facts	2/7	0.70	0.80	0.75	0.73

Generating false text, while maintaining coherency, is challenging for LLM. In this task, we have changed one fact: for example, the `Place of death` may be changed to another city or neighborhood. Then this fact must be changed in the article while maintaining other factual information. Here are the main issues:

- In the beginning some facts did not get changed, or the facts were altogether just removed from the article. We managed to reduce this error by adjusting the prompt. It is difficult to adjust all occurrences of the fact, especially if it is only implied and not explicitly stated. We managed to minimize this problem, by a method yet to be shown in section 4.5.
- What remains is the problem of a wider context, Suppose we change the town of the incident, then we must change the name of the neighborhood accordingly. LLM usually fails in this, leaving our article inconsistent, which is a widespread problem.
- LLM does not want to output the content because of harmful content or does not want to produce articles that could be used with illegal intent. This was quite a common problem, which is also reasonable, based on the violent content of articles and the possible abuse of LLM-generated content. The best thing to prevent this error is to use uncensored LLM. In other cases, one can adjust the prompts by removing suspicious words like "fake news".
- The Generated article was shorter, skipping the original text which was not linked to extracted facts. This problem was reduced but still exists in long articles.
- If the fact is not present in the article, then it is hard for LLM to incorporate a new fictitious fact into the text. Mainly it just adds the information in separate sentences.
- When we change facts, traces of the old facts still persist. This is especially common in complicated articles with diverse structures.
- Sometimes the change does not bring about any additional meaning. For example, LLM might change previously unknown casualties and designate them as civilians. They were implied to be civilians all along, and this makes only a minor change and is not really fake.

4.5 Fact verification with LLMs

Remember that in this task, the prompt asks: Does this fact "really correspond" to the content of the article? Performance largely depends on how the program takes the word "really correspond". Words have many nuances: different words can have different meanings, which can complicate labeling. To simplify: we can be stricter, in the sense that words must be the same in the literal sense, or we can count on the similarity of meaning [6]. Based on our goal of creating fake news it is best to focus on meaning and not concrete words.

Here are some common problems:

- Sometimes the fact is changed, but LLM skeptically assumes, that those two names refer to the same group.
- In longer articles, where there are many events, the names get changed only in some events (usually at the beginning of the article). In this case, the LLM can make unwanted predictions, labeling the fact as true rather than false.

Manual checking shows that labeling is more accurate than generation of fake news. This leads us to use labeling as a means to improve article generation.

Table 1 was used to compare different ways to generate fake news. It shows two of the best datasets, which contain true articles and their false twins, generated in two ways:

(1) Fake news generated by "standard" fact extraction and with additional summarization.
(2) Fake news generated by "detailed" fact extraction and with an additional paraphrasing of the article.

In this experiment, instead of merely categorizing the articles as true or false, the results shown in Table 1 reflect how well the generation process aligns with fact verification.

Low precision in the row with Detailed facts led us to detect articles that were not changed. We implemented a strategy where labeling was applied after generating the fake articles to assess the quality of the generation. LLMs often provide incomplete responses and struggle to correct them directly. By introducing an additional verification step, we were able to enhance the overall accuracy of the results.

4.6 Final Dataset Description

In the end, we constructed 100 fake-news based on a prior experiment, which can be found on GitHub [2]. In every article we randomly chose three facts and changed them. Afterward, we carefully went through 10 examples, which are also present on Git Hub, while here we present only the main points:

- Fact verification improved quality by making sure, that the synthetic fake article really incorporated new information. More than 90% new facts really got incorporated in the article. Sometimes new information is only added as additional text(and does not seriously change the main topic).
- Fact is not always incorporated in all places where it is referenced, which leads to inconsistencies. The new article is then a blend of old and new information.
- There are problems with ¨detailed" prompts. Containing more information results in contradictions as we change only one fact at a time.

5 Conclusion

In this article, we focused on exploring the potential of LLMs in fact extraction and generation of fake news. Our motivation was primarily to understand how accurate are LLMs in fact extraction and how reliably LLMs generate synthetic news by altering facts. As a result of our experiment, we have generated 100 synthetic news by randomly transforming there out of seven facts and have performed a manual evaluation, to observe the quality of the generated news dataset.

5.1 Problems, Capabilities and Possible Improvements

- In this stage, LLMs like *Lamma3.1:8B* are not able to coherently change certain facts of news articles. Changing facts can distort the article content, which appears to be extremely hard to manage. This normally does not happen for manageable data as dates (changing the time of some event), but for much more involved actors of the attack in the article. Even so, the synthetic fake news provides valuable information.
- We did not use the model, which has additional information about the news content. Providing additional context would likely have a beneficial effect on all the processes.
- In our case facts were largely dependent on each other. For example `Gender or age group` is an extraction of `Name of casualty or group`. We think it is best if such dependencies are removed because they bring to inconsistencies when changing facts. An additional solution would also be to change `Gander or age group` whenever `Name of casualty or group` is changed.
- Fact extraction is close to human-like quality. The issue is, that besides manual checking, it is hard to find a good measure of the quality of extracted facts.
- Detection of changed facts is in quality similar to extraction of facts (this is not surprising, since they are based on the same skill). Because of the diversity of meanings in language, it is hard to specify the exact reasoning procedure of LLMs and many mistakes come from this kind of miscommunication.

6 Acknowledgments

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Borrowing Words: Transfer Learning for Reported Speech Detection in Slovenian News Texts

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Abstract

This paper describes the development of a reported speech classifier for Slovenian news texts using transfer learning. Due to a lack of Slovenian training data, multilingual models were trained on English and German reported speech datasets, reaching an F-score of 66.8 on a small manually annotated Slovenian news dataset and a manual error analysis was performed. While the developed model captures many aspects of reported speech, further refinement and annotated data would be needed to reliably predict less frequent instances, such as indirect speech and nominalizations.

Keywords

reported speech, natural language processing, transfer learning, news analysis

1 Introduction

Reported speech, ubiquitous in literary and news texts, has clear lexical and syntactic patterns which may be reliably modeled via natural language processing (NLP) and may be useful for downstream tasks by drawing a distinction between source and background information. The paper applies transfer learning to extend reported speech classification to Slovenian news texts and provides a provisional classification model. A manual error analysis reveals the model's strengths and weaknesses, highlighting possible steps for further improvements.

2 Related Work

2.1 Role of Reported Speech

Reported speech is common in news texts, generally expressed as direct or indirect speech, with the former repeating the original utterance verbatim and the latter embedding it in a that-clause [18] (e.g., *Jimmy said: "Another systematic review would be great!"* and *Jimmy said that another systematic review would be great.*). More complex forms include mixed speech (*City officials rebuffed the accusations as "groundless and blatantly false".*) and reportative nominalizations with an analogous function as reported speech (*The speaker particularly emphasized the pressures on the media*) [7]. Around 50% of sentences in newspaper corpora may be attributed to a source in the text, predominantly through direct and indirect speech [17]. Verbs cue 96% of reported speech, followed by prepositional phrases (3%) [13]. Reported speech lends objectivity to statements [9], summarizes source statements [16], and is used in discourse analysis and communication studies to explore speaker representation by gender [1], institutional affiliations [8], and topic stances [15], or to distinguish between journalists' and sources' voices [11].

2.2 Existing Datasets and Modelling Approaches

Datasets with reported speech annotations mostly cotain literary or news texts. Key corpora include RiQuA [12], SLäNDa 2.0 [19], Redewiedergabe [3], QUAC [14], PolNeAR [10], Quotebank [21], and STOP [22]. RiQuA and Redewiedergabe are the largest annotated corpora, covering English and German 19th century texts. QUAC contains 212 annotated articles from the Portuguese newspaper Público, while Quotebank spans 162 million news articles with automatic annotations. PolNeAR, consisting of 1,028 news articles, includes attribution annotations, which include and exceed the definition of reported speech. A summary of the datasets is provided in Table 1.

The corpora differ in annotation complexity and size. They are mostly monolingual, warranting the used cross-lingual transfer learning for low-resource languages by employing multilingual models such as mBERT [6] and XLM-R [4]. Narrower multilingual models, such as CroSloEngual BERT, often outperform broader ones [20]. Reported speech modeling may be operationalized as speaker or quotation detection tasks [23, 17]. Simplifying the task to sentence-level classification is warranted by the fact news (unlike literary texts) rarely mix statements by sources and authors in the same sentence and can improve classification reliability at the expense of detailed aspects of reported speech [17] and simplify the annotation structure. Missing fine-grained outputs, such as speakers and boundaries of reported and reporting clauses, may thus be an acceptable trade-off for NLP-based content analysis in news texts. A systematic review of such approaches points to the limits resulting from a low number of features with no guarantee of reliable (joint) prediction, which preclude drawing rich conclusions expected from the method's manual counterpart [2].

3 Experimental Setting

3.1 Task Overview

We treated reported speech as a sentence-level classification task. Sentence splitters were applied to existing datasets, and binary labels were assigned by matching annotated spans with the split sentences. Reported speech sub-types were unified under a single label, joining the annotation schemes of individual datasets. A Slovenian dataset of 10 news texts was manually annotated at the sentence level. The datasets were split into training, evaluation, and test sets to train multilingual pretrained models. For CroSloEngual BERT, preprocessing also involved machine translating the German training data into English. The model outputs were binary labels indicating reported speech, used to calculate F-scores on the test data. A manual error analysis was performed on

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https://doi.org/10.70314/is.2024.sikdd.21

Table 1: Summary of Datasets' Characteristics.

Corpus	Type	Annotations	Language	Sentence No.	Role	Positive Class
RiQua	fiction	direct and indirect speech, cues, speakers, addressees	English	38,610	72% train, 18% development, 10% test	48%
Redewiedergabe	fiction, news	direct, indirect, free indirect and reported speech, speaker, cues	German	24,033	76% train, 16% development, 9% test	33%
Quotebank (manual)	news	speaker, direct speech	English	9,071	test	30%
QUAC	news	speaker, direct speech	Portuguese	11,007	test	11%
PolNeAR	news	speaker, cues, attributions	English	34,153	test	59%
Slovenian parliamentary news	news	sentence-level binary labels	Slovenian	744	test	43%

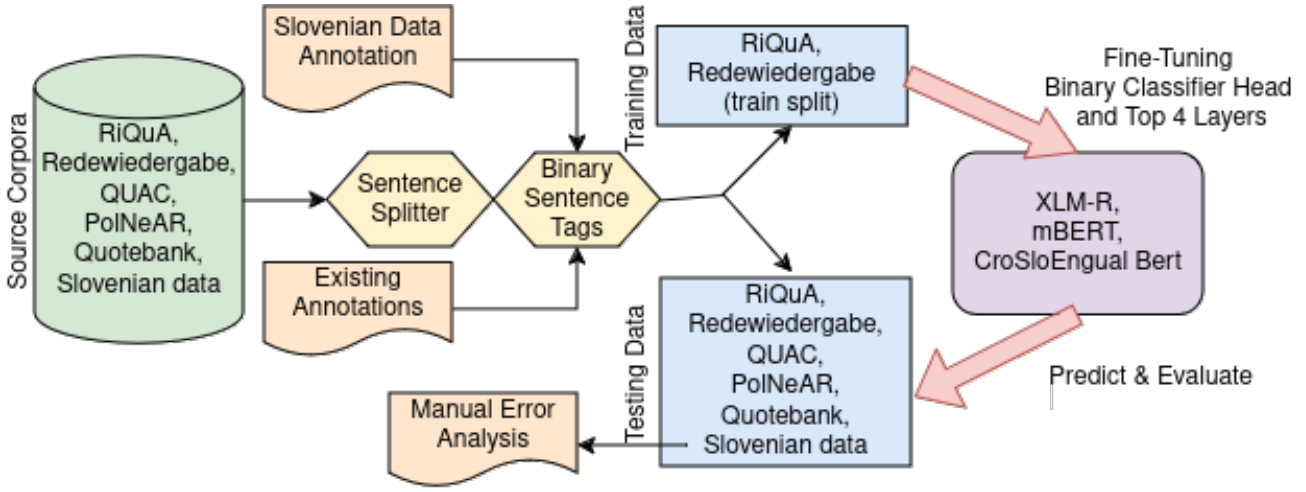

Figure 1: Flowchart of Data Preprocessing, Model Training and Evaluation Processes for Sentence-Level Reported Speech Classification.

the best model's outputs for Slovenian. Preprocessing, training, and evaluation steps are visualized in 1.

3.2 Training and Test Data

Our experiments were based on existing annotated reported speech datasets and a small Slovenian dataset. The training data included sections from RiQuA and Redewiedergabe, both large datasets with labels for direct and indirect speech. For CroSloEngual BERT training, the Redewiedergabe data was machine translated into English. Testing was conducted on the test sections of RiQuA, Redewiedergabe, the entire Portuguese corpus QUAC, and the manually annotated portion of the English Quotebank corpus. Additionally, we manually annotated 10 Slovenian news articles from RTV Slovenia. The datasets are summarized in Table 1.

The Slovenian dataset comprised 10 parliamentary news texts, covering various reporting strategies. Retrieved articles were split into sentences and annotated. Sentences were considered reported speech if they included direct or indirect speech cued by a reporting clause or prepositional phrase. We excluded nominalizations and phrasal quotes (e.g., *They emphasized the pressures on the media and the "illegal non-funding of the Press Agency."*) as well as implied quotes (e.g., *There will be more than 300,000 recipients, he emphasized. 169 million euros will have to be paid out.*).

3.3 Evaluation Procedure

The models' performance on the test datasets was calculated with an F-score. A baseline of assigning a positive label to all examples was calculated for all test datasets. The models' results on the test datasets were compared with a Friedman's test as suggested in the literature [5].

The best Slovenian model's predictions were reviewed with close reading. The error typology consisted of direct speech, indirect speech, speech fragments, annotation errors, annotation errors and *unrelated* and *other* tags. *Direct speech fragments* were sentences part of multi-sentence direct speech quotations. *Annotation errors* were examples with annotations inconsistent with the definition described in *Section 3.2.* For *unrelated* examples, close reading revealed no clear misclassification cause. *Other* was used for examples that did not fit any of the mentioned categories.

3.4 Training Settings

XLM-R and mBERT were used as base models with the default training settings from the *transformers* library with the exception of using 16 gradient accumulation steps and freezing the bottom 8 layers of all models. The latter reduces the training time without significant performance drops (Kovaleva idr., 2019; Merchant idr., 2020). Additionally, a Slovenian-Croatian-English BERT model was trained on English machine-translated data from Redewiedergabe.

4 Results

4.1 Model Results

The model performance varies based on the congruence between the language and precise task definitions in each dataset. The differences between model predictions were not statistically significant (χ^2_F = 9.66; df = 5; n = 8; p = 0.14) so post-hoc tests were not performed. As Table 2 demonstrates, the XLM-R model trained on both RiQuA and Redewiedergabe performed well across the datasets with an F-score of 80.5 and 77.6 on the Redewiedergabe and RiQuA test set, respectively. The high results from training on combined data suggests the RiQuA and Redewiedergabe datasets may benefit from additional or complementary data, at least when using cross-lingual transfer learning. The most successful strategy for Slovenian data was training on RiQuA and English machine-translated Redewiedergabe data using the CroSloEngual BERT model, reaching a F-score of 66.8. We did not evaluate the impact of using translated training data with mBERT and XLM-R.

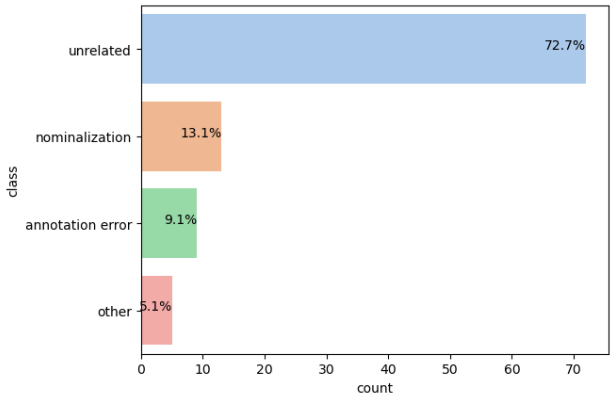

Figure 2: False Positives from the CroSloEngual BERT Classifier.

4.2 Error Analysis Results

The results from CroSloEngual BERT on Slovenian data were analyzed further. False positives were more common than false negatives, representing 23.4% and 9.8% of all examples (n = 744), respectively. Close reading of a sample of 100 false positives did not show a definite pattern for most (72.9%) of them. These examples were clearly unrelated to reported speech, although some did include words lexically related to reporting verbs (e.g. *The proposed law is still under discussion*). The second category of false positives were nominalizations of reported statements (13.1%) not included in our annotation schema. The final source of false positives were annotation errors consisting of wrongly

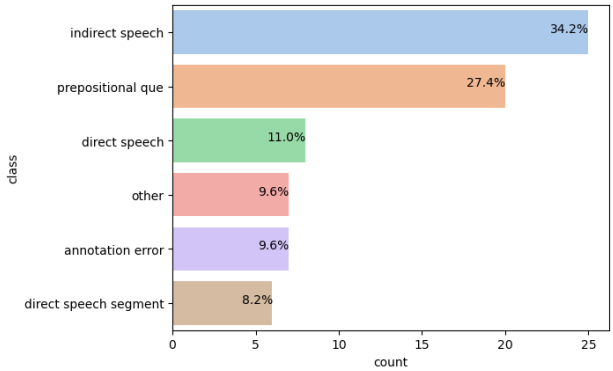

Figure 3: False Negatives from the CroSloEngual BERT Classifier.

unmarked examples of direct or indirect speech (9.1%). The distribution of categories identified in the sample of false positives are illustrated in Figure 2. The most common errors in the 73 false negative examples were instances of indirect speech (34.2% of false negatives) and prepositional queing of reported speech (27.4%). The remainder were instances of direct speech, direct speech fragments and annotation errors representing 11%, 8.2% and 9.6% of the false negatives, respectively. The annotation errors included nominalizations and statements reported as adjective complements (*The speaker was happy that the provisions were accepted)* not included in our annotation schema. Figure 3 summarizes the identified false negative categories .

5 Discussion

This paper presents the development of a reported speech classifier, tested through a small annotated Slovenian dataset and manual error analysis. Cross-lingual transfer learning from the annotated RiQuA and Redewiedergabe datasets achieved an F-score of 66.8 on a small manually annotated dataset of Slovenian news of parliamentary sessions using the base CroSloEngual model with RiQuA and English machine-translated Redewiedergabe training data [1]. This these results corroborate the observation that language models trained on a limited number of languages may outperform less specialized ones such as mBERT and XLM-R [20]. The major source of errors were false positives (23.4% of all sentences) for which no systematic pattern was discernible in the majority (72.9%) of examples. Instances of indirect speech and prepositional queing of statements were overrepresented in the false negatives, accounting for 61.6% of false negatives. Although rare, nominalizations were present in both false positives and false negatives and should be considered in future annotation guidelines. These obeservations indicate reported speech classifiers may benefit form approaches for addressing imbalanced classes.

6 Conclusion

This study developed a sentence-level reported speech classifier for Slovenian news texts using cross-lingual transfer learning. By leveraging existing multilingual models (mBERT, XLM-R, and CroSloEngual BERT) with the English and German datasets RiQuA and Redewiedergabe, we demonstrated that sentence-level

[1]The fine-tuned CSE model is available on the Hugging Face Hub under the name *zo-fi/rep-sp-CSE-rwg-riq*.

Table 2: Model Performances across Datasets (F-scores).

	Redewiedergabe	RiQuA	PolNeAR	QUAC	Quotebank	Slovenian dataset
Positive by default	52.1	60.6	74.2	19.5	45.8	60.3
mBERT+Both	77.5	77.4	73.1	40.5	53.5	63.2
mBERT+RiQuA	68.2	76.9	72.6	31.1	52.6	39.1
mBERT+RWG	78.4	70.4	65.5	43.4	49.1	63.2
XLM-R+Both	80.5	77.6	70	38.8	57.7	63.2
XLM-R+RiQuA	66.6	76.7	73.6	25.5	53.7	60.3
XLM-R+RWG	80.9	70.7	66.4	43.9	50	63.2
CroSloEngBERT+Both+MT	54	76.6	73	24	52.5	66.8

classification can detect some aspects of reported speech in Slovenian. However, the performance estimates are limited due to the small size of the Slovenian testing set and the limited definition used for the annotations. Future research should focus on developing a Slovenian annotated dataset, refining the annotation schema for multiple use cases, and exploring additional modeling features such as encoding broader sentence contexts. This work contributes a provisional tool for computational discourse analysis of Slovenian media texts. Further development is necessary for its application in more nuanced tasks.

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What kind of ESG is profitable? Connecting company performance to ESG terms in financial reports

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ABSTRACT

In this paper, we examine the relationship between the discussion of Environmental, Social and Governance (ESG) in companies' annual financial reports and their financial performance. Specifically, we analyse the companies' use of specific ESG terms alongside the performance metric, sector-normalized Return on Assets (ROA). Our motivation is to determine whether companies frequently mentioning terms such as "gender", "equality", "talent", and "innovation" in their reports demonstrate a higher annual ROA compared to those that rarely used these terms. To explore this, we used existing datasets with reports and performance metrics from 348 companies, covering the years from 2009 to 2021. In order to better examine differences, we then selected companies whose ROA significantly differed from the average (either higher or lower), allowing for a more pronounced examination of the impact of ESG term usage on financial performance. The filtered dataset consisted of 107 companies, with a total of 427 reports; split into two sections representing higher and lower performing companies. We then used an existing list of ESG terms derived from a range of separate data sources, and applied a basic statistical n-gram language model to extract the probabilities of each ESG term's occurrence in each of the higher- and lower-performing dataset sections. Results show that while certain sets of ESG concepts correlate with higher financial performance, others do the opposite, and give some initial interpretation into the light this sheds on company reporting behaviour.

KEYWORDS

financial report analysis, language modelling, environmental, social and governance reporting

1 INTRODUCTION & RELATED WORK

There is increasing interest in the behaviour of companies in the area of Environmental, Social and Governance (ESG) criteria, including a company's environmental impact (Environmental), relationships with the community including employees, suppliers and customers (Social), and leadership structures including executive pay and shareholder rights (Governance). Although until recently, ESG analyses were almost entirely performed manually by experts (see e.g. [10]), there has been a large amount of work in the last few years on applying computational machine learning and statistical methods to ESG analysis (see e.g. the recent review by Lim [9]).

However, much of this analysis examines numerical company performance data and categorical metadata; our interest is in developing and applying natural language processing (NLP) technologies to not only help automate analyses, but allow understanding of how human actors discuss and understand the important and meaning of ESG aspects.

Application of NLP in finance is not new: for example, topic modelling has been used to predict company performance and investigate strategies [14, 7]. Recent work also includes application to ESG aspects: Nugent et al. [12] automatically extract news about ESG controversies, and Lee et al. [8] analyse sentiment on ESG issues. Closer to our interests, Purver et al. [13] investigated how the use of ESG terms by companies has changed over time. By analysing and annotating a set of existing resources, they defined a set of 93 ESG terms categorised into 5 core ESG areas. They then showed how these terms can be used to analyse changes in reporting, by analysing a collection of company annual reports, collated over a period of 8 years, using language modelling and distributional methods to reveal changes in the frequency and in the usage of the ESG terms.

Here, we are interested not in changes in ESG discussion over time, but in whether and how the reporting of ESG aspects is connected to financial performance. We take Purver et al. [13]'s resources and methods as a starting point, but augment the financial report text data with available metadata on financial performance, allowing us to compare how ESG reporting varies between more and less well-performing companies.

2 DATA AND METHODS

2.1 Hypotheses

In general, we expect increased probability of appearance of ESG terms in the annual reports from the more profitable firms, based on a number of factors. In general, overall high ESG performing companies exhibit high financial performance [1, 5]; although we note that the link between high ESG score performance and mention of ESG terms is not guaranteed to be straightforward. More specifically, during the period between 2010-2020 analysed here, there was a growing emphasis on corporate social responsibility (CSR) and sustainability. Investors, consumers, and other stakeholders increasingly prioritised companies that demonstrated a commitment to innovation, diversity, and environmental sustainability [11, 2]. Busru and Shanmugasundaram [3] find that firms closely engaging in fostering innovation, attracting top talent,

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Year	# Reports	# Words
2012	178	12.5M
2013	181	14.0M
2014	184	15.0M
2015	196	16.3M
2016	198	17.5M
2017	200	18.4M
2018	200	19.6M
2019	202	21.2M
total	1539	134.6M

Table 1: Number of annual reports available by year

promoting gender and diversity initiatives, could confer a competitive advantage over the industry peers. Furthermore, some policy and regulatory changes (e.g. the 2018 UK Corporate Governance Code, the 2014 EU Directive on Non-Financial Reporting, Carbon Disclosure Project (CDP)) directly or indirectly encouraged companies to address issues related to diversity, gender equality, and environmental sustainability.

2.2 Data and pre-processing

To test this hypothesis, we build on the resources and methods of Purver et al. [13], who provide a dataset of annual reports from FTSE350 companies over the years 2012-2019, based on the FTSE350 list as of 25th April 2020 and obtained from the publicly accessible collection at www.annualreports.com. The reports are already converted to plain text, and we use their publicly available tools to tokenize the collection into words and build ngrams of length 1-4 padded with sentence start and end symbols; the dataset size is reported in Table 1 below (taken from [13]). We use their set of ESG terms, defined via a process of extracting candidate terms from a set of public ESG definitions and taxonomies, asking financial expert annotators to label them as to their representativeness as ESG terms and their ESG subcategory, and keeping the terms with high inter-annotator agreement (see [13] for details).

2.3 Financial performance analysis

The reports were then linked to financial indicators for the respective year and company. The data on company fundamentals was obtained from the Refinitiv EIKON Datastream.[1] Each entry contained annual financial indicators, as well as the companies' industry and sector codes. The main variable of interest was normalized, averaged *return on assets (ROA)* as defined below:[2]

$$\frac{\begin{array}{l}NetIncome - BottomLine \\ +((InterestExpenseOnDebt - InterestCapitalized) \\ \times(1 - TaxRate))\end{array}}{AverageOfLastYear'sAndCurrentYear'sTotalAssets}$$

After extracting financial reports with available ROA data, we categorized the financial reports into two groups, in order to examine differences in the associated reports' use of ESG terms. The distribution of ROA shows a heavy concentration around the mean, so in order to derive two distinctive groups we took the two extremes and excluded the central group around the mean. The 'negative' group comprised reports with a yearly ROA less than -0.2, indicating very poor performance. Conversely, the 'positive' group included reports with an ROA of at least 0.2, reflecting very good yearly performance.

Subsequently, we employed a statistical n-gram language model (using NLTK[3]) to analyze the occurrence of each ESG term. For each term, we calculated the probability of its occurrence in positive reports (p_+) and in negative reports (p_-), and the difference ($p_+ - p_-$). Terms with a large difference in these probabilities are more strongly associated with positive reports than with negative ones, and vice versa: terms with a large negative difference are common in negative reports but rare in positive ones. We conducted this analysis for both unigrams and bigrams.

3 RESULTS AND DISCUSSION

The results for 1- and 2-grams are shown in Figures 1 and 2 below (3- and 4-grams showed no clear interpretable associations).[4] As hypothesized, many ESG terms show a strong association with positive performance, with many of these being core terms associated with human resources (*innovation*, *talent*), with social aspects (*gender*, *diversity*), environmental aspects (*renewable*, *carbon footprint*, *environmental impact*) and overall ESG descriptors (*ethical*). However, many terms are conversely (and contrary to our general hypothesis) associated with negative performance, including, again, terms across various ESG categories including environmental (*carbon emissions*, *energy efficiency*, *greehouse*), human resources (*mental health*, *wellbeing*) and general ESG descriptors (*governance*).

However, by combining these terms with recent work in clustering and describing ESG terms [4], we can shed more light on which categories seem to be more positive and which more negative. Ferjancic et al. [4], using the same dataset and ESG term list [13], perform a further topic analysis using BERTopic [6], in which they derive 30 ESG-related topics and 6 higher-level clusters of ESG concepts; they then examine the correlations between these ESG topics and company ESG scores as obtained from external analysts. We align our ESG terms with Ferjancic et al. [4]'s 30 topics by matching against the words most associated with each topic (if a term appears in the top 10 words associated with a topic, we take the term and topic as aligned); we can then compare our positive/negative associations with Ferjancic et al. [4]'s correlations with company ESG scores. Table 2 shows this alignment for our most positive and negative bigram terms here, with the topic labels and an indication of the strength and direction of correlation with overall company ESG scores, as given by [4].

Given this, we see some systematic groupings. *Climate change*, as part of the 'climate risk and policy' topic, as well as *supply chain* and *human trafficking* as part of the 'human rights' topic, represent the themes that appear to be, across different industries, related to high company ESG scores. A similar observation holds for *gender balance*, *gender pay* and *environmental impact*, which all fall in a group of topics which are strongly and significantly correlated with high ESG scores throughout different industries. Overall high ESG performing companies exhibit high financial performance [1, 5], therefore our results for terms such as *climate change*, *supply chain* and *human trafficking* are not surprising: as indicators of topics associated with high ESG, they are good terms for tracking these ESG aspects associated with high financial performance.

[1] https://www.refinitiv.com
[2] We use this normalization and averaging to smooth and remove one-off effects.
[3] https://www.nltk.org/
[4] Note that these figures show differences in absolute probabilities: magnitudes are comparable within 1-grams, and within 2-grams, but not between 1- and 2-grams.

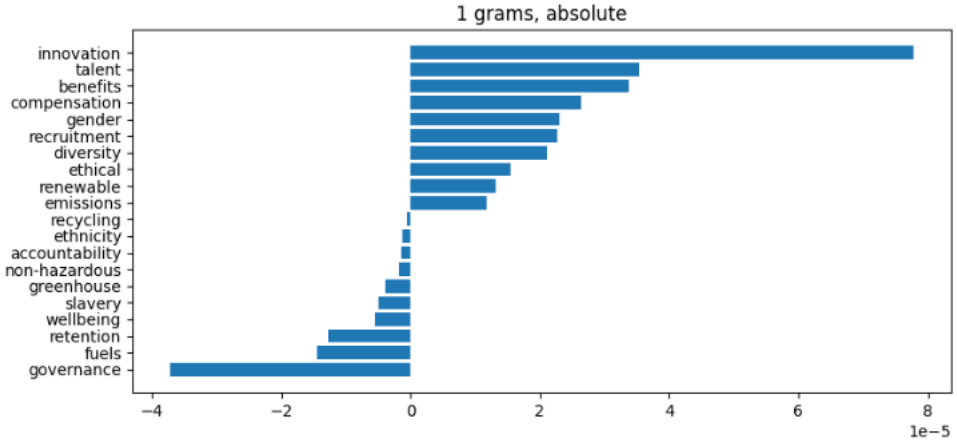

Figure 1: Difference in probability between positive and negative reports $p_+ - p_-$ for the most positive and negative unigram ESG terms.

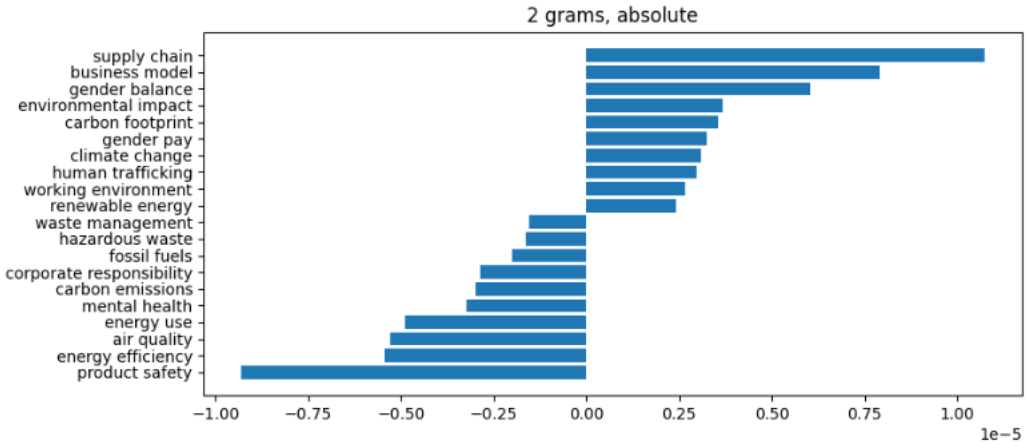

Figure 2: Difference in probability between positive and negative reports $p_+ - p_-$ for the most positive and negative bigram ESG terms.

Looking at the terms with low values which are associated with low RoA, *waste management* and *corporate responsibility* are associated with topics, for which in some industries proportion of these correlate with ESG scores significantly positively and in other industries this correlation is significantly negative. Based on overall correlation between ESG scores and topic proportions across different industries, these two topics are among the third of the topics for which negative correlation between the topic proportion and ESG score prevails. Due to the aforementioned correlation between ESG and financial performance it is therefore understandable that these terms are associated with mention in annual reports of companies with low RoA. Overly extensive discussion on specific topics (such as 'waste management' and 'corporate responsibility') can negatively impact ESG score (see [4]) which can by analogy of ESG and financial performance [1, 5] hold for companies with low RoA.

There is a surprising number of bigrams in both the high RoA and low RoA groups which seem to be associated with the same topic, namely 'climate footprint and energy management'. For companies with high RoA, these terms are *carbon footprint* and *renewable energy*, and for companies with low RoA, the terms are *fossil fuels*, *carbon emissions*, *energy use*, *air quality* and *energy efficiency*. It seems that better performing companies use *carbon footprint* instead of *carbon emissions*, and discuss more on the use of *renewable energy* than on *energy use*, *energy efficiency* and/or *fossil fuels*. In future work, we plan to analyse the use of these terms in more depth, including analysis of the lexical and topical contexts in which they appear, and adding techniques such as sentiment and topic analysis to shed more light on these distinctions.

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2 grams	Term/ROA correlation	Topic	Topic/ESG correlation	score
Supply chain	+	Human rights	++	
Business model	+	Customer services, People and culture	+; -	
Gender balance	+	Diversity and inclusion	++	
Environmental impact	+	General ESG	+	
Carbon footprint	+	Climate footprint and energy management	=	
Gender pay	+	Diversity and inclusion	++	
Climate change	+	Climate risk and policy	++	
Human trafficking	+	None directly related, in broader context in Human rights	++	
Working environment	+	People and culture	-	
Renewable energy	+	Climate footprint and energy management	=	
Waste management	-	Waste management	–	
Fossil fuels	-	No explicit match; contextually appears in Climate footprint and energy management	=	
Corporate responsibility	-	Corporate governance	–	
Carbon emissions	-	Climate footprint and energy management	=	
Mental health	-	Health and safety	+	
Energy use	-	Climate footprint and energy management	-	
Air quality	-	No explicit match; contextually appears in Climate footprint and energy management	-	
Energy efficiency	-	Climate footprint and energy management	-	
Product safety	-	Health and safety	=	

Table 2: Selected ESG terms with their ROA correlation direction (+/−), topic according to [4], and topic/ESG score correlation strength (+ + /+/= /−/−−) as calculated by [4].

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Classification of Patents Into Knowledge Fields: Using a Proposed Knowledge Mapping Taxonomy (KnowMap)

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Abstract

Various platforms, including patent systems and repositories like GitHub and arXiv, support knowledge dissemination across domains. As knowledge increasingly spans multiple disciplines, there is a need to track innovations that intersect various fields. Despite available data, a comprehensive knowledge taxonomy for effectively tracking innovations across domains is lacking. Developing such a taxonomy and employing automated classification methods will enhance the ability to track shared knowledge.

In this work, we first developed a knowledge taxonomy based on the CPC schema. We formulated the classification of textual data into defined knowledge fields as a multi-label problem. Then, we evaluated the effectiveness of the classification models by fine-tuning pre-trained transformer language models. The multi-label framework enables the tracking of knowledge trends at the intersection of various disciplines.

Keywords

Knowledge Taxonomy, Knowledge Tracking, Patent Classification, Hierarchical Classification, Multi-label Classification

1 Introduction

According to the World Intellectual Property Organisation (WIPO), a patent is an exclusive right granted for an invention, providing legal protection to the inventor while simultaneously benefiting society by making the invention publicly accessible [1]. Each year, patent offices receive numerous patent applications that need to be processed [13].To ensure the novelty of patent applications, inventors should also be able to search existing patents. Organising patents with unique codes in a hierarchical structure aids efficient retrieval and aligns with natural human navigation, starting from broad categories and narrowing down to specifics[21]. Among these hierarchical structures, the CPC system is widely recognised [6]. The CPC codes are organised as a taxonomy, meaning that each entity in the lower level is the detail group of the parent. A patent can be assigned to one or more labels by the experts in patent offices [8, 18]. In the first level of the CPC hierarchy, there are nine sections, which are divided into classes, subclasses, groups, and subgroups. Each level of this hierarchy can have several codes ending in approximately 250,000 classification labels [11]. An example of the hierarchical structure of CPC code is provided in Tab. 1.

The CPC schema's top level has only nine sections, but the number of groups increases substantially at lower levels. In this study, we created a knowledge field taxonomy by merging CPC's detailed classes into a more abstract representation. This taxonomy not only serves as a framework for knowledge representation but also offers a benchmark for patent classification systems. While some studies address the issue of numerous class labels by excluding less-represented classes or truncating hierarchies [24], a consistent benchmark taxonomy has been lacking. Since our proposed knowledge taxonomy aligns with the CPC schema, it is able to provide a benchmark for future studies, facilitating the comparison of different models.

In summary, our paper's contribution is the proposal of a knowledge field taxonomy, KnowMap, which aligns with the widely used CPC schema. The KnowMap merged several class labels within the CPC schema based on the scope of the knowledge field and the number of patents associated with each class. The KnowMap taxonomy is available online [2]. In this study, we also performed a classification task to categorise patents into the fine-grained classes defined by our proposed taxonomy.

Table 1: Example of a sequence of codes across different levels of the CPC hierarchy

CPC	Code	Title
Section	H	Electricity
Class	H03	Electronic circuitry
Subclass	H03C	Modulation
Group	H03C3/00	Angle modulation
Subgroup	H03C3/005	Circuits for asymmetric modulation

2 Related Work

Patent documents contain various types of information, including text, diagrams, plots, and references to other patents or scientific publications [20]. The textual content of a patent is divided into several sections, such as the title, abstract, claim, and description [11]. The title and abstract are shorter than the description but still provide relevant information for classification. Li et al. [15] evaluated various lengths of the abstract and title, finding that using the first 100 words of title and abstract resulted in the best classification performance in their study.

Various classification systems exist for organising patents [6]. In this work, we focus on the CPC schema. The hierarchical representations help organise patents and facilitate efficient searching. Kamateri et al. [11] discussed several potential challenges that artificial intelligence technologies face in patent classification. One such challenge is the extensive number of class labels. As an example, the IPC contains approximately 86,000 classes, while the CPC has around 250,000.

Patent classification is a multi-label classification problem since every patent can belong to several knowledge fields [18,

[1] https://www.wipo.int/portal/en/

[2] https://github.com/elmotamedi/KnowMap-Taxonomy

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10]. Given the large number of classes at the lowest level of the taxonomy tree, the performance of automatic models in predicting such granular categories is limited. Various models have been used to classify patents in a multi-label setting, ranging from classical machine learning models to deep learning models [15, 5, 8]. Several previous studies have focused on higher levels of the hierarchy, limiting classification to broader categories such as sections, classes, or subclasses within the taxonomy [3]. Bekamiri et al. [3] fine-tuned the SBERT model to predict labels at the subclass level (i.e., 663 class labels) using a multi-label formulation. They achieved F1-score of 66%, outperforming previous studies that used the same datasets. Aroyehun et al. [1] similarly truncated the IPC hierarchy at the subclass level and predicted these labels by transferring knowledge from two higher levels (section and class) to the lower level (subclass), achieving a precision score of 0.53. While it remains valuable for patent office experts to use an automatic model that can narrow down applications to higher levels of the taxonomy tree, this approach has limitations and challenges. One such challenge is that the choice of target class labels does not depend on the scope of the knowledge area. More established and expansive areas may benefit from directing experts to detailed groups, while less developed areas may be adequately served by broader classifications.

3 Methods and Materials

In this work, we developed a knowledge taxonomy and classified patents into fine-grained classes by fine-tuning pre-trained models. Below, we outline the methods and materials used.

3.1 Patent Collection and Preprocessing

The dataset used in our experiments is the Google Patents Public Datasets on BigQuery [3]. Each patent has several pieces of information, including the publication number, application number, CPC code, title, abstract, and detailed description. We have expanded the dataset to include the titles associated with each CPC code from Espacenet. [4]. In this study, we focused on the textual data. We generated the input text by concatenating the title, followed by the abstract, and then the description. We included only those documents where the concatenated text is at least 100 words long. Previous studies have examined various lengths of textual data and found that using the first 100 words often results in higher performance for classification tasks [15].

To create a hierarchical structure where we have enough documents among leaf-node labels (i.e., avoiding scenarios where one group contains only a few hundred documents while others contain hundreds of thousands as an example), we needed to count the number of documents which fall into the defined categories. As a preprocessing step before counting, we performed de-duplication, which involved removing duplicate and near-duplicate textual data [4, 12, 14].

Due to the large size of the dataset, we employed MinhHash Locality Sensitive Hashing (LSH) as a deduplication method to efficiently identify similar documents [7, 9, 22]. Specifically, we used MinHash to approximate the Jaccard similarities between sets of n-grams within the documents. MinHash is particularly advantageous for large datasets because it supports parallel computation, enhancing scalability [2]. We set the similarity threshold at 0.9, meaning that documents with a Jaccard similarity of 90% or higher were considered duplicates. To generate the hash signatures in MinHash, we used 128 permutations. For the n-gram representation, we used a range of 1 to 3, incorporating 1-grams, 2-grams, and 3-grams.

3.2 Refining Hierarchical Structure Through Group Merging

The hierarchical structure of the CPC groups was refined at each level of the tree. We started with nine sections at the top level (i.e., *level 1*), which were preserved. At subsequent levels (i.e., *level 2* to *level 4*), groups were merged by manual analysis based on shared knowledge and the number of documents. Groups with relatively few documents (i.e., groups with fewer than 40,000 for *level 2*, 20,000 for *level 3*, and 9,000 for *level 4*) were combined with other groups at the same level that shared similar knowledge. As an example, at the subclass level of the CPC hierarchy, "A01B" (i.e., Soil working) and "A01C" (i.e., Planting, Sowing, Fertilising) represent related steps in agricultural practices, as both are foundational processes in land preparation and management. We merged them into a single group labelled "Soil working and planting," resulting in 162,567 patents in this category. The refinement continued until the fine-grained classes contained at least 9,000 documents.

3.3 Text Classification

We formulated the classification problem as a multi-label problem, in which each document can be assigned to multiple knowledge fields. In this study, we aimed to classify the patents into the fine-grained classes in the lowest level of the proposed taxonomy (i.e., 83 classes). To balance performance and computational cost given the large size of the dataset, We used the pre-trained language models *distilroberta-base*, a distilled version of RoBERTa [16, 19], and *all-MiniLM-L6-v2*, a version of MiniLM fine-tuned for semantic similarity [22, 17]. The pre-trained models were fine-tuned for the downstream task by adding a classification head. The classification head takes the hidden state of the first token from the model and processes it through a fully connected dense linear layer, followed by a dropout layer for regularisation and a tanh activation function for non-linearity. Since our task is multi-label classification, the output logits for each class are converted into probabilities using a sigmoid function.

For model training, we used a learning rate of 4e-5 with a linear scheduler and a weight decay of 0.1. To prevent overfitting, the best checkpoint was selected based on evaluation metrics on the validation set. We trained the model for up to 5 epochs with early stopping criteria based on validation accuracy. The dataset, consisting of 1,092,991 samples randomly selected after deduplication, was split into training, validation, and test sets with ratios of 0.8, 0.1, and 0.1, respectively. To preserve the ratio of samples per class in training, validation, and test sets, we used stratified splitting [5].

3.4 Classification Evaluation

The F1-score is a common metric for classification tasks. We report both Micro-F1, averaged across all instances, and Macro-F1, averaged across all classes.

4 Results and Analysis

In this section, the results are presented in two parts. First, we present our proposed KnowMap taxonomy. Then, we report the

[3]https://github.com/google/patents-public-data
[4]https://worldwide.espacenet.com/
[5]https://github.com/trent-b/iterative-stratification?tab=readme-ov-file#multilabelstratifiedkfold

performance of classifiers in categorising patents into the fine-grained classes of this taxonomy.

4.1 The Proposed Knowledge Mapping Taxonomy (KnowMap)

The taxonomy, along with the associated CPC sections, classes, subclasses, groups, and subgroups are provided in the shared online source. An example of detailing the knowledge field of *soil working and planting* within the broader knowledge field of *human necessities* is illustrated in Fig. 1.

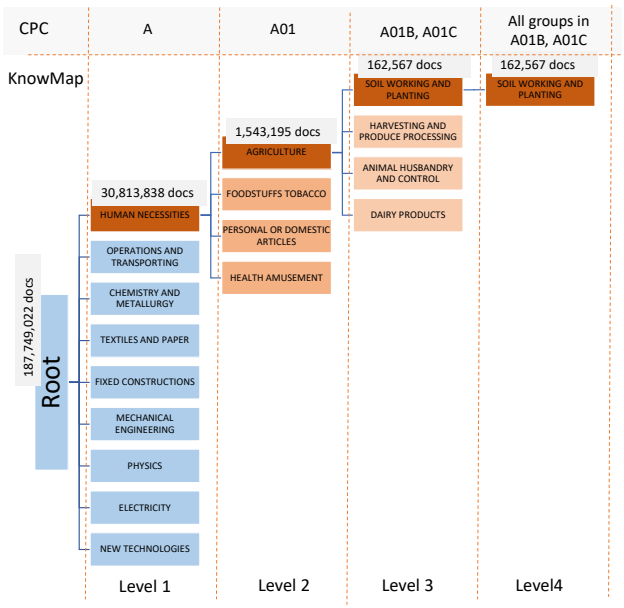

Figure 1: An example of a branch extension in KnowMap from the root to the lowest level, showing the association of KnowMap classes with corresponding CPC classes at each level.

4.2 Classification Results

The classification task in this study was to classify patents into 83 fine-grained classes within our proposed KnowMap taxonomy. The dataset comprised 1,092,991 documents, which were split into the train, validation, and test sets with a ratio of 0.8, 0.1, and 0.1 respectively. We preserved the ratio of samples per class in all three sets with stratified splitting. The average number of documents in the train set, validation set, and test sets are presented in Tab. 2.

Table 2: Overview of sample metrics: total number of samples, average number of samples per class, and normalised average number of samples per class across training, validation, and test sets.

Set	Total	Avg/ class	Normalised Avg
Train	1,092,991	132,202	0.012
Val	874,372	16,476	0.012
Test	218,619	15,543	0.012

Table 3: Classification Results

Metric	RoBERTa	SBERT
Micro-F1 (Val)	0.76	0.76
Macro-F1 (Val)	0.86	0.86
Micro-F1 (Test)	0.77	0.76
Macro-F1 (Test)	0.90	0.90

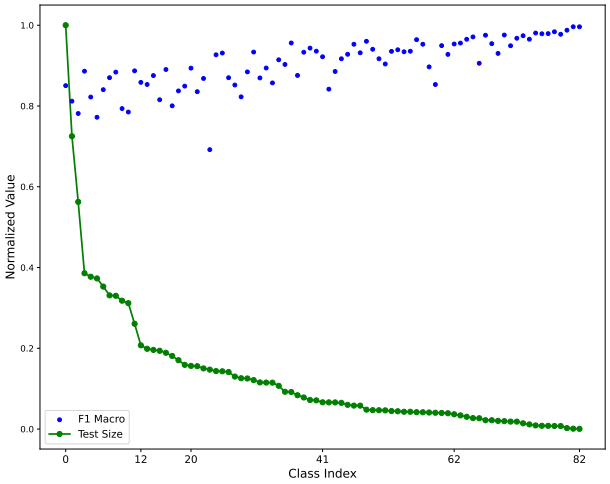

Figure 2: Normalised test size along with F1 Macro scores for each class. The x-axis represents class indices. The y-axis shows normalised values for test size and F1 Macro scores (blue dots).

We demonstrated the experimental results on the two classification models *RoBERTa* and *SBERT* in Tab. 3.

As observed from the results, the Macro-F1 score is higher than the Micro-F1 score, which may indicate that the model performs better for minority classes compared to majority classes. To gain more insights into these results, we generated a plot (see Fig.2), showing the F1 scores along with the normalised number of documents for each class in the test set. We used normalised values to allow both F1 scores and class sizes to be displayed in a single figure, facilitating better comparison.

The plot shows that the Macro-F1 score is higher for minority classes than for majority classes, also indicating that random sampling led to an unbalanced dataset. The imbalanced sample likely caused the higher Macro-F1 score relative to Micro-F1, reflecting poorer performance in the majority classes. Future work will focus on using balancing techniques when sampling to address this issue and enhance model performance.

When looking more closely at the lowest F1-Macro scores, we found that the bottom 10 classes were all leaves under the *chemistry and metallurgy* section. Moreover, the highest F1-Macro scores (0.996) were achieved by the two classes in the *textiles and paper* section, followed by all 17 leaves from the *physics* section. We suspect this performance difference may be due to greater variation in the textual data of *chemistry and metallurgy* class compared to *physics* and *textiles and paper*, leading to more variation between the training and test sets. Analysing this variation in detail remains a task for future work. Additionally, we believe future work could benefit from adapting the classifier to a hierarchical structure, prioritising correct predictions at higher

levels before refining predictions at the leaf level. In our current approach, the classifier does not account for the hierarchy and predicts all leaves directly.

5 Discussion and Conclusions

In this work, we proposed a knowledge field taxonomy, KnowMap, which aligns with the widely used CPC schema. The taxonomy consists of 83 groups at the lowest level, with fine-grained classes containing a minimum of 9,000 samples from the original Google Patents Public Dataset after preprocessing. KnowMap serves as a benchmark taxonomy, addressing a gap in the existing literature.

From the preprocessed original dataset, we randomly selected 1,093,151 samples to fine-tune pre-trained RoBERTa and SBERT models for downstream tasks. However, the random sampling resulted in an unbalanced dataset, which contributed to higher Macro-F1 scores compared to Micro-F1 scores. To enhance classification results, we plan to create a balanced dataset from the original data. Additionally, we aim to use larger models than those used in this study to further improve the fine-tuning process.

6 Future Work

Several knowledge platforms, such as news sites and GitHub, host various types of information shared online. In future work, we aim to incorporate these sources to extend and enhance the knowledge taxonomy's coverage. For example, the All Science Journal Classification (ASJC), which organises research publications by subject area, can be used to identify alignments with the existing taxonomy. This taxonomy alignment can then be further analysed to determine whether to merge or split classes at various levels. Beyond patents, we plan to evaluate the classifier on other data, using domain adaptation methods to transfer knowledge from the labelled patent domain to those with limited or no labels. Large language models (LLMs) could further aid in evaluating the classifier's performance across different domains. Recent research has shown the potential of LLMs to augment or even replace human-labeled training data with labels generated by these models [23].

Moreover, we plan to enhance the classification task by balancing the dataset using balancing techniques for multi-label problems and leveraging larger pre-trained models. we will also closely examine the different knowledge fields to better understand the variations in classifier performance across them.

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Enhancing causal graphs with domain knowledge: matching ontology concepts between ontologies and raw text data

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ABSTRACT

When building a causal graph from textual sources, such as media reports, a key task is to provide an accurate semantic understanding of the causal variables encoded as nodes and to link them to existing ontologies with at least two purposes: (i) expand the knowledge with the domain knowledge captured in such ontologies and (ii) provide accurate and different levels of abstraction of the extracted causal variables. This article describes how we used OntoGPT, a tool for matching raw text to ontology concepts initially designed for the medical domain, to match concepts from media events to relevant ontologies. We build upon our previous work on extracting causal variables and enrich the extraction pipeline by matching causal variables to concepts from specific domain ontologies. In particular, we describe our work regarding the GEO ontology. Future work will focus on expanding OntoGPT's capabilities by utilizing a wider selection of ontologies. Addressing its limitations, such as dealing with multiple instances of the same class, will also be crucial for improving its utility. These improvements will allow the tool to better support strategic foresight applications by providing more detailed insights across a multitude of different sectors, further enriching causal graphs and facilitating more accurate predictive modeling.

KEYWORDS

strategic foresight, ontology matching, artificial intelligence

1 INTRODUCTION

Strategic foresight is a discipline concerned with anticipating future trends, uncertainties, and disruptions to inform decision-making and enable the creation of resilient, long-term strategies. As such, it is valuable to governments, organizations, and enterprises, who can use it to remain competitive and adaptable in a rapidly changing world [4].

The pace of technological advancement, shifting geopolitical landscapes, environmental crises, and unpredictable market trends make it essential to react quickly to change. Traditionally, foresight has been based on trend analysis, expert opinion, and qualitative insights. Such approaches lack the agility required to scan real-world events in near-real time and produce strategic foresight outcomes at such a pace. Nevertheless, this would be possible with the use of artificial intelligence.

AI enhances strategic foresight by automating the analysis of data and detecting patterns that may go unnoticed by human experts [1]. Machine learning algorithms can continuously monitor emerging trends, geopolitical shifts, and market fluctuations in near-real time, offering dynamic insights into potential future scenarios. Natural language processing (NLP) enables AI to sift through massive amounts of text, extracting relevant information from reports, news, and social media, thus accelerating the forecasting process. By integrating AI into strategic foresight, organizations can adapt more swiftly and make more informed, data-driven decisions in the face of uncertainty.

Ontologies provide structured knowledge informing the relationships between concepts within a specific domain. Furthermore, they describe those concepts through properties and can link such classes to specific instances observed in the real world. As such, they are of key importance when building a causality graph, given they can augment our understanding of the causal relationships between variables with a better understanding of the context and the variable implications [3]. For example, if the causal relationship reports about the ceasing of an armed conflict, knowing whether a causal variable relates to a country, the location of that country, the neighboring countries, and international organizations it is involved in would help to understand the magnitude of that event and contextualize other likely outcomes (refugee repatriation, impacts on investments, and others).

In the scope of the graph massive project, ontology matching is being used to link the extracted causal relationships from text to concepts inside the ontologies, allowing for a more detailed understanding of the concepts that appear in causal relationships and their interconnectivity.

2 ENRICHING CAUSAL GRAPHS WITH DOMAIN KNOWLEDGE

We consider ontologies a framework (an organized and structured system for representing knowledge) used to represent knowledge within a specific domain by defining the relationships between concepts. They consist of classes (concepts), properties (attributes), and relationships that connect different concepts. This structure provides a standardized way to organize and interpret data, ensuring consistent understanding across systems. For example, in a medical ontology, concepts like "disease" might be linked to "symptoms," "treatments," and "causes," each with its own defined properties. By formalizing these relationships, ontologies allow AI systems to better interpret and reason about

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complex information, leading to more accurate data processing and decision-making.

Ontologies enhance causality graphs by providing domain-specific knowledge that improves the accuracy and depth of relationships represented. When extracting causal relationships from large datasets, such as media reports, the data can often be ambiguous or incomplete. Ontologies address this by offering structured knowledge that defines concepts and their relationships within a specific domain, linking extracted causal relationships to well-defined entities in the ontology. This enriches the causality graph, uncovering implicit connections and non-obvious relationships that may otherwise be missed. In strategic foresight, for example, ontology-based enrichment helps capture a broader range of potential future scenarios by incorporating knowledge beyond the immediate dataset. This leads to more reliable predictions, especially when the training data is limited or domain-specific. Ultimately, ontologies are expected to enable the system to generalize better, predict outcomes with higher accuracy, and improve the overall reliability of causality graphs.

The causality graph pipeline in the Graph Massivizer strategic foresight project is designed to automate the extraction, organization, and analysis of causal relationships from large datasets, particularly news articles. The Figure 1 showcases the structure of our causality graph's data pipeline. The process begins with extracting these relationships from news articles, which are then organized into a causality graph that maps the interactions between various factors and events. The goal is to develop link prediction models that estimate the likelihood of future events based on observed patterns. For instance, one use case involves predicting oil price trends by analyzing factors that influence pricing.

Ontology matching is then integrated into the pipeline to link extracted causal relationships with concepts from structured ontologies. This enrichment adds layers of context and enables the discovery of connections that may not be evident from raw data alone. By incorporating ontologies, the pipeline transcends the limitations of its training data, identifying causal relationships that may be implied by broader knowledge contained in the ontologies. This not only enhances the accuracy of the graph but also allows it to capture more complex and non-direct relationships, improving its predictive capabilities.

As shown in Fig. 1B, the process of ontology linking in our pipeline consisted of creating ontology matching templates, then linking the concepts in text to ontologies, using the information to add additional data to existing causalities, all with the purpose of finding extra implicit connections based on the information provided by the ontologies.

The main problem that needed solving for that purpose was, how to link ontologies to raw text data. In our case that was done using OntoGPT [2], which is a tool used for ontology linking. Another key challenge is inter-ontology matching, which involves linking multiple ontologies through shared concepts. This process expands the knowledge framework, making it even more valuable for our purposes. The challenge of inter-ontology matching hasn't been addressed yet and remains a matter of future work.

3 ONTOGPT: A BRIEF OVERVIEW

OntoGPT is an advanced tool that integrates large language models (LLMs) with ontologies to improve knowledge extraction and organization across various domains. Ontologies provide a

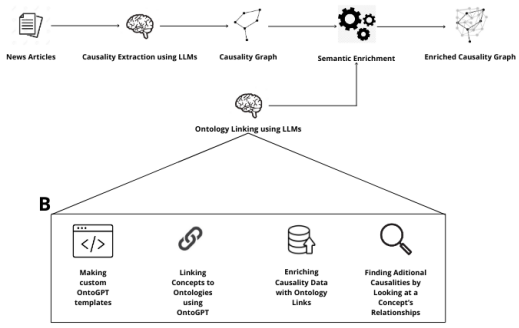

Figure 1: The figure showcases our pipeline for building a causality graph. The sub-figure B showcases how the process of ontology linking was executed as a part of our pipeline

consistent and accurate representation of complex information by defining structured relationships between concepts.

The primary purpose of OntoGPT is to enhance AI systems' understanding, processing, and categorization of data by linking extracted information to predefined concepts and relationships within an ontology. This structured approach ensures greater accuracy and reliability compared to traditional AI systems that rely on unstructured data.

OntoGPT works by connecting data from sources such as text or reports to specific concepts in an ontology, allowing for more informed and contextually accurate connections. For example, in healthcare, OntoGPT can link symptoms from patient records to diseases and treatments outlined in medical ontologies, helping to suggest possible diagnoses or treatment plans.

By combining the language-processing capabilities of LLMs with the structured knowledge available in ontologies, OntoGPT enables AI systems to go beyond keyword matching and consider the relationships between terms. This leads to more intelligent data interpretation and improved decision-making.

OntoGPT is widely used in fields where structured knowledge is critical for high accuracy, such as healthcare, biology, and pharmaceutical research. In medical research, for instance, OntoGPT links clinical trial data, medical records, and scientific literature to medical ontologies, supporting better analysis and decision-making.

The key advantage of OntoGPT lies in its ability to ground AI outputs in domain-specific, structured knowledge, reducing the likelihood of errors and improving the relevance of insights. This grounding ensures that AI responses are not just based on patterns but also on well-defined concepts and their relationships.

In summary, OntoGPT bridges the gap between the raw data-processing power of LLMs and the structured knowledge in ontologies. By leveraging both, it provides a more accurate and reliable approach to extracting and linking data across various domains, particularly when working with large, complex datasets.

3.1 OntoGPT's role

At a lower level, OntoGPT operates using YAML templates that define how data should be extracted from text and linked to ontological concepts. These templates serve as blueprints, specifying which types of entities, relationships, and properties to look for in the input text. The templates guide the large language model by mapping textual data to predefined concepts and relationships

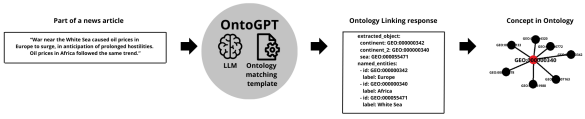

Figure 2: A Showcase of the function of OntoGPT

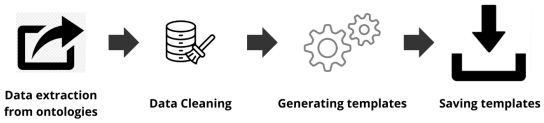

Figure 3: The Process of Templates Generation

from the ontology, ensuring that the extracted information is both relevant and structured. The figure 2 shows the process of ontology linking for an example of a simple sentence. Each YAML template contains detailed instructions on how to identify key terms, their corresponding ontology classes, and the relationships between them. This allows OntoGPT to recognize when a piece of text, such as a sentence from a media article, contains a concept that aligns with an entity or event in the ontology. Once identified, the tool links the extracted data to these ontology entries, enabling richer and more meaningful connections in the data, as it is now grounded in an established knowledge framework.

The approach described in this article uses an ontology file as input to create such templates for data extraction and linking. This enables for a broader range of ontology linking, as the templates can be created on demand.

4 TEMPLATES AND PYTHON CODE GENERATION

The approach works by using the information defined inside the ontology, to generate the YAML templates. The Figure 3 showcases the process of how this is done.

First the class information, for each class inside the ontology, is extracted. This is done by using the "owlready2" python library to parse the ontology into an object, and then extract the relevant information from the new object.

Every class inside the ontology is used to create a corresponding template class, which is optimal, as it covers all parts of the ontology that could potentially be linked. A small portion of the data extraction process is ontology-specific and was custom-tailored to the individual ontology, as some information (like class descriptions) is saved in different parts.

Secondly the data extracted from the ontology is processed and used to create custom YAML templates. This is done by simply using the extracted information to fill in a "general template" we used for generation. Specifically the class names and descriptions are used, to do so. This gives OntoGPT the names of the classes inside the ontology, that we are trying to link the text data to, and their descriptions, which assists OntoGPT in more accurately identifying these classes inside the text. The YAML file also contains the information of "annotators" which tells OntoGPT, which ontology to ground the responses to. The generated YAML templates are saved into a separate file after generation, which makes them ready for use.

The python code that is used by OntoGPT in the process of ontology linking, is similarly generated by using the extracted information to fill in the "general template" and is then saved to a separate file.

5 LIMITATIONS

5.1 Multiple Same-Class Concepts

OntoGPT has problems trying to link two or more concepts to a place in the ontology if the concepts are of the same class. This happens because both concepts suit the description and similar criteria that OntoGPT extracts the information based on. This causes OntoGPT to merge both concepts into a single string and then try to locate the said string inside the ontology, which fails because there is no individual inside the ontology class with such a name. An example of such a response is shown in Listing 1:

Listing 1: Example of a bad response

```
extracted_object:
  continent: AUTO:Europe%2C%20Africa
named_entities:
  - id: AUTO:Europe%2C%20Africa
    label: Europe, Africa
```

If OntoGPT managed to locate the concept inside the text in the ontology, it returns its id (an example of this is "sea: GEO:000055471" and "id: GEO:000055471 : White Sea") If the concept suits the class criteria, but couldn't be located inside the ontology, it returns it as a "AUTO" detection. For the purpose of ontology linking this is not optimal as it does not give us access to the additional information that is stored inside the ontology's individual information. The ontology's individual information is a set of predefined relationships and properties, that an individual concept has. For example, if the individual "Africa" is defined inside the ontology, the individual's data would include its size, countries on the continent, population, and climates, among others. This information gives us reliable information about a certain concept, allowing for more contextual understanding.

To solve this problem, the approach of creating "buffer" classes was taken, where a certain class from ontology would be used to generate three classes describing the different occurrences of the ontology class and a description that would provide sufficient context to OntoGPT to separate the same class concepts into different entities. The corrected response is showcased in Listing 2:

Listing 2: Example of a corrected response

```
extracted_object:
  continent: GEO:000000340
  continent_2: GEO:000000342
named_entities:
  - id: GEO:000000340
    label: Africa
  - id: GEO:000000342
    label: Europe
```

While this approach deals with a high percentage of this type problem, it does not cover the cases where more than three same-class concepts are inside the piece of text being analyzed.

6 CONCLUSIONS

Using OntoGPT in the Graph Massivizer strategic foresight project will prove valuable for enriching causal graphs with linked ontology data, aiming to improve predictive accuracy in predicting future events. Despite OntoGPT's initial focus on medical data, some custom adaptations were successfully implemented to suit a portion of different domains. However, limitations persist in distinguishing between multiple instances of the same concept class. These challenges highlight the need for further development to enhance the tool's versatility across a broader array of applications and ontologies.

ACKNOWLEDGMENTS

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Measuring and Modeling CO_2 Emissions in Machine Learning Processes

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Abstract

With the rapid expansion of the computing industry, efficient energy utilization and reduction of CO_2 emissions are critically important. This research develops analytical tools to predict CO_2 emissions from various machine learning processes. We present a novel methodology for data acquisition and analysis of CO_2 emissions during model training and testing. Our results demonstrate the environmental impact of different algorithms and provide insights into optimizing energy consumption in artificial intelligence applications.

Keywords

CO_2 Emissions, Machine Learning, Energy Consumption, Environmental Impact, AI Model Optimization, Green AI, Sustainable Computing, Carbon Footprint

1 Introduction

The global computing industry significantly contributes to CO_2 emissions, with data centers accounting for 2.5 to 3.7 percent of global greenhouse gas emissions [1]. These emissions exceed those of the aviation industry due to continuous operations and heavy reliance on fossil fuels [11]. Given the growing demand for artificial intelligence (AI) applications, there is an urgent need for CO_2-conscious solutions.

This research aims to develop tools for predicting CO_2 emissions associated with machine learning processes, thus enabling the reduction of the environmental impact of AI models. In collaboration with Eviden (Spain) and under the FAME EU project, we have developed a CO_2 emissions analysis system using tools like CodeCarbon [2] and eco2AI [3].

1.1 Research Goals

The primary goal of this research is to develop a service that predicts CO_2 emissions and power consumption of different machine learning models during both training and evaluation phases with emphasis on hyperparameter dependency. The CO_2 emissions are measured in kilograms per second ($\frac{kg}{s}$) , while the power consumption is measured in kilowatt-hours (kWh).

While existing services, such as CodeCarbon [2] or eco2AI [3], provide real-time measurement of emissions, they do not offer insights into a model's emissions before its construction or use. The service we aim to provide addresses this gap by offering an estimation of emissions and power consumption for different models before they are selected for specific use cases. This forward-looking approach allows for more informed decisions when choosing models, potentially reducing their environmental footprint.

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2 Related Work

The environmental impact of machine learning models has been a growing concern in recent years. Several studies have focused on quantifying and reducing the carbon footprint of artificial intelligence (AI) processes. For instance, [12] highlighted the energy consumption of training large neural models and suggested methods for minimizing emissions. Similarly, tools like CodeCarbon [2] and eco2AI [3] have emerged to measure real-time CO_2 emissions from computational tasks. However, these tools often lack predictive capabilities for assessing emissions before model selection, as pointed out by. Our work builds on these existing methodologies, concretely on the work of eco2AI[3], by providing a forward-looking approach that estimates emissions during the model selection phase, thus complementing real-time monitoring tools. This is achieved through heavy dependency on eco2AI[3] measuring systems for data collection, later used for modeling based on the collected data and registered hyperparameters.

2.1 Research Gap and Contribution

Despite the growing availability of tools like CodeCarbon [2] and eco2AI [3], a significant gap remains in the preemptive evaluation of environmental impact during the machine learning (ML) model selection phase. The mentioned tools are valuable for post hoc analyses but do not assist ML practitioners in making **informed decisions upfront**—before model development—on the environmental footprint of different model architectures or hyperparameters.

This gap is crucial, as the model selection phase often involves trial-and-error across multiple models and configurations, potentially leading to unnecessary resource consumption. Without predictive capabilities, practitioners have limited insight into which models will have the lowest environmental impact before engaging in resource-intensive training.

Our research aims to fill this gap by introducing a **predictive service** that estimates the environmental footprint of different ML models before they are trained or used. This service leverages the data collected from existing tools like eco2AI [3], incorporating key features such as hyperparameters, and model architecturre into predictive models. By doing so, we enable developers

to make **more sustainable choices** at the model selection stage, reducing carbon emissions from the start of the ML lifecycle.

The table 1 below presents a feature matrix comparing our proposed service with current tools, showing how our approach addresses unmet needs:

3 Methodology

Due to the lack of suitable data on CO_2 emissions of machine learning models, we began by developing an infrastructure for data collection. This infrastructure is composed of the following steps:

- **Dataset Generation:** Creating synthetic datasets using random data generation methods.
- **Data Preprocessing:** Cleaning and preparing the data for analysis.
- **CO_2 Emission Measurement:** Recording CO_2 emissions during both training and testing phases using different machine learning algorithms.
- **Feature Extraction:** Extracting relevant features such as project ID, experiment details, epoch duration, power consumption, and hardware configurations.
- **Adding Hyperparameters to Final Dataset:** Documenting hyperparameters used in each experiment to assess their impact on emissions.
- **Containerization:** Utilizing Docker for containerization to ensure reproducibility and scalability of the experiments.
- **Data Storage:** Storing all datasets, features, and emission records systematically in a database for further analysis.
- **Modeling:** Developing and training machine learning models to predict CO_2 emissions and power consumption.

The software implementation uses Python, with dependencies including pandas [7], scikit-learn [10], matplotlib [5], eco2AI [3], TensorFlow [**abadi2016tensorflow**], Keras [**chollet2015keras**], and Docker for containerization [**merkel2014docker**].

3.1 Dataset Generation

In this step, we created a synthetic dataset by generating random data points using tools like `sklearn.datasets.make_regression` or `make_classification`. The primary objective here is not to reflect real-world data scenarios but to produce a controlled environment where the focus is on measuring CO_2 emissions and power consumption during model training and evaluation. Datasets generated vary in size from ranges of 250 to 15000 samples and 5 to 2000 features. In classification cases additionally the number of classes ranges from 2 to 50. These parameter ranges were selected to mitigate the risk of computational overload, ensuring that the experiments remain feasible within the available computational resources while maintaining the integrity of the analysis.

3.2 Data Preprocessing

Before analysis, the dataset must be cleaned and prepared. This includes handling missing values, normalizing or standardizing data, encoding categorical variables, and splitting the data into training and testing sets. Proper preprocessing ensures that the data is in the optimal format for the models to learn from and minimizes biases that may affect model performance and emission measurements.

3.3 CO_2 Emission Measurement

We measure CO_2 emissions produced during both the training and testing phases of the machine learning models. This involves using tools like eco2AI [3] to track energy consumption and convert it into equivalent CO_2 emissions. The measurements are taken for various models, such as Decision Trees, Random Forests, Logistic Regression, and Neural Networks, to assess their environmental impact under different computational loads.

3.4 Feature Extraction

To gain deeper insights, we extract various features that could impact CO_2 emissions and energy consumption. These features include project identifiers, detailed descriptions of each experiment, the duration of each training epoch, power consumption metrics, hardware configurations (such as the type of CPU/GPU used), and hyperparameters. The project identifiers refer to unique alphanumeric codes assigned to each machine learning experiment upon execution. These identifiers help differentiate between various model configurations and experimental setups. They are generated and stored automatically by our system during the dataset generation process to ensure traceability and reproducibility of the experiments.

3.5 Adding Hyperparameters to Final Dataset

We document the hyperparameters used in each machine learning experiment, such as learning rates, batch sizes, and the number of layers in neural networks. This allows us to evaluate how these hyperparameters influence CO_2 emissions and energy consumption.

3.6 Containerization

To ensure reproducibility and scalability of our experiments, we employ Docker for containerization. This approach encapsulates the code, dependencies, and environment settings, allowing the experiments to be easily replicated and deployed across different platforms.

3.7 Data Storage

All datasets, extracted features, hyperparameter configurations, and CO_2 emission records are systematically stored in a database. This central repository facilitates efficient querying, retrieval, and analysis of data to support ongoing and future research.

3.8 Modeling

In this step, we develop and train machine learning models to predict CO_2 emissions and power consumption based on various features, such as the type of algorithm used, hardware configuration, and model parameters. This modeling allows us to estimate emissions for different machine learning workflows before their actual deployment. The models help identify the most efficient algorithms and configurations, thus guiding the selection of environmentally friendly AI solutions.

The general pipeline for the previously mentioned steps can be seen below (see Figure 1).

A more thorough view of the workings of this can be seen as shown below for running a single measurement (see Figure 2).

4 Model Architecture

In this section, we explain the architecture of the model used for predicting CO_2 emissions and power consumption based on

Tool/Technology	Platform Compatibility	Model Coverage	Metric Granularity	Carbon Metrics	Energy Metrics	Additional Features	Real-time measurement	Forward-looking Prediction
CodeCarbon	Cloud, On-Premise	All ML models	Per training session	CO_2 emissions (kg)	Energy consumption (kWh)	Dashboard Visualization	Yes	No
eco2AI	Cloud, On-Premise	All ML models	Per training session	CO_2 emissions (kg)	Energy consumption (kWh)	Not RAPL based	Yes	No
Proposed Service	On-Premise	Specific models (mentioned bellow)	Per model, per selection phase	CO_2 emissions $\frac{kg}{s}$	Energy consumption (kWh)	Predictive modeling	No	Yes

Table 1: Feature comparison of existing tools and the proposed service

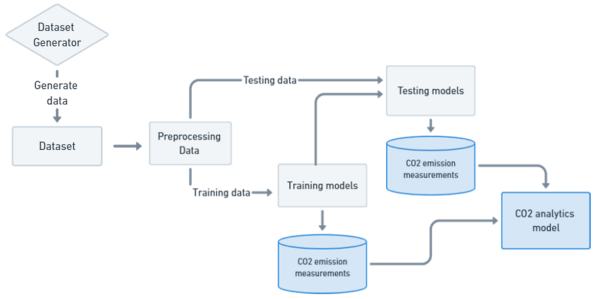

Figure 1: General Measurement Pipeline

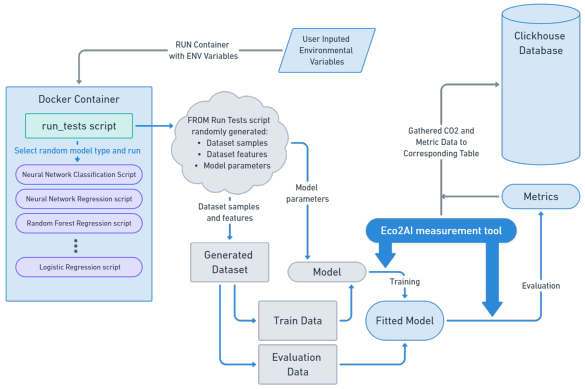

Figure 2: Single Model Measurement Pipeline

various features such as CPU type, GPU type, region, and other experiment-specific details. The model implementation is encapsulated within a Python class named `MultiModel`, which is responsible for managing the entire process from data preprocessing to training and prediction.

The model employs two separate neural networks for predicting CO_2 emissions and power consumption. The architecture for each neural network is as follows:

- **Input Layer:** Receives the scaled and encoded features.
- **Hidden Layers:** Consist of multiple Dense layers with ReLU activation functions. The CO_2 emissions model includes three hidden layers with 128, 64, and 128 neurons, respectively, while the power consumption model has three hidden layers with 64, 64, and 128 neurons.
- **Output Layer:** A single neuron that outputs the predicted value for either CO_2 emissions or power consumption.

4.1 Model Training

The model is compiled using the Adam optimizer [6] and the Mean Squared Error (MSE) loss function. Seeing as we were unable to gather adequate real-time environmental data of factors that may influence our predictions (e.g. Distribution of energy sources, real time CO_2 per kWh), our model relies on static yearly averages of these values[8] [9] . Our model uses the aforementioned features for the purpose of regression with the goal of predicting power consumption and CO_2 emissions gathered by previously mentioned random tests. Each model is trained for 25 epochs using the preprocessed data. After training, the models, along with their respective scalers and encoders, are saved to disk for later use.

4.2 Prediction

Once trained, the model can predict CO_2 emissions and power consumption for new data points by loading the appropriate model, scaler, and one-hot encoder. The input data is preprocessed in the same manner as during training, and the predictions are obtained by applying the trained models.

This modular approach allows for easy extension to additional models or data sources and provides a scalable solution for analyzing the environmental impact of machine learning processes.

5 Web Application Interface for CO_2 Emissions and Power Consumption Prediction

In addition to the backend model developed for predicting CO_2 emissions and power consumption of various AI models, a web application was created to provide a user-friendly interface for real-time predictions. The web app, as shown in Figure 3, allows users to select different machine learning models and configure parameters to estimate the associated environmental impacts.

5.1 Key Features of the Web Application

The web application interface is designed with simplicity and functionality in mind. It includes several key components:

- **Model Selection:** Users can choose the type of machine learning model they are interested in evaluating (e.g., Logistic Regression (abbr. LogR), Decision Tree Classifier (abbr. DTC), Decision Tree Regression (abbr. DTR), Neural

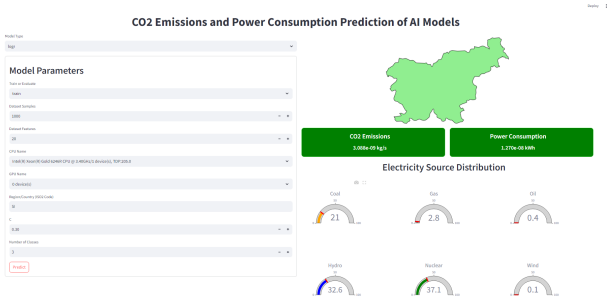

Figure 3: Web App Interface

Network Classifier (abbr. NNC), Neural Network Regression (abbr. NNR), Linear Regression (abbr. LinR), Random Forest Classifier (abbr. RFC) and Random Forest Regression (abbr. RFR)). The dropdown menu in the upper-left corner of the interface provides a list of available models.

- **Model Parameters Configuration:** A section labeled "Model Parameters" allows users to specify various inputs:
  - **Train or Evaluate:** Users can choose whether to estimate emissions for the training or evaluation phase of the model.
  - **Dataset Samples and Features:** Input fields are provided for users to define the size of the dataset in terms of the number of samples and features.
  - **CPU and GPU Specifications:** The app allows the selection of the CPU and GPU type, reflecting different hardware configurations, such as "Intel(R) Xeon(R) Gold 6246R CPU @ 3.40GHz/1 device(s), TDP:205.0" or "AMD Ryzen 7 4800H with Radeon Graphics/1 device(s), TDP:45.0".
  - **Region/Country Selection:** A dropdown to select the geographic location where the model is being executed, which influences the CO_2 emissions based on local energy sources.
- **Real-Time Predictions:** Once all parameters are configured, the application dynamically calculates and displays:
  - **CO_2 Emissions:** The predicted emissions are shown in kilograms per second (kg/s).
  - **Power Consumption:** The power consumption is provided in kilowatt-hours (kWh).
- **Electricity Source Distribution:** A graphical representation is provided for the distribution of electricity sources, such as coal, gas, and oil, in the selected region. This information is crucial for understanding the environmental impact of power consumption based on the local energy mix.

5.2 User Experience and Accessibility

The web application is developed with accessibility in mind, ensuring that users, regardless of technical background, can interact with the model's predictive capabilities. By offering a clear and intuitive interface, it aims to make the process of estimating CO_2 emissions and power consumption transparent and straightforward.

Figure 3 illustrates the application's main screen, where the model type, parameters, and results are all visible at a glance. This real-time feedback loop allows users to make informed decisions based on the predicted environmental impact.

6 Results

6.1 Model Error

To evaluate the performance and accuracy of the models, we conducted a 10-fold cross-validation to estimate the errors in predicting CO_2 emissions and power consumption. The results are presented in Table 2. The errors for both CO_2 emissions and power consumption were computed for both training and evaluation phases of each model type.

Note: In this context, "Train." refers not to the error on the training set, but rather to the error made by our model in predicting the CO_2 emissions / Power Consumption during the training phase of the listed model. Similarly, "Eval." refers not to the error on the evaluation set, but rather to the error made by our model in predicting the CO_2 emissions / Power Consumption when the listed model makes predictions. This distinction is crucial to understanding the results accurately.

Table 2: Model Scaled Error Estimates from 10-Fold Cross-Validation

Model	Phase	CO_2 Error	Power Error
DTC	Eval.	0.0036	0.0043
DTC	Train.	0.0631	0.0649
DTR	Eval.	0.0032	0.0034
DTR	Train.	0.0133	0.0517
RFC	Eval.	0.0094	0.0098
RFC	Train.	0.3242	0.3582
RFR	Eval.	0.0087	0.0081
RFR	Train.	0.2565	0.2779
LogR	Eval.	0.0063	0.0057
LogR	Train.	0.0055	0.0043
LinR	Eval.	0.0099	0.0105
LinR	Train.	0.0104	0.0095
NNC	Eval.	0.0018	0.0030
NNC	Train.	0.1083	0.1216
NNR	Eval.	0.0045	0.0112
NNR	Train.	0.1051	0.1008

Based on the results obtained through the 10-fold cross-validation, it is evident that the model performance varies significantly across different algorithms and phases. One notable observation is that the errors in predicting CO_2 emissions and power consumption are relatively higher during the training phases, particularly for more complex models like Neural Networks and Random Forests [4].

This discrepancy in model performance can be attributed to the sparsity of the data collected during the measurement phase. The limited data points lead to substantial gaps in the attribute space covered by the models, resulting in erratic behavior when predicting outside these ranges. Consequently, the models show diminished accuracy and reliability when confronted with input configurations that fall beyond the scope of the original data.

Future research should focus on enhancing the robustness of these models by expanding the dataset to include a broader range of scenarios and conditions. This would help mitigate the effects of sparsity and improve the model's generalizability, ensuring more reliable predictions across diverse settings.

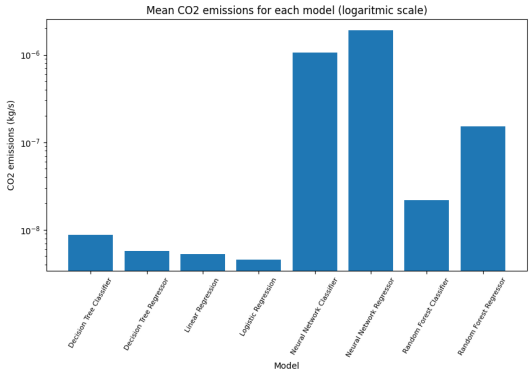

Figure 4: Logarithmically scaled mean emissions across different models

6.2 CO_2 Emission Analysis Across Different Models

Figure 4 provides a comparative analysis of the mean CO_2 emissions generated by different machine learning models during their operation, represented on a logarithmic scale to accommodate the wide range of emission values.

The chart highlights significant variations in CO_2 emissions among models, with the Neural Network Classifier and Neural Network Regressor exhibiting the highest emissions by a considerable margin. This is expected due to the intensive computational requirements and numerous parameters these models necessitate, resulting in elevated power consumption and consequently higher CO_2 output.

In contrast, simpler models like Logistic Regression, Linear Regression, and Decision Tree models show substantially lower CO_2 emissions, reflecting their reduced computational complexity and lower resource demand.

Interestingly, the Random Forest models, particularly the Regressor, present moderate emissions, illustrating that even ensemble methods, which typically involve training multiple decision trees, can maintain reasonable emission levels depending on their configuration.

This analysis underscores the importance of model selection not only for performance but also for minimizing environmental impact, particularly when scaling up operations or deploying in resource-constrained settings.

7 Discussion

The results highlight the significant environmental impact of training complex AI models, particularly neural networks. The variability in emissions suggests that optimizing model hyperparameters and selecting appropriate hardware configurations can reduce CO_2 output.

Future research should focus on model improvement for better and more accurate prediction, expanding the range of algorithms studied, as well as intensive data collection to accommodate gaps in training data.

8 Limitations

This study presents several limitations, particularly regarding the data, model evaluation, and hardware configurations, which must be considered when interpreting the results.

8.1 Training Duration and Model Learning

The models were trained for a fixed number of epochs (e.g., 10 or 20), prioritizing computational cost over learning performance. The focus was on estimating CO_2 emissions rather than model accuracy or convergence, meaning the models may not have fully captured patterns in the data. As such, the reported emissions reflect standardized training durations (with an upper limit for computational efficiency), not optimized learning outcomes.

8.2 Lack of Meaningful Learning Objective

The use of randomly generated data limits the evaluation of model learning. Since the data lacked inherent structure, the models' ability to learn was not assessed. Instead, the models were primarily evaluated on their resource consumption during training, reducing the focus on generalization or predictive power.

8.3 Hardware and Software Considerations

The experiments were conducted on specific hardware (e.g., GPU/CPU configurations), and variations in hardware were not examined. Different hardware setups, especially energy-efficient systems, could significantly impact CO_2 emissions and energy consumption. Therefore, the findings may not generalize across all hardware environments. However, we would like to point out that this was due to lack of infrastructure for broader experimentation.

9 Future Work

Future research should incorporate real-world datasets, optimize hyperparameters, and evaluate diverse hardware configurations to extend these findings to broader machine learning scenarios. The exploration of more complex architectures and learning objectives will provide a deeper understanding of the trade-offs between performance and environmental impact.

10 Conclusion

Our study presents a methodology for monitoring and analyzing CO_2 emissions during machine learning processes. The findings demonstrate that different machine learning models exhibit significant variability in their energy consumption and CO_2 emissions, with complex models like neural networks having a higher environmental impact. By providing predictive insights into these emissions, our approach enables more informed decision-making during model selection, thus contributing to the broader goal of reducing the carbon footprint of AI applications.

Future work will focus on expanding the dataset to include more diverse models and configurations. Additionally, we plan to integrate real-time monitoring tools to compare predictions with actual emissions, further refining our predictive capabilities. Moreover, optimizing model hyperparameters and exploring alternative, more sustainable hardware configurations will be key areas of investigation for minimizing the environmental impact of machine learning workflows.

Acknowledgements

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Enhancing Ontology Engineering with LLMs: From Search to Active Learning Extensions

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Abstract

This paper explores the use of LLMs in ontology engineering within the HumAIne project, focusing on the discovery, analysis, and extension of ontologies in Data Mining, Machine Learning, and manufacturing. The methodology leverages fine-tuned prompts and combines LLMs with traditional tools like Protege for validation. A multi-LLM approach improved domain-specific concept coverage and reduced errors, though challenges remain in addressing deep domain-specific gaps and ensuring logical consistency.

Keywords

LLMs, Ontology Engineering, Active Learning, Data Mining, Machine Learning, Ontology Selection, Ontology Extension

1 Introduction

The HumAIne project, funded by the European Commission under the Horizon Europe program, aims to develop a platform integrating advanced AI paradigms such as Active Learning (AL), Neuro-Symbolic AI, Swarm Learning, and Explainable AI. This platform is designed to enhance human-AI collaboration in dynamic, unstructured environments, with applications spanning healthcare, manufacturing, finance, energy grids, and smart cities. Its primary goal is to support decision-making by combining human expertise with AI capabilities.

One of the project's key challenges is developing multiple ontologies that provide a structured framework for integrating domain-specific knowledge. This framework is essential for enhancing the clarity and reliability of AI-driven decisions, while ensuring adaptability across diverse applications. To construct these ontologies, we first explored publicly available ontologies relevant to the project's scope, then extended selected ones with concepts from HumAIne's AI paradigms, starting with Active Learning

However, manual ontology construction is a complex, resource-intensive process that requires expertise across multiple domains, collaboration among stakeholders. Ensuring modularity, reusability, and scalability adds to this complexity.

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Recent studies show that leveraging Large Language Models (LLMs) can streamline ontology construction by reducing manual effort and improving consistency and quality. For instance, [1] demonstrates semi-automatic knowledge graph construction using open-source LLMs, while [2] proposes methods for automatic concept hierarchy generation through LLM queries. Building on this research, this paper contributes a methodology that integrates LLMs with traditional tools like Protege to streamline the discovery, analysis, and extension of ontologies. By employing a multi-LLM approach, we address challenges in domain-specific concept identification and ensure more consistent, accurate results in ontology development for fields like Data Mining, Machine Learning, and manufacturing.

2 LLM-Assisted Search and Analysis of Domain Ontologies

Our experimentation with methodologies and tools for efficient web search and ontology analysis in Data Mining (DM), Machine Learning (ML), and manufacturing domains led to the development of the LLM-leveraging algorithm shown in Fig. 1. This algorithm uses carefully crafted prompts to guide LLMs in generating accurate, targeted queries. Before each step, the initial prompt is optimized through several iterations in a dialogue with the LLM to improve accuracy and relevance. Further details on the iterative query refinement process are provided in the Discussion section.

Step 1: Define the Search Objective. At this stage, LLMs like Bing Chat, Google's Bard, or ChatGPT with Web Browsing are employed to iteratively refine the search objectives initially formulated by the researcher, along with relevant keywords, phrases, and terms describing the ontologies or concepts of interest. For instance, our initial search objective for DM and ML ontologies was to "Find ontologies that offer up-to-date, detailed descriptions of the DM and ML domains, following best practices in ontology engineering." Keywords included "Active Learning" and "CRISP-DM standard."

Step 2: Formulate Search Queries Using LLMs. Based on the refined search objectives and keywords, and using a carefully crafted prompt, LLMs generate targeted search queries. These queries are fine-tuned through feedback or early search results to maximize relevance and accuracy. For example, for a DM ontology, the LLM generated queries such as "Data Mining ontology for semi-supervised machine learning," which were further refined before finalizing the query.

Step 3: Conduct Web Search. This step involves real-time browsing tools like Copilot in Microsoft Edge (GPT-4) and Perplexity AI to execute searches and identify relevant sources. Our study prioritized high-quality sources like ontology

repositories (e.g., BioPortal, OBO Foundry) and academic databases (Google Scholar, IEEE Xplore, ACM Digital Library).

It is important to acknowledge that LLM-driven web searches are generally confined to public repositories and a limited range of academic databases. As a result, proprietary or lesser-indexed ontologies may require manual exploration to ensure a more thorough search.

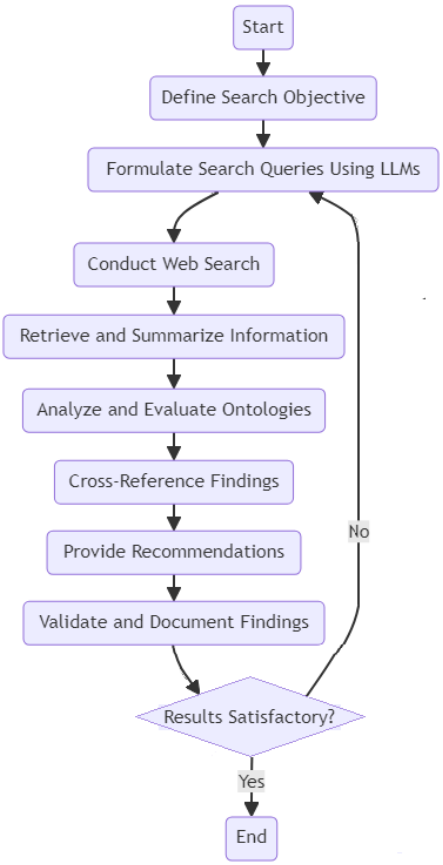

Figure 1: Key steps of LLM-leveraging algorithm

Step 4: Retrieve and Summarize Information. LLMs (Google Bard, Copilot (GPT-4), Perplexity AI) were employed to extract and summarize key information from ontology descriptions found in publications, technical papers, and repository documentation identified during the search. Using a specifically tuned prompt, LLMs extracted 11 characteristics for each of the 34 identified DM and ML ontologies. These characteristics included purpose, availability, ontology metrics, reused ontologies, software editors, representation language, and evaluation methodologies. This structured data, organized in table format, provided valuable insights into each ontology's scope, quality, and reusability. From these results, we selected 6 ontologies for further exploration, prioritizing comprehensive coverage of DM and ML concepts, adherence to ontology engineering best practices, and alignment with established standards in these domains.

Step 5: Analyze and evaluate ontologies. LLMs were further utilized to assess the relevance, content, and structure of the selected ontologies. In our study of DM and ML ontologies, LLMs such as GPT-4, which can process, explain, and generate OWL and RDF code, were used alongside ontology tools like Protege. This combination ensured that the ontologies addressed relevant concepts and aligned with frameworks like CRISP-DM. GPT-4 helped significantly in bridging the gap between textual descriptions and formal ontology representations.

Step 6: Cross-Reference and Compare Findings. LLMs with contextual understanding were employed to integrate and refine information from multiple sources. For this task, we used. Additionally, ChatGPT (GPT-4) categorized 65 manufacturing ontologies categorized 65 manufacturing ontologies, assessing them for relevance to process planning, standardization, industry adoption, interoperability, and support for advanced manufacturing concepts. Further exploration of the top 8 LLM-scored ontologies showed strong alignment with expert evaluations, but domain-specific tasks required carefully crafted prompts and human oversight for effectiveness.

Step 7: Provide Recommendations for Further Exploration. LLMs generated recommendations for the most suitable ontologies or areas for additional research based on the previous step's results. This includes identifying underexplored concepts and areas needing further investigation.

Step 8: Validate and Document Findings. The findings were manually validated for accuracy and relevance, then systematically documented. ChatGPT (GPT-4) was used to summarize and structure the documentation.

Step 9: Iterate and Refine Search (if needed). When results were too broad or irrelevant (e.g., Active Learning misinterpreted as an educational method), we refined the search prompt by adding more context.

By using this LLM-based algorithm, we conducted comprehensive web searches and extracted relevant information to identify the most suitable ontologies for the HumAIne project. In the DM and ML domains, we selected the OntoDM suite (OntoDM-Core, Onto-KDD, and OntoDT). For the manufacturing domain, we identified the Industrial Ontologies Foundry Core (IOF Core) as the best fit.

3 LLM-Assisted Ontology Extension with Active Learning Concepts

Integrating Active Learning (AL) into an ontology requires extending it with new classes, properties, and relationships representing key AL concepts. While traditional methods of building and extending ontologies are well-documented, we leveraged GPT-4 for this task using iteratively refined prompts (see Discussion section). This section outlines how LLMs, particularly GPT-4, were used to extend the IOF Core ontology with AL concepts.

Step 1: Define the Problem and Objectives. Through iteratively refined prompts, LLMs formulated clear objectives, specifying the domain (e.g., manufacturing) and key concepts (e.g., Active Learning). These outputs were used to guide further steps, with LLMs leveraging contextual understanding, knowledge synthesis, and language generation to suggest relevant AL applications such as adaptive scheduling. Queries like "How can Active Learning improve adaptive scheduling in manufacturing?" generated valuable insights into potential use cases. where AL would be most beneficial.

Step 2: Analyze the Ontology to be Extended. By combining Protege's visualization and navigation tools with GPT-4's ability

to process textual and machine-readable data (e.g., OWL/RDF), we thoroughly examined the IOF Core ontology structure and identified areas for introducing AL concepts. For example, GPT-4 helped uncover key classes like “Process,” “Resource,” and “PerformanceMetric” within IOF Core, highlighting relevant properties for AL integration. Queries such as "What aspects of IOF Core can benefit from AL integration?" and "What key concepts are missing from the IOF Core ontology for integrating Active Learning in manufacturing?" guided us in identifying areas for improvement, including handling uncertainty and adjusting dynamic processes.

Step 3: Identify Active Learning Concepts. The main tasks of this step and the role of LLMs in supporting each task are summarized in the Table 1:

Table 1: LLMs applications for Identifying AL Concepts

Task	LLM Application	Example Output
1. Identify fundamental AL concepts	Use LLMs to generate a list of core AL strategies and techniques	Concepts like“Uncertainty sampling,” “Query-by-committee”
2. Extract domain-specific AL concepts	Query LLMs about AL in specific industrial contexts	Concept like "Query Efficiency" in decision-making for manufacturing
3. Mine AL concepts from literature	Process academic papers, reports to extract relevant AL terms	Concepts like “Stream-base selective sampling” from papers on AL in manufacturing
4. Assign properties to new classes	Generate properties for AL ontology classes	QueryStrategy class properties: “hasuncertaintySampling” “queryByCommittee”
5. Refine and validate terminology	Ensure definitions, resolve overlaps	Refined and validated terms based on domain-specific standards

By prompting, LLMs generated nearly 200 fundamental AL concepts, structuring them into a hierarchy by leveraging their vast training data. Additionally, LLMs helped generate definitions, assisting in verifying and refining concepts. However, after a point, LLMs began repeating concepts or producing less relevant terms. LLMs were also effective in generating domain-specific concepts through targeted queries. For instance, querying AL in manufacturing led to concepts like "uncertainty management" and "query efficiency." More specialized concepts required extraction from academic papers, which were cross-referenced with existing standards in DM, ML, and manufacturing (e.g., CRISP-DM, IEEE 7000 Series, ISA-95, ISO 15531). Ontology learning tools like Text2Onto and OntoLearn were combined with LLMs for cross-verification.

*Step 4: Develop Ontology Extensions.*LLMs helped create AL-related classes, properties, and relationships based on the identified concepts, using OWL-compliant syntax (see Fig. 2). By combining GPT-4’s knowledge synthesis with Protege’s structural reasoning and consistency checking, we improved the efficiency and accuracy of reviewing, debugging, and validating OWL code.

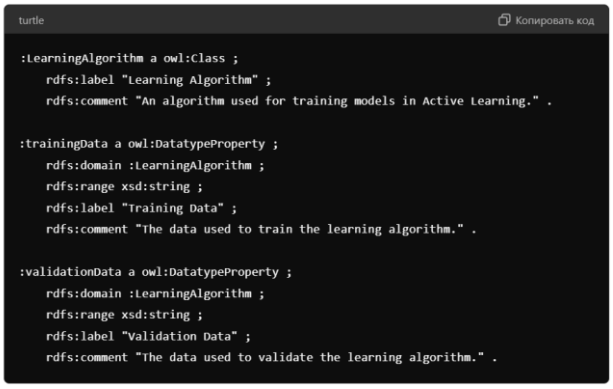

Figure 2: Screenshot of LLM-generated code defining the “LearningAlgorithm” class with properties “trainingData” and “validationData”

Step 5: Ensure Semantic Consistency. LLMs, such as GPT-4, assisted in ensuring semantic consistency by reviewing new and existing ontology elements and suggesting how new concepts could align with the existing framework. For example, an LLM suggested how an AL “QueryStrategy” class fits within the IOF Core ontology.

Example Prompt: " Review the new QueryStrategy class and suggest how it can align with the existing classes in IOF Core."

LLM Output: The QueryStrategy class aligns with decision-making aspects of the Process concept. Strategies such as “UncertaintySampling,” “QueryByCommittee,” “ExpectedModelChange,” and “ExpectedErrorReduction” can be viewed as specialized decision-making processes within the broader process framework of IOF Core.

However, LLMs cannot guarantee logical consistency and face limitations in handling complex relationships, making it necessary to use ontology reasoners, such as Protege or HermiT, to perform consistency checks.

Step 6: Map to Existing Ontologies. LLMs, such as GPT-4, assist in generating initial mapping suggestions by analyzing similarities in definitions, relationships, and properties between new and existing concepts. This involves creating explicit relationships like “owl:sameAs,” “owl:equivalentClass”, and “owl:equivalentProperty”.

Example LLM Output:

:FeedbackMechanism a owl:Class ;
owl:equivalentClass :ControlSystem ;
rdfs:label "Feedback Mechanism" ;
rdfs:comment "Mechanisms that provide feedback in Active Learning to control systems."

While LLMs are effective in identifying high-level similarities, they may face challenges with complex or domain-specific relationships, requiring further refinement. Although we didn’t encounter these issues during our initial work extending IOF Core with AL concepts, we used Protege’s alignment plug-ins to refine LLM-generated mappings. For more complex mappings, tools like AgreementMaker or COMA can further refine the suggestions.

Step 7: Prototype and Test. LLMs, such as GPT-4, were prompted to generate validation scenarios, competency questions, and SPARQL queries based on the integrated AL concepts. For instance, a prompt like "Suggest validation scenarios for adaptive scheduling with Active Learning" helped us produce realistic test cases, including prototype code, descriptions of initial setup, process flows, validation steps, and queries based on newly integrated concepts.

SPARQL queries generated by LLMs were executed using Protege with SPARQL plugins to assess the ontology's ability to retrieve relevant information and answer competency questions.

However, some LLM-generated scenarios revealed limitations in domain-specific knowledge, resulting in generic outputs that required refinement. Additionally, LLMs struggled with modeling intricate relationships or complex data retrieval conditions, making human oversight essential for ensuring accuracy and thorough testing.

Step 8: Iterative Refinement. Following initial prototyping and testing, we gathered feedback from domain experts and users to further refine the ontology. Validation reports were uploaded to AskPDF Research Assistant (GPT-4), where LLMs reviewed the reports, extracted key improvement suggestions, and refined task lists. The LLM provided insights into areas where ontology relationships or properties required adjustments and identified additional concepts that might have been overlooked.

Step 9: Document and Disseminate. LLMs like ChatGPT or Bard were instrumental in generating comprehensive documentation, including details on the ontology extensions. Additionally, LLMs contributed to drafting technical reports and research papers.

Using this methodology, we successfully extended the IOF Core ontology with Active Learning (AL) concepts. Future stages of the HumAIne project will focus on further validation and refinement, particularly during pilot case implementations.

4 Discussion

This study highlights LLMs' potential in ontology engineering by reducing manual effort and increasing efficiency. LLMs rapidly identified key ontologies like OntoDM and IOF Core and generated structured classes, properties, and relationships, reducing the need for manual OWL/RDF code generation and concept mapping. However, LLMs face challenges in domain-specific precision, requiring human oversight to refine outputs and address nuances in specialized fields. While tools like Protege excel at ensuring logical consistency, LLMs offer dynamic capabilities for generating new concepts and relationships. Despite these advantages, traditional tools like AgreementMaker and COMA are still necessary to refine and validate LLM-generated mappings.

One strategy to mitigate LLM limitations was iterative prompt engineering. We refined prompts for ontology search and extension tasks through multiple cycles of improvement. These cycles, with LLMs like GPT-4, involved clarifying questions, refining queries, and generating more focused outputs. Initial prompt for starting the cycle can be the following:

"Your role is my Prompt Creator. Your goal is to craft the best possible prompt for my needs. The prompt will be used by you, [LLM's name]. I want to write about: [keyword/topic]. Based on my input, you will now generate 3 sections. a) Revised prompt (clear, concise, and easily understood by you), b) Suggestions (on what details to include in the prompt to improve it), and c) Questions (ask any relevant questions to improve the prompt). We will continue this iterative process with me providing additional information to you and you updating the prompt until it's complete."

After 4-5 cycles, the prompts were highly optimized, ensuring relevant outputs. This refinement process reduced inconsistencies and improved LLM-generated content across both search and extension phases.

We integrated multiple LLMs, including Bing Chat (GPT-4), Google's Bard, and Perplexity AI, to cross-validate outputs, reducing errors and refining results. This ensured consistency in LLM-generated ontologies and mappings.

To evaluate this multi-LLM approach, we propose the following metrics: Inter-Model Consistency (measures alignment between LLM outputs). Error Rate Reduction (Tracks how often one LLM corrects another's errors),.Coverage of Relevant Concepts (assesses LLMs' ability to capture domain-specific concepts). Although these metrics provide a framework, formal measurements are yet to be implemented.

Future stages will involve applying these metrics to validate outputs and testing extended ontologies in real-world applications. This hybrid method combines LLMs and traditional tools, ensuring both efficiency and accuracy in scalable ontology development.

5 Conclusions

This study demonstrates how LLMs can streamline ontology engineering by automating the search, analysis, and extension of domain-specific ontologies. Leveraging multiple LLMs, we successfully identified and extended key ontologies, including OntoDM and IOF Core, for the HumAIne project, improving efficiency in generating classes, properties, and relationships.

While LLMs significantly enhance the process, they face challenges in domain-specific precision and require human oversight, particularly for complex relationships. Traditional tools like Protege and ontology reasoners remain critical for ensuring logical consistency and validation.

Future work will focus on refining these extended ontologies through real-world pilot tests and applying evaluation metrics to LLM-generated outputs. This hybrid approach, combining LLM automation with traditional validation tools, offers a scalable solution that balances efficiency with the need for human expertise.

Acknowledgments

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On the Brazilian Observatory for Artificial Intelligence

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ABSTRACT

Artificial Artificial Intelligence (AI) is rapidly transforming industries and economies worldwide, with Brazil and South America emerging as significant players in this global shift. The fundamental need to monitor the impact of artificial intelligence (AI) in the verticals for sustainable development, government engagement, investment and society at large motivated the Brazilian Artificial Intelligence Observatory (OBIA). It is also an integral part of the Brazilian Artificial Intelligence Plan (PBIA), and a former objective of the Brazilian Strategy of AI aims to become the leading platform for monitoring the uses of AI in the country. OBIA is part of Axis 5 of the PBIA focused on supporting the regulatory and governance process of AI. This research paper explores the current state, challenges, and potential of AI development in the region, examining how technological advancements are influencing economic growth, societal change, and policy-making across South America, with a particular focus on Brazil as a leading hub of innovation. It is also investigating common aspects of the research agendas as with IRCAI's SDG Observatory, particularly in what regards machine learning workflows and approaches complementing traditional and crowdsourced heterogeneous data collection and analysis.

KEYWORDS

Artificial Intelligence, Observatory, Survey Data Analysis, Complex Data Visualization, Multidisciplinary Collaboration.

1 Introduction

AI is increasingly shaping the economic landscape and societal dynamics across Brazil and South America, positioning the region as a growing hub for technological innovation. Despite challenges such as uneven infrastructure and regulatory hurdles, Brazil is making significant strides in AI research and development, contributing to the regulation and better understanding of the impact of AI in South America. OBIA [5] is answering this need, serving as a platform to support the strategy and other government actions with data on the uses and impacts of AI (see Figure 1).

Figure 1: Screenshot of OBIA showing some results on the preparedness of Brazilian industry to adopt AI workflows.

The objectives of OBIA include compiling, recording, and providing information related to Artificial Intelligence in Brazil, enabling analyses of its adoption and its main impacts on society. It also has the mission of consolidating and disseminating knowledge about the repercussions of this technology, providing support to guide policies, strategies, and actions in promoting development and responsible use of AI.

The observatory gathers Brazilian data on the use and adoption of Artificial Intelligence by different sectors, such as education, business, government, health, and others (see Figure 2).

The currently available indicators rely mostly on traditional data sources for analysis, such as surveys and data sets made available for the team. The first product of OBIA is the book "Artificial Intelligence in Healthcare - Potentialities, Risks and Perspectives", published in July 2024. In a second line of action, it functions as a repository of guiding documents in the area, originating from all parts of the world. In a third line, it acts as an "information exchange point" between AI centers operating in Brazil: the IAX. All indicators collected will be public and can be accessed on the OBIA portal [4].

The Center for Artificial Intelligence (C4AI) at the University of São Paulo, funded by FAPESP (the public agency for research funding in the State of São Paulo) and IBM, participates in the OBIA through its Humanities area. C4AI will contribute with qualitative research in the horizontal axes of "Legislation, Regulation, and Ethical Use" and "AI Governance," while also conducting studies across various vertical axes to be monitored. The research group dedicated to this effort comprises scholars from the fields of law, computer science, electrical engineering, sociology, and political science, allowing for an interdisciplinary analysis of the key topics monitored by

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OBIA. This interdisciplinary approach will provide a comprehensive view of the current state of AI development and implementation in Brazil. Various reports, articles, and data will be provided to support OBIA in fulfilling its mission.

In addition to the participation of professionals from various NIC.br departments, the Observatory has a network of external partners, including the Center for Management and Strategic Studies (CGEE), the São Paulo State System Data Analysis Foundation (SEADE), C4AI, CIAAM (Center of Artificial Intelligence and Machine Learning) and others. The following will explore how C4AI contributes to OBIA through a complementary approach, focusing on the qualitative analysis of decisions by the São Paulo Court of Justice related to AI.

2. Data and Methodology

2.1. Legislation, Regulation, and Ethical Use: A Qualitative Analysis

The research presented in this paper is the base of an action contributing to implement the PBIA strategy [7], responsible for monitoring AI regulation and legislation. It has divided its research into three main areas: the Executive, the Judiciary, and the Legislative branch, combining traditional and modern data collection methods. Regarding the Executive branch, monitoring is being conducted through data scraping of government transparency websites based on a curated and continuously updated list of AI-related terms developed by the group. This monitoring aims to understand what AI systems are being purchased or contracted by public authorities. For the Judiciary, we have been analyzing court decisions from the São Paulo Court of Appeal (TJSP) related to AI, to understand judicial interpretations and rulings in the absence of specific AI legislation [2]. As of the latest data scraping in August 2024, more than 13.000 relevant decisions have been identified. Lastly, in relation to the Legislative Branch, the group is closely following the progress of discussions on Bill 2338/2023, which focuses on AI regulation, by participating in public hearings and issuing technical notes to guide legislators. The goal is to expand this research to monitor AI-related legislation at the state and municipal levels, as many municipalities are legislating on the matter to prepare their cities to assume roles of “smart cities”.

2.2. Monitoring and exploring the local data

To effectively monitor developments in AI, it is essential to establish a comprehensive list of AI-related terms that can guide data collection efforts. This list is derived from multiple sources, including scientific articles, standards like [3], and reports such as OECD's [1]. The monitoring process involves monthly web scraping of court rulings, based on the AI-related terms list, from TJSP (Judiciary Power) and data from the Brazilian Transparency Portal (Executive Power), which occurs on the 15th of each month. For the Judiciary Power, the scrapes and data treatment are performed with scripts developed in Python and R programming languages, based on the TJSP API, by Jesus Filho (github.com/jjesusfilho/tjsp). For the Executive Power, a script was developed to scrape data from the Data Download section of the Brazilian Transparency Portal (portaldatransparencia.gov.br/download-de-dados).

Currently, we are developing an automation tool, based on NLP techniques, to enhance the qualitative analysis of these court rulings, allowing for more efficient identification and categorization of data relevant to AI research. The first approach for this automation tool is using a NER (Named Entity Recognition) model, to automate the identification of relevant entities, including litigants and court judgments. The next step would be to apply a classification model, yet to be chosen, to filter out noise data. The process of constructing the terms for web scraping is a critical step to ensure the relevance and accuracy of the data collected for AI research. This process begins with the development of a comprehensive list of AI-related terms, which is built using multiple authoritative sources. One primary source is the OECD's report "Identifying and Measuring Developments in Artificial Intelligence," which offers a foundation of 226 AI-related terms identified through extensive analysis of scientific articles, open-source systems, and patents. Another source is the ISO/IEC 22989:2022 standard [3], which provides a framework for AI concepts and terminologies. These terms are carefully selected, refined, and translated into Portuguese by experts working within the Brazilian Technical Standards Association (ABNT) to ensure that only those terms that are highly relevant and specific to AI are included. Terms that are too general or contextually irrelevant—such as "transparency," which could result in unrelated hits concerning Brazil's Access to Information Law—are excluded to avoid false positives in the scraping process. The final list of terms, consisting of 103 terms in both English and Portuguese, is used to guide the web scraping data collection processes, allowing a focused and efficient retrieval of information that aligns with specific research objectives.

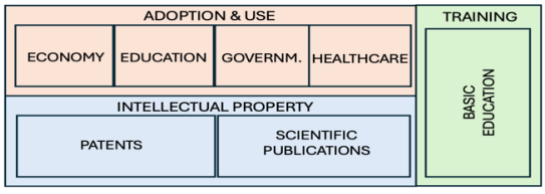

Figure 2: Current Dimensions of OBIA’s monitoring topics

2.3. How to implement and classify repositories with reference documents and statistics?

As part of the data collection and structuring process for qualitative analysis, we are implementing and classifying repositories containing reference documents and statistics. These repositories will focus on key thematic areas, such as "Legislation, Regulation, and Ethical Use" and "AI Governance," and will be populated with data from sources like TJSP, the

Transparency Portal, and other relevant databases. By combining different methods, data retrieval becomes more efficient and targeted, ensuring the collection of relevant information. Web scraping supplements this process by capturing data unavailable through APIs, ensuring comprehensive coverage. The data is regularly updated, with documents classified by relevance to AI terms, creating a dynamic and organized repository (see Fig 3) described in [6].

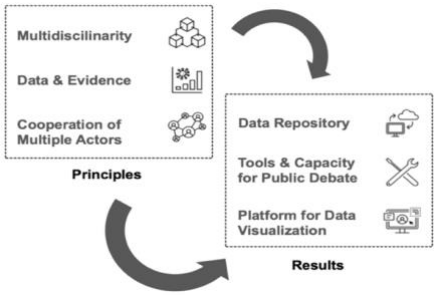

Figure 3: OBIA's guiding principles and expected results [6]

2.4. How to establish and maintain cooperation networks?

Establishing and maintaining cooperation networks requires fostering collaboration among interdisciplinary researchers from fields such as law, computer science, engineering, sociology, and political science. These networks are essential for sharing insights and methodologies related to AI monitoring. Using APIs and web scraping tools enables access to current data, supporting continuous knowledge exchange. Regular workshops, webinars, and joint research projects help keep participants engaged. Publishing reports, articles, and datasets strengthens the network and supports OBIAs mission to monitor AI developments comprehensively.

3 Discussion of initial results

As of June 28, 2024, a total of 13,064 decisions were scraped from the São Paulo State Court of Justice based on AI-related terms. Out of 103 terms searched, 45 returned at least one result. Graph 1 shows the monthly distribution of all results, while Figure 5 (logarithmic scale) displays the distribution of results by AI term. Both Portuguese and English terms were used for scraping. The top 15 terms with the most occurrences were analyzed over time, and Figure 6 presents the temporal evolution of these results by publication date. A qualitative review of 597 decisions from the São Paulo Court of Justice (TJSP) using a detailed list of AI-related terms, focused on terms like "Facial Recognition" and "Facial Biometrics," showing they are often used in various legal contexts, sometimes diverging from their technological meanings.

Terms like "Facial Expression Recognition" and "Learning Agent" were often interpreted in psychological or social contexts rather than purely technological ones. The analysis used analytical, comparative, and monographic methods, with the latter focusing on case-specific factors to draw broader generalizations. From TJSP's website, 597 rulings were reviewed: "Facial Recognition" (1), "Facial Expression Recognition" (1), "Machine Learning" (7), "Artificial Intelligence" (163), "Artificial Intelligence" in English (4), "Machine Learning" in Portuguese (3), "Learning Agent" (1), and "Facial Biometrics" (417).

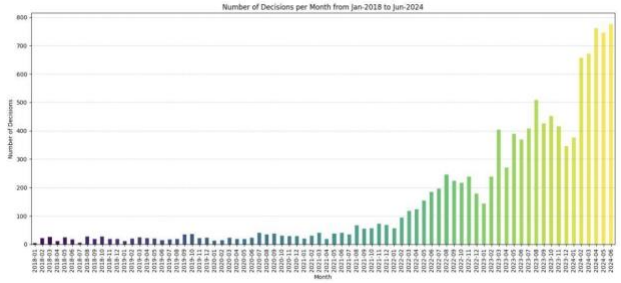

Figure 4: Nr. of Decisions per Month from Jan 2018 to Jun 2024.

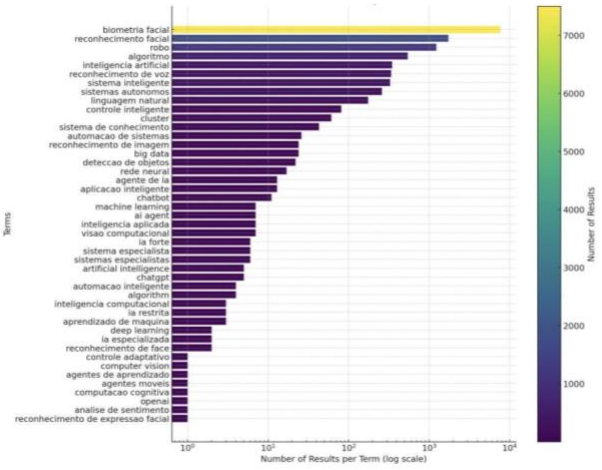

Figure 5: Number of results per AI term.

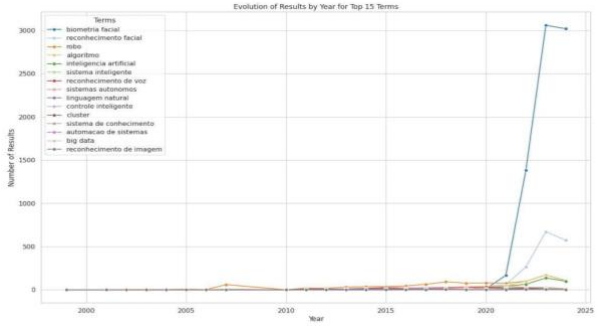

Figure 6: Evolution of results by year for top 15 terms.

The rulings followed a structured format, and the analysis included 14 categories, such as case number, appeal type, judge, district, and the context of term usage. Key findings highlighted the use of "Artificial Intelligence" and "Machine Learning" in commercial disputes and credit issues rather than solely technological matters. The rulings analyzed represent

decisions, rendered by collegiate bodies composed of multiple magistrates. Each ruling follows a structured format: Description and Qualification, covering aspects such as appeal, case number, judicial district, presiding judge, and parties involved; Summary of the ruling; Report, offering a brief description of the facts; Majority Opinion; and Dissenting Opinion (if applicable). The analysis was conducted with each of the 14 subcategories corresponding to columns in a single row: case number; type of appeal; reporting judge; district; judicial body; subject matter; judgment date; publication date; summary; parties; reasoning; final decision; context of term usage in the full text; and relevant jurisprudence. While the first nine categories were predefined based on the complete jurisprudence search, the remaining five were more subjective, created to enhance the understanding of the rulings' content and improve data visualization. Significant findings were noted in cases involving "Artificial Intelligence" and "Machine Learning," where the terms were often associated with commercial disputes, service contracts, or credit-related issues rather than purely technological applications. A recurrent theme in cases involving "Facial Biometrics" was the legality and validity of loan contracts signed through biometric recognition. The majority of decisions upheld the legality of such contracts, highlighting issues of consent and the technical reliability of biometric systems [1]. However, inconsistencies in judicial reasoning were identified, where similar cases had varying outcomes depending on the presiding judge. Overall, the analysis highlighted several gaps and challenges in the legal treatment of AI-related technologies, particularly concerning transparency, fairness, and consumer protection. The study underlined the need for more consistent legal standards and better understanding among judges of the technical nuances involved in AI applications to ensure fair and equitable rulings.

4 Conclusions and further work

The qualitative research findings from the analysis of court decisions related to AI reveal several key conclusions. AI-related terms such as "Facial Recognition," "Voice Recognition," and "Autonomous Systems" are frequently used in judicial contexts that extend beyond their traditional technological meanings, intersecting with areas like consumer protection, contract law, and fraud. The inconsistency in judicial reasoning and varying outcomes in similar cases highlight the need for clearer legal frameworks and a deeper understanding of AI's technological implications among judges. Moving forward, the incorporation of NLP techniques into the analysis will help extract key arguments from judicial decisions, providing deeper insights into the legal discourse on AI. This will enhance the robustness of future research on AI regulation and its implications for public policy.

Furthermore, a preliminary analysis of news using the NLP capabilities of the *Eventregistry.org* system (see Figure 7) show how this source can provide complementary results to the study when, e.g., capturing the attention of media on the terms "criminal law" and "AI" in "Brazil" in the past 12 months, where 1.4% exhibits discussions on Human Rights, and terms like "democracy" and "discrimination" are within the top 30. When performing sentiment analysis over these results we can see large variations after the summer of 2022 with a predominantly negative sentiment regarding this search topic.

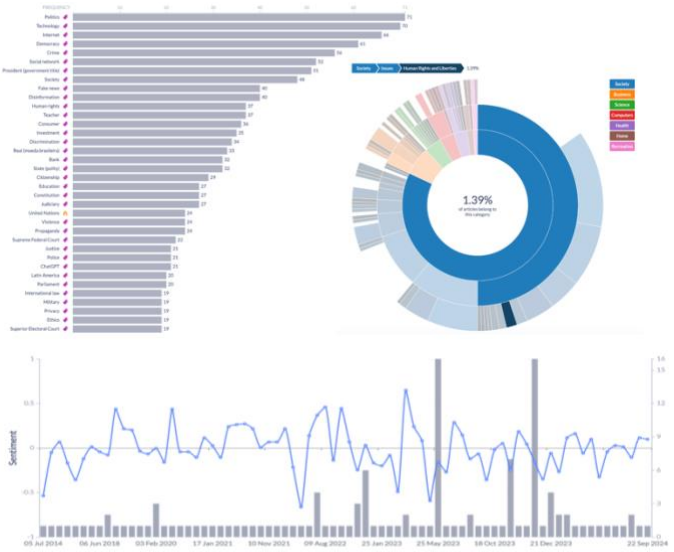

Figure 7: Significance of criminal law and AI in the news.

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Pojavljanje incidentov ob uporabi Umetne Inteligence

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Povzetek

Prispevek predstavi prve rezultate ob uporabi sistema, ki je bil zasnovan in razvit v sodelovanju z OECD za spremljanje incidentov, povezanih z umetno inteligenco. Glavna motivacija teh prizadevanj je podpora zakonodaji, povezani z umetno inteligenco, in učinkovitemu oblikovanju politik, saj sistem zagotavlja vpoglede na podlagi zbranih podatkov. OECD AI Incidents Monitor za spremljanje incidentov, povezanih z umetno inteligenco, dokumentira incidente in nevarnosti v zvezi z umetno inteligenco, da bi oblikovalcem politik, strokovnjakom za umetno inteligenco in vsem zainteresiranim stranem po vsem svetu pomagal pridobiti dragocen vpogled v tveganja in škodo, ki jo povzročajo sistemi umetne inteligence. Ideja je, da bo sistem sčasoma pomagal povečati ozaveščenost javnosti in vzpostaviti skupno razumevanje incidentov in nevarnosti umetne inteligence, in tako prispeval k zaupanja vredni umetni inteligenci.

Ključne besede

umetna inteligenca, analiza podatkov, oblikovanje politik,incidenti

Abstract

This paper presents a system designed and developed in collaboration with OECD for monitoring of AI-related incidents. The main motivation behind the efforts is in supporting AI-related legislation and effective policymaking, as the system provides evidence based on the collected data. The OECD AI Incidents Monitor documents AI incidents and hazards to help policymakers, AI practitioners, and all stakeholders worldwide gain valuable insights into the risks and harms of AI systems. The idea is that over time the system will help to raise awareness and establish a collective understanding of AI incidents and hazards contributing to trustworthy AI.

Keywords

Artificial Intelligence, data analysis, policy making, AI incidents

1 Uvod

Ob vse širši uporabi umetne inteligence (UI) prihaja tudi do incidentov ob njeni uporabi. Spremljanje teh incidentov je nujno za zagotavljanje preglednosti, nadzora in razvoj politik, ki lahko takšne incidente preprečujejo ali vsaj zmanjšujejo. Predstavljeni sistem deluje kot orodje, ki pomaga uporabniku, ki si prizadeva v realnem času slediti dejanskim incidentom, povezanim z umetno inteligenco, ter zagotavljati dokazno osnovo za oblikovanje okvira poročanja o incidentih in povezanih političnih razpravah o UI. Z zbiranjem podrobnih vpogledov v vsak incident omogoča učenje iz preteklih napak ter spodbuja varnejši in bolj odgovoren razvoj ter uporabo umetne inteligence. Koristi skupnosti, ki se ukvarja z umetno inteligenco, saj izpostavlja trende in področja, ki potrebujejo pozornost ali regulativni poseg.

Prednost sistema je, da je zbiranje podatkov avtomatizirano, kar je prednost v primerjavi s podobnimi repozitoriji, ki so urednikovani ročno, kot je na primer AIAAIC Repository [2]. Repozitorij je prosto dostopen in namenjen tako oblikovalcem politik, kot razvijalcem UI, raziskovalcem, pravnikom in javnim organizacijam.

V nadaljevanju predstavimo metodologijo za spremljanje incidentov, prikažemo delovanje sistema na nekaj realnih primerih, predstavimo deležnike in nekaj zaključkov.

2 Metodologija

Metodologija OECD za spremljanje AI incidentov se osredotoča na identifikacijo in klasifikacijo incidentov, s čimer zagotavlja vpogled v realno dogajanje in podpira razvoj okvira za poročanje o incidentih. Začetna točka je identifikacija in klasifikacija incidentov, ki so poročani v uglednih mednarodnih medijih, s pomočjo modelov strojnega učenja, kar omogoča gradnjo zanesljive baze podatkov (incidenti so zajeti od 2014 naprej).

Kljub prizadevanjem, ti incidenti predstavljajo le podmnožico vseh globalnih AI incidentov. Incidenti so razvrščeni glede na resnost, industrijo, povezane AI principe (OECD AI Principles [3]), vrste škode in prizadete deležnike. Analiza temelji na naslovih, povzetkih in prvih odstavkih novinarskih člankov, pri čemer se pridobljeni podatki uporabljajo za izgradnjo zanesljive, objektivne in kakovostne baze podatkov o incidentih, povezanih z AI. Kot vir novic služi sistem Event Registry [4].

Razvoj sistema, h kateremu smo prispevali, nadgrajuje delo mednarodne skupine strokovnjakov (OECD Expert group), ki razvija teoretično ogrodje za poročanje o incidentih, definira pojem AI incidenta in oblikuje povezano terminologijo, kot je AI nevarnosti in njene potencialne posledice. Podrobna metodologija in definicije so razložene na spletni strani OECD: https://oecd.ai/en/incidents-methodology.

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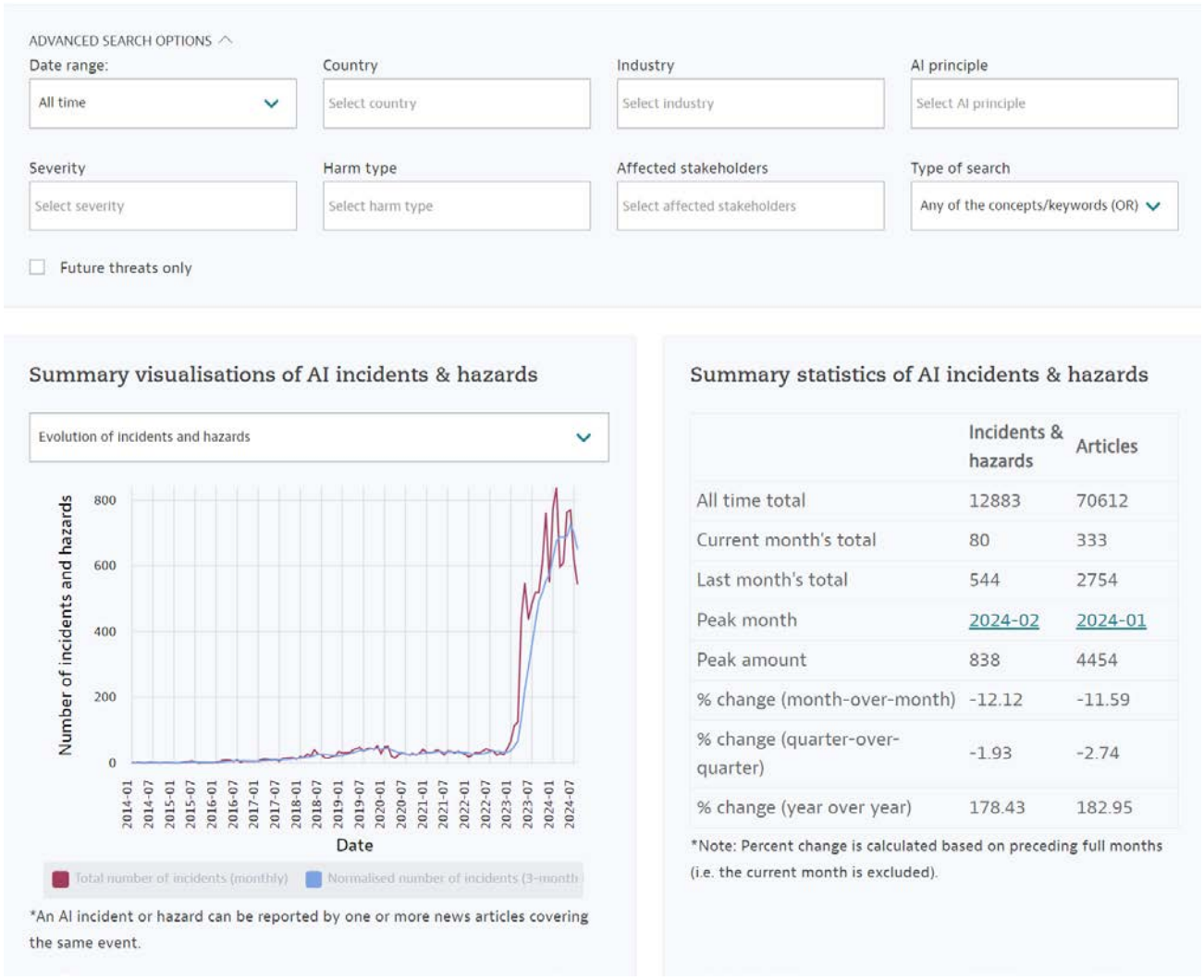

Slika 1 Prikaz začetne strani OECD monitorja AI incidentov (https://oecd.ai/en/incidents) prikazuje vmesnik za iskanje po konceptih, vizualizacijo incidentov v času (spodaj levo; y os: število incidentov; x os: čas (2014-danes) in statistični povzetek (spodaj

3 AI Incidents Monitor

AI Incidents Monitor je do konca avgusta 2024 zaznal preko 12 000 incidentov in nevarnosti v zvezi z UI, Kot je razvidno iz Slike 1. Sistem je popolnoma avtomatski in zaznava incidente s skeniranjem številnih podatkov objavljenih v novicah, ter nato s pomočjo UI določa kaj se označi kot incident ali nevarnost. Na naslovni strani (Slika 1) je prikazan črtni diagram naraščanja incidentov v času (levo) in pripadajoča statistika (desno). Uporabnik lahko izbira med absolutnim prikazom incidentov (kot na Sliki 1) ali v ustreznem meniju izbere pod-področja. Če se poglobimo v prikaz na Sliki 1, vidimo z različnimi barvami označeni kumulativni incidenti (vijolična) oz. njihovo trimesečno povprečje (modra). Statistika na desni prikazuje absolutno število incidentov glede na izbrano področje (12 883 incidenti in nevarnosti o katerih je poročalo 70612 novičarskih člankov), statistiko za zadnji mesec in mesece z največjimi vrednostmi (februar 2024). Iz statistik o spremembi glede na mesec, na četrtletje in na leto, vidimo padec števila incidentov in nevarnosti o katerih so mediji poročali v zadnjem mesecu glede na prejšnji mesec oz. prejšnje četrtletje.

3.1 Primer analize pojavitve incidentov UI

Sistem omogoča napredno filtriranje po incidentih UI za sledeče kategorije: čas, država, industrija, princip UI, resnost, tip škode, oškodovanci, tip iskanja po vsebini (glej Sliko 1). Tako so na primer možne vrednosti za resnost: smrt, poškodba, nevarnost, nefizična nevarnost, možni tipi škode pa so: fizična, psihološka, ekonomska, ugled, javni interes, človekove pravice, neznana.

Sistem omogoča napredno iskanje po konceptih, recimo za primer generativne UI, sistem poroča statistike, ki kažejo 2302 incidenta in nevarnosti, en od primerov incidentov, ki jih je sistem zaznal pa se nanaša na Apple in razvoj »AI personality«, ki naj bi nadomestil obstoječi Applov Siri.

Poleg konceptov uporabnik lahko nadalje izbere tudi napredno iskanje za natančnejšo identifikacijo želene podskupine incidentov, ki ga zanimajo. Tako lahko recimo izbere državo, ki je povezana s poročanjem o incidentih in nevarnostih UI. Na Sliki 2 je tako prikazan primer iskanja po kategoriji države, za Slovenijo. Sistem najde dva incidenta, ki sta bila povezana s Slovenijo. Prvi incident se nanaša na Microsoftov povečan prispevek k emisiji CO2. Na prvi pogled ni očitna povezava s Slovenijo, ko pa pogledamo povezane novice naletimo na omembo Slovenije: *»…But the tech giant's electricity consumption last year rivaled that of a small European country—beating Slovenia easily.«* [6]. Vsak primer je tudi semantično označen. Tako je na Sliki 2 za prvi primer označena povezanost s principi UI učinkovitost, trajnostni razvoj. Microsoft s tem lahko prizadene več deležnikov: splošno javnost, podjetja, delavce, vlade (Affected Stakeholders, Slika 2). Poleg tega predstavlja nevarnost za okolje, javne interese in človekove pravice (Harm type, Slika 2). Klasificirano je kot ne-fizična nevarnost (Severity, Slika 2).

Iz podrobnih analiz, ki so zbrane v nedavnem poročilu *»Observatory of the social and ethical impact of artificial intelligence«* [5], je razvidno, da večina incidentov (96%) spada pod kategorijo ne-fizično nevarnih, a imajo lahko zelo resne psihološke in finančne posledice, vključujoč nadlegovanja, odvisnosti in škodo ugledu tako posameznikom kot tudi inštitucijam.

4 Deležniki

OECD-jev monitor incidentov AI (AIM) je dragoceno orodje, zasnovano za različne deležnike, ki sodelujejo pri razvoju, regulaciji in uporabi umetne inteligence. Potencialni uporabniki tega orodja vključujejo oblikovalce politik, razvijalce AI, raziskovalce, pravne strokovnjake in javne organizacije.

Oblikovalci politik lahko AIM uporabljajo za sledenje in analizo podatkov v realnem času o incidentih, povezanih z AI, po vsem svetu, kar jim pomaga pri oblikovanju informiranih in na dokazih temelječih predpisov. Zmožnost orodja za kategorizacijo incidentov glede na resnost, industrijo in vrste škode je ključna za razumevanje širših posledic tehnologij umetne inteligence in oblikovanje politik, ki zmanjšujejo tveganja.

Razvijalci AI in raziskovalci lahko koristijo AIM, da prepoznajo pogoste težave, povezane s sistemi umetne inteligence. S preučevanjem incidentov, zabeleženih v AIM, lahko izboljšajo svoje modele, da bi se izognili podobnim težavam in povečali varnost ter zanesljivost aplikacij umetne inteligence.

Pravni strokovnjaki lahko uporabljajo AIM za pridobitev vpogledov v spreminjajočo se pokrajino tveganj, povezanih z umetno inteligenco, kar bi lahko bilo koristno v pravnih primerih ali ocenah skladnosti. Razumevanje preteklih incidentov in njihovih pravnih posledic lahko usmerja razvoj robustnih okvirov upravljanja AI.

Nazadnje lahko javne organizacije in zagovorniške skupine uporabljajo AIM za spremljanje družbenih vplivov umetne inteligence, s čimer zagotavljajo, da so interesi javnosti zaščiteni. To lahko vključuje analizo vzorcev incidentov z umetno inteligenco za zagovarjanje boljše zaščite potrošnikov in etičnih standardov pri uvajanju AI.

5 Diskusija

V prispevku smo predstavili OECD-jev monitor incidentov umetne inteligence, pri razvoju katerega smo sodelovali. Sistem služi kot dober vir za širok nabor uporabnikov, ki želijo razumeti in upravljati tveganja, povezana s tehnologijami UI. Sistem se nadgrajuje z dodatnimi podatkovnimi viri.

V prihodnosti je predvideno, da bo omogočen odprt postopek oddaje podatkov, ki bo dopolnil informacije o incidentih, pridobljene iz trenutnih virov. Nadaljnje delo zajema tudi avtomatsko analizo podatkov o incidentih za namen bolj celovitega vpogleda. To vključuje avtomatsko odkrivanja vzorcev, kot so verižne reakcije ali učinki na več industrij hkrati. Za potrebe preverjanja resničnosti poročanih incidentov, bi lahko vključili kombiniranje informacij iz več neodvisnih virov in uporabljal algoritme za odkrivanje lažnih novic, kot tudi ročno preverjanje.

Zahvala

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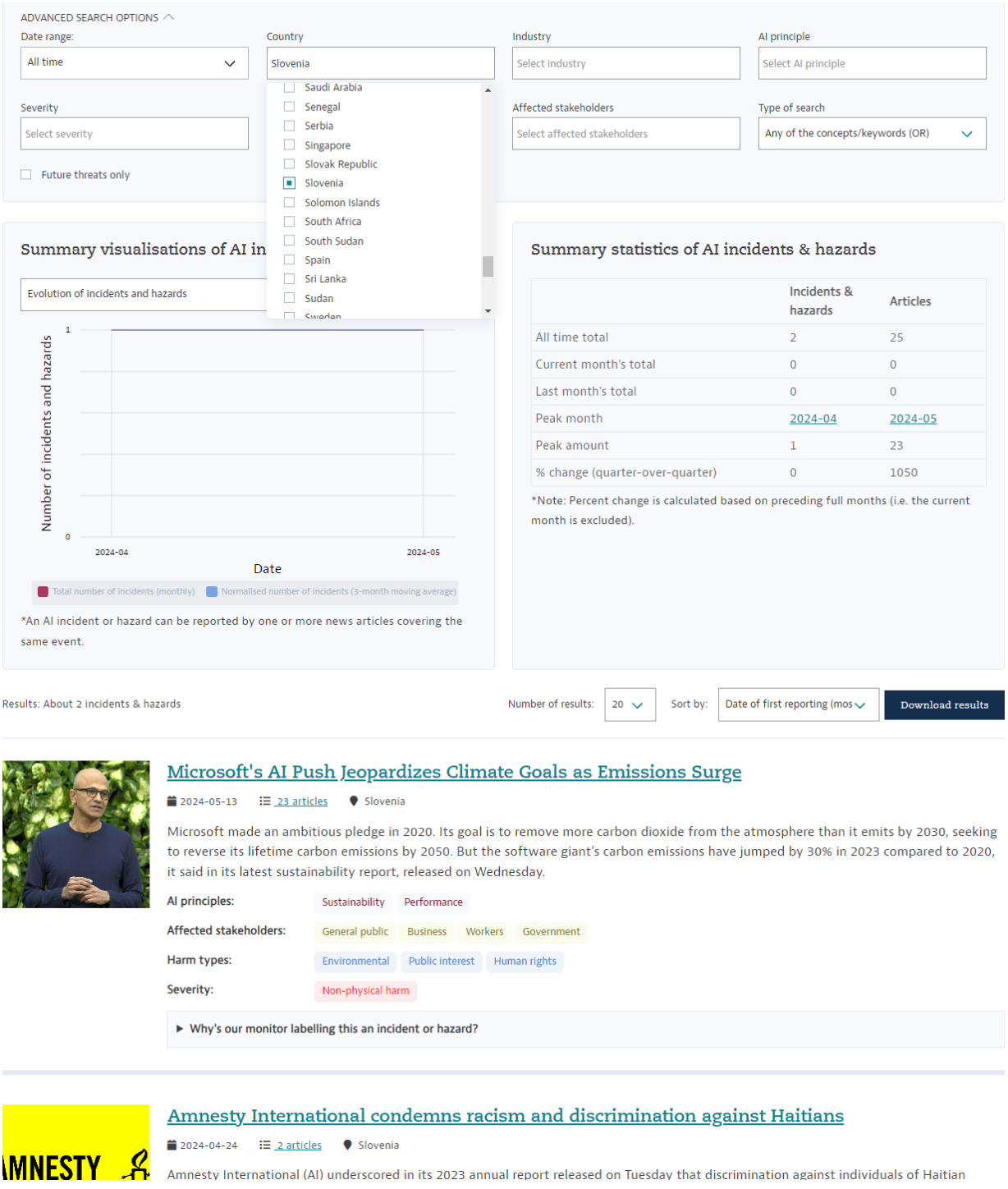

Slika 2 Prikaz naprednega iskanja na OECD monitorju AI incidentov (https://oecd.ai/en/incidents) filtrirano po državi za Slovenijo. Podane so statistike dveh incidentov o katerih je poročalo 25 novičarskih člankov, in spodaj sta prikazana oba incidenta.

Perception of AI in Slovenia

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Abstract

This paper introduces the AI News Monitor system developed for real-time monitoring and analysis of artificial intelligence (AI) perception in global and local news media. Leveraging data from the Event Registry platform, the AI News Monitor tracks AI-related news articles across multiple dimensions, providing insights through three key views: a global historical overview, current global trends, and local trends specific to Slovenian media. The system facilitates both passive observation of AI discourse and active exploration of specific AI-related events. Our illustrative analysis reveals significant global trends, including heightened media focus on deep learning, generative AI, and robotics, and examines the implications of these trends on public trust in AI. Additionally, the paper discusses the practical applications of the AI News Monitor for stakeholders such as policymakers, journalists, business leaders, and researchers. We conclude with a discussion on the impact of media coverage on public perception of AI and propose possible future enhancements of the system, including broader language and source coverage.

Keywords

datasets, artificial intelligence, media monitoring, perception

1 Introduction

Artificial Intelligence (AI) is increasingly becoming an integral part of society, influencing various aspects of daily life and industries [4]. As AI continues to evolve, so does its portrayal in the media, which plays a critical role in shaping public perception and trust. Understanding how AI is perceived globally and locally is essential for policymakers, businesses, and researchers to ensure that AI technologies are developed and deployed in ways that are socially acceptable and trustworthy [3, 4].

In response to this need, we have developed the AI News Monitor system designed for real-time monitoring and exploratory analysis of AI-related news coverage. The AI News Monitor offers a comprehensive view of how AI is discussed in the media, capturing data from the Event Registry platform on a monthly basis [7].

The AI News Monitor system is structured around three main views: a global overview that presents historical data from the past year, global trends that highlight recent AI-related events, and local trends focusing on mentions of AI by Slovenian news sources. These views allow the users to either passively monitor ongoing developments in AI or actively explore specific events and trends that may influence public opinion.

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Following are the main scientific contributions of this paper:
(1) We present a methodology to understand public perception about AI in news.
(2) We analyse some trends in AI's Perception.
The remainder of the paper is structured as follows. Section 2 describes the methodology to collect historical data, AI news categories and gaining insights in public perception about AI in news. Section 3 presents the analysis of trends in AI's Perception. We present different user scenarios and possible applications of AI News Monitoring in Section 4 and discussion in Section 5. Section 6 concludes the paper and outlines possible areas of future work.

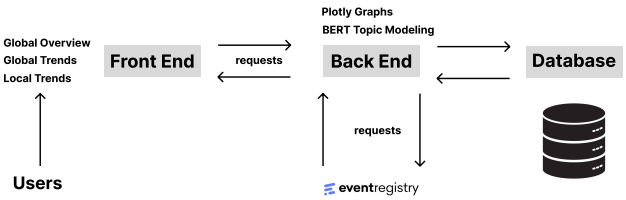

Figure 1: Architecture for Real-Time AI News Monitoring and Visualization based on Event Registry and implemented using Flask and Plotly.

2 Methodology

The proposed approach to creating a web service to analyze public perception involves two key steps: 1) identifying AI-related categories and gathering news within these categories, and 2) developing a web service that displays trends across these categories, news publishers, and highlights current trends among both global and local (Slovenian) news sources (see Figure 1).

Firstly, we selected AI-related categories based on the Slovenian AI observatory[1] and Wikipedia[2]. The key categories associated with Artificial Intelligence include 'Generative AI', 'Artificial Intelligence', 'NLP', 'Chat-GPT', 'Deep Learning', 'Robotics', 'Computer Vision', 'Neural Networks', 'Graph Neural Networks', 'Self-supervised Learning', and 'Zero-shot Learning'.

Next, we collected news articles from the last year related to these categories. These articles were classified into the appropriate categories based on Wikipedia concepts, and we also obtained sentiment data from Event Registry. The portrayal of AI-related news significantly impacts public perception, with the emphasis on risks, benefits, or ethical concerns shaping public opinion and driving narratives that can either build trust or instill fear[8],[12], [1].

To understand global trends, we retrieved news events published globally in the last month. For local trends, we focused on news

[1] http://siai.ijs.si/dashboards/Main/SlovenianObservatoryIntro?globalCountry=SVN
[2] http://country-dashboards.ijs.si/dashboards/Main/Index?

Figure 2: Time series of the number of news articles by specific areas (in colors, at the top). Detailed view upon precise exploration (middle) and corresponding sentiment of news from specific areas (at the bottom).

articles published by the top 50 Slovenian news publishers. Finally, we employed topic models to analyze the corpus of news articles and extract underlying themes [9], [2].

3 Analysis of trends of AI's Perception

3.1 Global Overview

The global overview provides a historical review of global AI-related news (see Figure 2). Users can explore the number of news articles across 13 AI fields (Generative AI, Chat-GPT, Deep Learning, Robotics, Computer Vision, Neural Networks, Graph Neural Networks, Artificial Intelligence, Federated Learning, Few-shot Learning, Meta Learning, Self-supervised Learning, and Zero-shot Learning) or by news providers and have an overview of the sentiment of the news.

Global trends allow for the review and exploration of global AI-related trends based on captured events from the last month. Figure 3 shows a detailed view of the Global Trends, where a written report of the number of news articles and events, a histogram of the number of AI-related news articles over time, and the ability to explore the last 10 events in a selected field.

3.2 Local Trends

Local trends allow for the review of news from Slovenian news providers for the last month. The local trends show the detailed view, where a written report of the number of news articles and events, a histogram of the number of AI-related news articles over time, and the ability to explore (see Figure 4).

3.3 EXAMPLES OF TRENDS

Figure 3: A detailed view of Global Trends, showing the option to select news events based on chosen AI fields.

3.3.1 Global Overview. In the historical overview of AI trends in March 2024 (Figure 2), there was a significant increase in the number of news articles and interest in deep learning, generative AI, and robotics. Specifically, on March 18th, there were 1,800 news articles about generative AI, 970 about robotics, and 274 about deep learning. This spike in news highlights several key events: one of the standout stories was the launch of Gen-2 by Runway, a generative video model capable of creating high-quality short clips. An important topic was the use of AI in political campaigns, particularly the creation of deepfakes and misinformation. This raised concerns about AI's impact on elections and voter trust. In the field of robotics, researchers were inspired by advancements in generative AI to develop more versatile robots. These new robots can perform various tasks using a single, comprehensive

model, demonstrating significant progress in robotic capabilities. Overall, the sentiment in March 2024 was positive (as seen from the sentiment analysis), reflecting enthusiasm and optimism regarding this technological progress. The increased media attention highlights the rapid development and growing importance of AI in various fields.

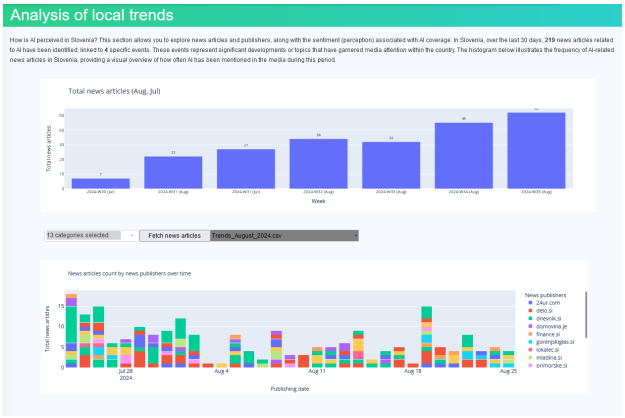

Figure 4: A detailed view of Local Trends, showing the option to select news events based on chosen AI fields.

3.3.2 Global Trends. In our examination of global trends, we selected the news story "AI and heat waves pose dual threats to the power grid" and found that two specific newspapers published more articles on this topic compared to others. The sentiment of these articles, as shown in the middle graph (Figure 4), fluctuates between positive and neutral. Upon delving into the content of these publications, we found that Forbes focused on the issue of fake news generated by AI, while Lexology explored future AI applications in various fields.

3.3.3 Local Trends. In the last month (at the time of writing the report, this was June 2024), there was an increase in AI-related news from Slovenian news providers, particularly from Delo.si and Sta.si (Figure 5). When analyzing the sentiment of these articles, most were neutral, with a few expressing positive opinions about AI. Delo.si focused on the growing adoption of AI by companies in Slovenia, highlighting discussions on the potential of quantum computing and recent advancements in AI technology. This coverage indicates a balanced view of AI's impact and potential. Sta.si reported on the construction of a state-of-the-art data center in Maribor, which will also house a supercomputer. This event represents a major development in Slovenia's technological infrastructure. Additionally, Sta.si wrote about AI trends that benefit semiconductor manufacturers, reflecting a positive outlook on the economic impact.

4 User Scenarios and Applications

The AI News Monitor can cater to a range of stakeholders with varying use case objectives [10], [6], [5]. Policy makers can utilize the developed system to track global and local trends in AI-related topics, enabling them to craft data-driven policies that balance innovation with societal concerns. Journalists can leverage the system to gather comprehensive insights into public sentiment and media coverage, enriching their reporting with accurate and timely information [11]. Detailed scenarios for both policy makers and journalists are explained below, illustrating how the AI News Monitor can support their specific goals. Other potential stakeholders are business executives, NGOs, researchers and educators.

Policy Makers: Scenario: A policymaker uses AI News Monitor to track trends in robotics.
Background: Jure, a decision-maker at a government agency for technology and innovation, is tasked with drafting new guidelines for the development and implementation of robotics in Slovenia. To understand the broader context and local trends, he needs to explore the global perception of robotics and compare it with local perspectives.
Steps: Step 1: Searching for a Global Overview: Jure logs into AI News Monitor and searches for "robotics" under the global overview section. The system displays a line chart showing how robotics has been mentioned over time, along with a sentiment graph for the past year. He finds that robotics is globally discussed with mostly positive sentiment, particularly in Asia and North America. Step 2: Global Trends: Jure selects "robotics" among the topics and reviews recent events on this subject. He chooses an event focusing on robotics in the EU and examines the sentiment of the publications and the main themes. In his browser, he looks at the specific articles and discovers that discussions predominantly revolve around automation and industrial robotics. Step 3: Local Trends in Slovenia: Next, Jure is interested in a review for Slovenia to understand how robotics is perceived at the local level. The dashboard for the selected topic displays an analysis of recent articles from Slovenian media. By using the browser, he discovers that discussions mainly focus on the impact of robotics on employment and the potential use of robots in healthcare. Jure finds that local concerns are more focused on social and economic impacts. He includes these insights in his preparatory documents for the new guidelines. Step 4: Compiling the Report and Recommendations: Finally, Jure exports key data, including sentiment graphs and media summaries, from AI News Monitor. He compiles a report that summarizes global trends and local concerns and proposes balanced guidelines that promote innovation in robotics while addressing social impacts.
Journalists: Scenario: A policymaker uses AI News Monitor to track trends in robotics.
Background: Ana, a journalist at a technology magazine, is tasked with writing an article on the growing trend of using generative AI to create videos. She needs to explore both global trends and local perspectives in Slovenia to provide a comprehensive overview.
Steps: Step 1: Searching for a Global Overview: Ana searches for "generative AI" under the global overview section. The system displays a line chart showing that this topic is on the rise, identifies the media outlets reporting on generative AI, and provides a sentiment graph for the past year. Step 2: Global Trends: Ana selects "generative AI" and reviews recent events on this topic. She focuses on deepfake video generation, checking who has written about it and what the main themes are. She then looks up these articles in her browser. Step 3: Local Trends in Slovenia: Ana shifts her focus to Slovenia to understand local views. The dashboard reveals that Slovenian media coverage is largely positive, particularly for certain providers. However, Ana realizes the need to include concerns about authenticity and misinformation to provide a balanced perspective. Step 4: Compiling and Writing: Ana exports key data, including sentiment graphs and media summaries, from AI News Monitor. She drafts her article, starting with global trends and then delving into specific concerns in Slovenia, enriched with visual data.

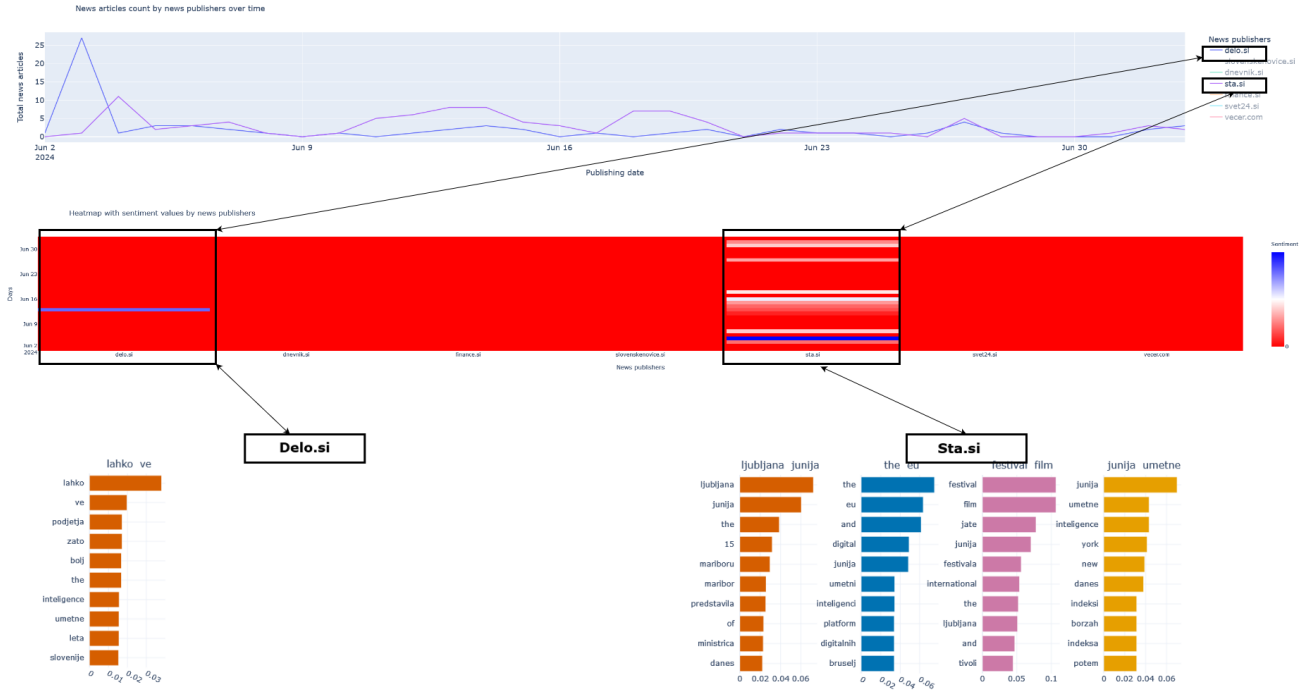

Figure 5: Time series of the number of news articles by news provider in Slovenia (at the top). Sentiment analysis (in the middle) and frequency of topics for this period (at the bottom).

5 Discussion

Services like AI News Monitor can play a role in fostering greater transparency around AI by offering detailed insights into how AI is being discussed across various media platforms. By tracking public sentiment and highlighting both positive and negative trends, it helps to ensure that the development and deployment of AI technologies are aligned with public concerns and expectations.

While AI News Monitor offers valuable insights, it has limitations, such as its reliance on media reporting, which may not capture the full spectrum of public opinion. Additionally, potential biases in media sources or the algorithms used for sentiment analysis could skew the results, presenting challenges in ensuring a fully accurate and balanced representation of public perception.

6 Conclusions

AI News Monitor was developed to understand and track public sentiment around AI, offering policymakers, journalists, and other stakeholders the insights needed to make informed decisions. AI perceptions can be monitored globally and locally, for the context of Slovenia. However, there are opportunities for future work to enhance its capabilities. Expanding the its coverage to include more languages and diverse sources would provide a more global perspective, while refining sentiment analysis techniques could improve accuracy and reduce potential biases.

7 Acknowledgments

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What will happen tomorrow? Predicting future event types for businesses

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ABSTRACT

Strategic foresight helps organizations anticipate future challenges and opportunities, allowing them to handle uncertainty better. While strategic foresight is becoming more widely adopted across organizations, the process still heavily relies on expert knowledge, and little of it has been automated through artificial intelligence. In this research, we explore how media news events can be analyzed to forecast event types that will take place in the near future. In particular, we consider it a supervised machine learning problem with a well-defined set of event types and leverage graph representation of the media news events to create graph embeddings, train a classifier, and predict event types that will likely occur one day ahead. We validated our approach on a real-world dataset of an American multinational conglomerate operating in industry, worker safety, healthcare, and consumer goods.

KEYWORDS

strategic foresight, event prediction, machine learning, graphs

1 INTRODUCTION

Strategic foresight helps organizations anticipate future challenges and opportunities, allowing them to handle uncertainty better [9]. Therefore, predicting future event types as a part of strategic foresight became necessary for businesses to manage their operations without significant losses. Various events on a major scale, such as floods, earthquakes, internet failures, or pandemics, as we are witnessing recently, or on a minor scale, such as road closures due to sports events or promotions at fairs, can have a major impact on business operations. By predicting the next event type, businesses can adjust prices, reschedule staff, manage stocks, reschedule transportation routes to avoid delays, and more, and thus reduce losses or increase their sales and profits.

There is currently a massive number of articles written on Future Event Predictions. Based on Zhao [11], the event prediction methods can be classified in terms of goals into time prediction, location prediction, semantics prediction, and a combination of these. Each goal is divided into subgoals for which various techniques can be applied. According to the classification provided by Zhao, our technique can be classified as a semantic prediction.

In this research, we explore how graphs can be used to model media news events and to forecast event types in the near future. By doing so, we provide a valuable tool for decision-makers, offering them a clearer view of potential outcomes. Specifically, our research focuses on using a JSON dataset containing a variety of articles about a particular business company. We create a graph representation of the articles and use Graph2Vec to create embeddings that can be used downstream to fit other machine-learning models. Using this information, we apply a Random Forest Classifier to predict the categories of articles about the company for the following day.

In particular, we expect this to be useful to give organizations a competitive advantage in fast-changing markets [5]. While human expertise is valuable, it varies from person to person, leading to inconsistent predictions. Manually analyzing large datasets is also time-consuming and prone to errors. AI, however, can process vast amounts of data, spot patterns, and predict future event types more accurately.

This work is structured as follows. Section 2 presents related work that is relevant for this paper. Section 3 describes the data in the dataset, and the data extraction process. Section 4 introduces a new approach to predict future event types. Section 5 presents the results of this research. Section 6 concludes this work and proposes future improvements.

2 RELATED WORK

In recent decades there has been an increasing interest in strategic foresight in the academic field. According to Fergnani (2020) [2] this is because by "using corporate foresight, organisations can reconfigure their strategy based on the analysis of business opportunities suggested by future possibilities". Even in academia "one of the domains heavily impacted by Artificial Intelligence is innovation management and in this context especially the area of Strategic Foresight (SF)" as per Brandtner et. al (2021) [1].

However it seems that strategic foresight methods related to AI only end up being used by bigger companies with a larger number of resources. As noted by Kim and Seo (2023) [6], "except for AI start-ups and players in the consumer electronics and information and communication industry, small- and medium-sized enterprises (hereafter SMEs) in other industries do not demonstrate competence in AI." Therefore, effective implementation of AI solutions for strategic foresight in smaller and medium sized

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https://doi.org/https://doi.org/10.70314/is.2024.sikdd.24

companies would be one of the topics to be explored in future research.

In this research however, we focus more on the general implementation of strategic foresight by means of next event prediction. Exploring similar fields, we found that there was already some research exploring the field of event predictions, which rather than focusing on businesses focused on other domains. In the field of sequential event prediction, several researchers are exploring diverse methods. Although the methods share some conceptual similarities with our research, they differ significantly in methodology and focus. Letham, Rudin, and Madigan (2013) [7] developed a model that predicts the next event using an ERM-based approach with logistic regression, focusing on the presence of events rather than their order. On the other hand, our work uses labeled article databases and considers the sequence of past events, using techniques like graph construction, random walks, and random forests. Yeon, Kim, and Jang (2015) [10] focus on predicting event flow through visual analytics, using LDA for topic extraction and emphasizing specific keywords, while our approach is entirely text-based and relies on graphs. On the other hand, Hu et al. (2017) [4] use LSTM networks for predicting future subevents, which offers an alternative method to our non-LSTM-based text analysis.

Although these studies provide useful insights and have offered significant improvement in sequential event prediction, they may face certain challenges. For instance, Letham, Rudin, and Madigan (2013) [7] emphasize event presence over sequence, potentially missing key temporal relationships, while Yeon, Kim, and Jang (2015) [10] depend heavily on keywords, overlooking broader context. Additionally, LSTM-based models like those used by Hu et al. (2017) [4] are powerful however they require significant computational power. In contrast, our work addresses these limitations by employing a graph-based approach that prioritizes event sequences and leverages standardized data from sources like DMOZ and Wikipedia. This enables us to make more accurate and efficient predictions, offering a practical and scalable solution that enhances predictive accuracy.

3 DATASET

3.1 Data Extraction Pipeline

The event detection pipeline processes about 300.000 English news articles per day. Each news article is first annotated using tools like entity linking, topic classification and sentiment detection. Each article is then split into sentences where each sentence retains it's annotations and other meta-data. For each pair of the entities in the sentence, an event classifier then determines if there is a particular relation of interest expressed in the sentence between the two entities. The predefined taxonomy currently includes 133 event types of interest, ranging from security, environment, natural disasters, accidents, politics, and other areas. To classify the events, a neural network transformer architecture with a pretrained encoder is used. The entire network, including the encoder, is trained on our supervised dataset using best practices like online hard example mining, class balancing, dropout, and consistency regularization. The sentences for which the classifier finds that it mentions a relation of interest are then stored in a database, together with the pair of associated entities and other available meta-data.

data = {"uri": ["2024-07-423118842-0"], "date": ["2024-07-16"], ..., "eventType": ["et/business/equity-actions/fundraising"], ..., "slots": ["http://en.wikipedia.org/wiki/Czech_Republic"]}

Figure 1: Sample of relevant data considered when parsing an event type to build the dataset.

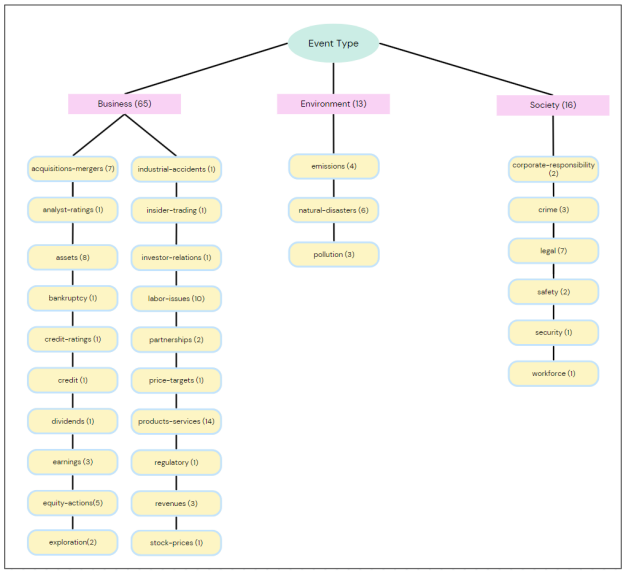

Figure 2: Event Type Taxonomy

3.2 Data Description

For our research, we used a dataset of events provided by Event Registry, with media events encoded in JSON format. Specifically, we analyzed 4,216 events related to the company 3M, recorded between June 23, 2021, and July 23, 2024. We used a URI to classify each event, drawing from DMOZ and Wikipedia categories (Fig. 1). These were selected because they provide standardized descriptions of the events being reported, which makes the data consistent and reliable. The events are categorized into 94 distinct types, which are further grouped into three primary domains: business, environment, and society. The business domain makes up the largest proportion of events, accounting for 65 types (69% of the total), while the environment and society domains contain 13 types (14%) and 16 types (16%), respectively. Within these domains, the event types are further divided into smaller subdomains, which can be aggregated into larger subdomain units as demonstrated in the event type taxonomy (Fig. 2).

4 METHODOLOGY

This study uses graph-based techniques to predict future event types from news articles about a specific company. The process starts by building a graph that maps relationships between event types and concepts from Wikipedia and DMOZ. Random walks are then performed on this graph to extract key information such as URIs, dates, and event types, which are then transformed into embeddings using Graph2Vec [8]. Next, the event types are encoded and adjusted through a process called target shifting. This step aligns the features to better forecast future outcomes based on previous data. The predictions are made using a Random Forest classifier, which is then validated through stratified k-fold

a) b) c)

Figure 3: Event Type Graphs

cross-validation for higher accuracy. The following sections will present each step of this process in more detail (see Fig. 4).

4.1 Graph Construction

For each article in the JSON dataset, a detailed graph G is generated using the NetworkX library [3]. The graph construction process starts by extracting key information such as the article's URI(unique identifier), as well as the date associated with the article and the event types, which are represented by specific URIs. In addition to these elements, each article also includes two important lists: 'slots' and 'categories'. The 'slots' list contains wiki and dmoz addresses that are directly related to the event described in the article, while the 'categories' list includes various classifications of the event. To complete the graph, labels are created by extracting URIs from the 'slots' list and filtering the 'categories' to focus on those with the "dmoz" prefix.

4.2 Random Walks for Feature Extraction

Once the graphs for each article are constructed, random walks are performed, starting at a given node (event type) and moving to adjacent nodes based on specific probabilities. Several random walks are generated for each node, forming the foundation for feature extraction processes. A single random walk begins by initializing the path with the starting node and iterating over a specified path length. At each step, a random number is compared with a probability p. If the number is less than p, the walker stays at the current node, otherwise it moves to a random neighbor. If no neighbors are available, the walk ends.

Generating multiple random walks for every node follows a similar approach, using p as the probability of staying at the current node (set at 0.05). The process involves creating an empty list to store all random walks and iterating through each node in the graph. For each node, the specified number of random walks is generated, and each walk is appended to the list.

4.3 Embedding Generation Using Graph2Vec

The random walks from the graphs are processed similarly to word sequences in a document. The 'embedding_data' function generates vector embeddings for graph data using the Doc2Vec model. It begins by converting each random walk into a TaggedDocument, storing these in 'documents_gensim'. The Doc2Vec model, with a vector size of 5 is trained on these documents, creating a vector space where similar sequences are positioned close together.

The function then processes each graph in the graphs dictionary, extracting uri, date, and event type, and generating additional random walks. These walks are converted into embeddings using the 'infer_vector' method, and the resulting vectors are averaged into one final embedding. This embedding is stored in a dictionary across 'embedding1' to 'embedding5', alongside the graph's metadata.

4.4 One Hot Encoding & Target Shifting

To transform the categorical event types into binary vectors, One hot encoding is applied. This allows the model to treat each event type as a separate class. After extracting relevant column names, the encoded target data is concatenated with the feature embeddings, creating a dataset for model training and evaluation. The dataset is then aggregated by averaging out the embeddings and calculating the maximum value of the encoded target columns for a given day. Finally the 'target' data is shifted by one day, which allows the embeddings to forecast the event types for the following day.

4.5 Random Forest Classification & Stratified K-Fold Cross Validation

To ensure an effective classification and prediction of the data, A Random Forest classifier is created. When employing this method, embeddings are used as features and the one-hot encoded event types are used as labels. The data itself is split into testing and training sets, followed by the incorporation of the Stratified K-Fold cross validation. This technique splits the data into 10 folds, while ensuring that the event type proportion in each fold remains equal. The model is then trained on 9 folds, with the remaining fold being used for validation. This ensures balanced representation of each class across the folds resulting in a more effective performance.

5 RESULTS

As mentioned above, the model was trained on a training set, and then evaluated on a test set. The training set included approximately 508 samples for each fold, and the test set included about 10% of the whole set, which amounted to 56 samples per fold. Using this, the model then predicted the probabilities for event types for each set. When training the model for each class, we noticed certain classes did not have enough occurrences to have at least one entry of such a class per dataset fold and were skipped. We, therefore, trained the model and predicted for a total of 45 classes.

To evaluate the discriminative performance of the model, the ROC AUC score was used. The results produced showed us how well the model distinguishes between different classes, as well as the model's ability to predict future event types. The ROC AUC score showed us that the average performance of the model was around 0.5674, and the median was close to it, with an AUC ROC score of 0.5559, with the highest score reaching 0.8194 and the lowest reaching a value of 0.3338. While the best scores demonstrate we can effectively forecast event types ahead of time, further work is required to enhance results, which in most cases remain close to 0.5.

6 CONCLUSIONS

This study was used to develop a graph-based approach to predicting event types in articles. In the process, we utilized random walks for feature extraction and Doc2Vec for embedding generation. Then, we trained the resulting model on a Random Forest classifier and evaluated it with a Stratified K-Fold Cross Validation. The model demonstrated solid performance with an average ROC AUC score of around 0.5674, reaching a peak at approximately 0.8194. This indicates the model's effectiveness in capturing relationships within the data and predicting future event types.

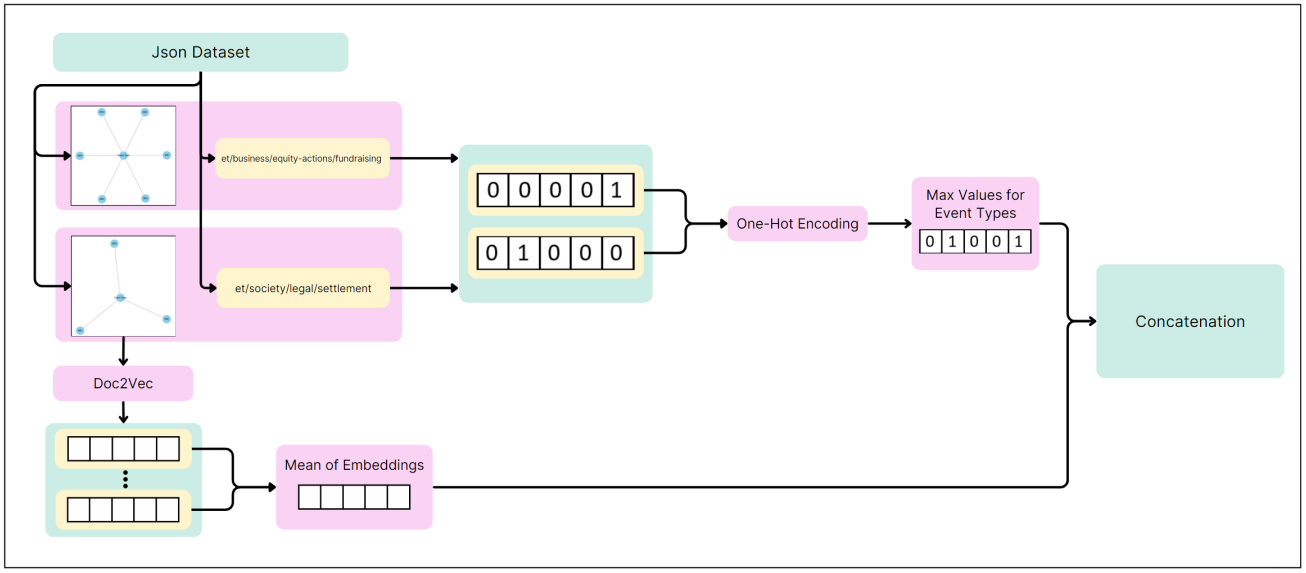

Figure 4: Data Extraction Pipeline

However, while the model performed well overall, occasional fluctuations in accuracy suggest space for further improvement. We are currently striving to find ways to make graphs more informative. In future work we could refine the feature extraction process by incorporating larger datasets, with a wider variety samples and a larger number of companies.

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Generating Non-English Synthetic Medical Data Sets

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Abstract

Using synthetic datasets to train medicine-focused machine learning models has been shown to enhance their performance, however, most research focuses on English texts. In this paper, we explore generating non-English synthetic medical texts. We propose a methodology for generating medical synthetic data, showcasing it by generating Greeklish medical texts relating to hypertension. We evaluate our approach with seven different language models and assess the quality of the datasets by training a classifier to distinguish between original and synthetic examples. We find that the `Llama-3` performs best for our task.

Keywords

Synthetic data, healthcare data, multilingual data, large language models, classification

1 Introduction

The healthcare domain produces a lot of medical data that can be used to train machine-learning models to help medical personnel. For example, a machine-learning model designed to perform Named Entity Recognition (NER) on electronic health records (EHRs) needs extensive labeled datasets to accurately identify medical terms like diseases, treatments, and patient details. However, the data contains a lot of personal information, and hospitals cannot share it freely due to data protection. In addition, there are not enough examples to train the models for some problems, such as those relating to rare diseases. Because of this, synthetic data is being used as a substitute to train the models.

Most synthetic data generation approaches focus on generating English texts. These usually utilize large language models trained on predominantly English documents retrieved from the web. However, there are few examples of using them to generate non-English texts. Furthermore, the language models have difficulties generating texts that do not reflect the distributions found in the training sample. This includes medical texts, which are usually not accessible to the general public.

This paper proposes a methodology for generating medical synthetic data using open-source large language models. We apply the methodology to a medical data set written in Greeklish, a combination of Greek and English scripts. We test it with seven large language models and assess performance by training a classifier to distinguish original examples from synthetic ones. Using the same prompt, we find that the open-source Llama-3 model best generates synthetic data that reflects the original data set.

The remainder of the paper is as follows: Section 2 presents the related work on generating synthetic data using large language models. Next, the proposed methodology is described in Section 3. The experiment setting is presented in Section 4, followed by the experiment results in Section 5. We discuss the results in Section 6 and conclude the paper in Section 7.

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2 Related Work

This section describes the related work, focusing on large language models and methods for generating synthetic data.

2.1 Large language models

Large Language Models (LLMs) are models that were trained to generate human-like texts based on an extensive process of training on vast amounts of data. Models, such as Llama 3 [2], GPT-4 [9], Aya 23 [3] and Mistral [7], are often easy to work with by providing an input textual prompt, based on which the models respond. The LLMs are helpful in specialized fields, such as medicine, since they can be fine-tuned on extensive data sets containing medical terms and concepts. This enables them to perform well in tasks such as medical synthetic data generation [12]. Despite that, they are sometimes unable to follow the instructions in the prompt accurately, leading them to hallucinate, i.e. confidently produce wrong responses [5].

In our experiments, we investigate the LLMs' performance in generating synthetic medical data given specific constraints and detailed prompts to simulate the original data set as best as possible.

2.2 Synthetic medical data generation

Recently, synthetic medical data, generated using LLMs, has been used to enhance the performance of models for solving different natural language processing tasks in medicine.

One work focuses on generating a synthetic dataset of electronic health records of Alzheimer's Disease (AD) patients based on a label that is provided [8]. They find that the performance of their system for detecting AD-related signs and symptoms from EHRs improves vastly when trained on synthetic and original data sets as opposed to training the system only on the original one. Another work investigated using LLMs for extracting structured information from unstructured healthcare text [13]. By generating synthetic data using LLMs and fine-tuning the model, they significantly improved the models' performance for medical-named entity extraction and relation extraction tasks.

Most related works focus on English synthetic data due to scarce non-English training data and the dominance of English in medical terminology [6]. This paper focuses on generating non-English texts, specifically medical texts written in Greeklish about hypertension.

3 Methodology

This section outlines our research methodology. We first present the pre-processing of the data set, followed by describing the synthetic data generation process. Finally, we present the description of synthetic dataset evaluation using a classifier. Figure 1 shows the diagram overviewing the proposed methodology.

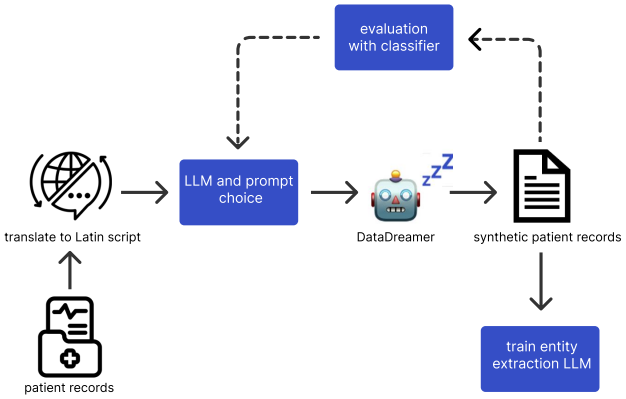

Figure 1: An overview of the methodology. The image was designed using resources from flaticon.

3.1 Data pre-processing

The data set used consisted of 1,299 examples of medical history in Greeklish, where the Latin and Greek scripts were used interchangeably. It also contained 1,495 labels, most of which were in English. The labels consisted of drugs, medical events, and measurements.

To translate the labels into Greek, we used the `NLLB-200` [14] translation model[1]. Since LLMs were predominantly trained on texts written in Latin script, we decided to transliterate both the labels and examples from Greek to Latin script. This allowed the LLMs to generate longer tokens with richer information.

We split the original data set into two subsets to ensure no data leakage. The first one, consisting of 930 examples, was used for synthetic data generation. The second one, containing the remaining 369 examples, was used for evaluation.

3.2 Synthetic data generation

We utilized the datadreamer library [10] to generate the synthetic data set. The library enables open-source models to create synthetic data sets and was developed to work in research settings, supporting prompt templates and few-shot learning.

We developed a prompt containing the instructions and restrictions on generating the examples. To better showcase the structure of the generated text, we also provided five random examples from the original data set as few-shot examples. Next, using datadreamer, we sent the prompt to the chosen LLM. We experimented with multiple LLMs, and about 800 examples were generated for each used LLM. When experimenting with LLMs that required calling an external provider (e.g., OpenAI), we provided five static few-shot examples that did not include any patient personal data due to data privacy concerns.

To ensure the quality of generated data, we implemented a post-processing step. This included formatting the generated text into one line and excluding examples where the length was too long or where the model started repeating words meaninglessly. This ensured that all generated examples followed the same format and could be used for evaluation.

Table 2 presents generated examples for the label "OSTEOPOROSH". Similarities in the examples highlight the need for rigorous methods to evaluate how closely they resemble the original data set. The methods are explained in Section 4.1.

[1]https://huggingface.co/facebook/nllb-200-distilled-600M

3.3 Technical details

In this section, we describe the models and the parameters used in the experiment. All models used are available via the HuggingFace's transformer library [15].

We tested five open-source models to generate the synthetic data sets, all of which can be run on a 32GB GPU: `Llama-3` [2] only has support for the English language but has been fine-tuned to understand user prompts, which is a feature we expected would help a lot with the synthetic data generation.[2] `Aya-23` [3] is a multilingual language model and offers support for 23 languages, including Greek.[3] `Mistral` [7] supports a variety of languages but omits Greek[4]. The models `Gemma-2` [4] and `Phi-3` [1] were also tested and compared in the experiments.[5][6] In addition, we experimented with `GPT-4o` [9] and `GPT-3.5-Turbo`, which are accessible via the OpenAI API.

All models were given the same prompt containing instructions that included (1) generating Greek texts written in Latin script and (2) containing a label randomly selected from the original data set, (3) examples are supposed to be at most 6 words long, (4) should provide concise responses, (5) structured format (all text must be in a single line, must use // and commas as separators, and must be similar in format as the provided few-shot examples). To stress some more important instructions, some instructions were given in capital letters and were also repeated.

4 Experiment Setting

This section describes the experiment setting, which consists of the evaluation process and the metrics used to measure the approach's performance.

4.1 Evaluation approach

The quality of the generated synthetic data was measured in two parts. The first consisted of statistical measurements, such as calculating the average length of the generated examples and finding the proportion of examples that included the required labels. These statistics were then compared to the original data set.

The second part consisted of training a classifier to discern if the input text was from the original or from the synthetic data set. The data set used to train and evaluate the classifier involved 369 randomly selected synthetic examples and 369 examples from the original data set, transliterated into Latin script. We chose 5-fold validation as our classification procedure and calculated the mean performance across all trials.

The classifier was trained using the BERT [11] language model, specifically the `bert-base-multilingual-cased` variant[7]. The classifier was trained using the following parameters: batch size = 16, epochs = 3, and learning rate = 2e-5. The same parameters were used for all synthetic data sets.

4.2 Metrics

To assess the quality of the generated synthetic data sets, we used the F1 score as our main metric for evaluating the classifier's performance. The target value was 0.5; if the performance is greater than 0.5, the classifier can discern the original from the synthetic examples. Hence, the synthetic data does not reflect the original data set. If the performance is less than 0.5, the

[2]https://huggingface.co/meta-llama/Meta-Llama-3-8B-Instruct
[3]https://huggingface.co/CohereForAI/aya-23-8B
[4]https://huggingface.co/mistralai/Mistral-7B-Instruct-v0.3
[5]https://huggingface.co/google/gemma-2-9b-it
[6]https://huggingface.co/microsoft/Phi-3-medium-4k-instruct
[7]https://huggingface.co/google-bert/bert-base-multilingual-cased

classifier has difficulties separating the synthetic from the original data, which can be because the synthetic data contains copies of the original examples. In addition to the F1 score, we measured the classifier's accuracy, precision, and recall, which are also reported.

5 Results

In this section, we present the results of our experiment. We first present the statistical results, followed by the classifier's evaluation.

5.1 Statistical analysis

Table 1 compares the synthetic data sets and the original one regarding label occurrence and average example length. The label occurrence is 1.000 in the original data set, as all examples from the original data set are assumed to include relevant labels and information.

The most aligned synthetic data set regarding label occurrence was generated using `GPT-4o`, followed by `Llama-3`. However, in terms of average example length, the data set generated using `Gemma-2` performed the best, followed by `Llama-3`.

The worst-performing models, in terms of label occurrence, were `Mistral` and `Phi-3`, which in about 25% did not include the selected label. The data set generated using the `Aya-23` had the largest difference in terms of average example length, on average generating examples with three extra words.

Table 1: Statistical comparison between the original and synthetic data sets. The bold and underlined values represent the best and second-best statistics, respectively.

LLM	Label occurrence	Avg example length
original dataset	1.000	4.682
`Llama-3`	<u>0.990</u>	<u>5.330</u> (+0.648)
`Aya-23`	0.949	8.040 (+3.358)
`Mistral`	0.740	6.376 (+1.694)
`Gemma-2`	0.988	**4.207** (-0.475)
`Phi-3`	0.782	6.071 (+1.389)
`GPT-4o`	**0.996**	3.691 (-0.991)
`GPT-3.5-Turbo`	0.867	6.764 (+2.082)

Looking at both statistics, we can conclude that `Llama-3` had the best alignment to the original data set in terms of label occurrence and example length, closely followed by `GPT-4o`.

To better imagine the differences between the generated examples, we handpicked an example from each synthetic data set related to the label "OSTEOPOROSH", shown in Table 2.

5.2 The classifier evaluation

Table 3 shows the F1, Precision, Recall, and Accuracy performances of the trained classifier on different synthetic data sets. The best performance was achieved by `Mistral` with approximately 0.85 scores in all four metrics, followed by `Llama-3`, with approximately 0.88 scores in all metrics. The worst performances were on data sets generated by the `Aya-23` and `GPT-3.5-Turbo` models. Surprisingly, the `Aya-23` is a language model supporting Greek; thus, it was expected to generate better examples.

6 Discussion

This section discusses the synthetic data generation performance, outlines our methodology's limitations and drawbacks, and proposes potential improvements to the approach.

6.1 LLM performance

Results in Table 1 show significant quality differences among synthetic datasets from different LLMs, with label occurrence ranging from 0.740 for `Mistral` to 0.996 for `GPT-4o`, and average example length from 3.691 for `GPT-4o` to 8.040 for `Aya-23`.

However, Table 3 indicates no significant performance differences within a single synthetic dataset, with a maximal standard deviation of the metrics being 0.021 for the `Llama-3` dataset.

We can also notice that the F1 and accuracy scores are very close for all synthetic data sets. This means the classifier was likely performing relatively similarly on both classes (synthetic and original datasets) without significant bias to either class.

We can observe much better performance on the `Llama-3` data set, which is primarily trained on English data, than on the `Aya-23` data set, which is also trained on Greek data. This shows that a model does not need to be extensively trained in Greek texts to generate this type of synthetic medical data well.

6.2 Limitations

Due to limited computing power, only one GPU with 32GB of space was available, restricting the testing of larger LLMs. To address these challenges, using cloud-based resources or distributed computing could help run larger models and improve the variety of synthetic data generated.

Due to privacy concerns, when using `GPT-4o` and `GPT-3.5-Turbo` models, which are not locally-run models, we had to use five fixed examples when generating synthetic data instead of a larger variety. This potentially led to larger similarities of the `GPT` synthetic datasets to the examples instead of the original dataset and, consequently, worse performance.

6.3 Potential improvements

The prompt was the same for all seven LLMs and was primarily tested on `Llama-3`. Hence, the performance might be biased towards the model. The method could be improved by tailoring the prompts to each model individually.

The evaluation of synthetic datasets could be further extended by checking for repeating examples in the synthetic dataset or by checking how different the generated example is from the five provided examples. The evaluation could also be improved by checking for overfitting to the original data set.

7 Conclusion and Future Work

This paper presents a method for generating Greek synthetic medical data sets. To synthetically create datasets similar to the original, we carefully craft a prompt and perform pre-processing and post-processing of the data to increase performance and eliminate the effect of hallucinations.

Using a classifier and considering the inclusion of labels and generated text length, we conclude that `Llama-3` is best for generating examples that most closely resemble the original dataset. In the future, we plan to explore the underlying architectures of the models to understand their performance differences in multilingual contexts. This will allow us to further refine our methods and create more accurate data sets.

Furthermore, we intend to use the synthetic dataset to train a named entity recognition (NER) system to recognize medical labels from medical history examples. Measuring the performance of the NER trained on synthetic datasets will give us another way of evaluating their quality. We also intend to create a more general pipeline enabling the code to generate synthetic medical data in a wider variety of languages and formats.

Table 2: Generated examples for label "OSTEOPOROSH".

LLM	Examples
original dataset	APO 2O ETON YPERTASH ME AGOGI// OSTEOPOROSH // YPOTHYROIDISMOS
Llama-3	YPOTHYROEIDISMOS, OSTEOPOROSH, APO//
Aya-23	CA ORTHOU, ANEYRISMA KOILAKHS AORTHOU, OSTEOPOROSH.
Mistral	OSTEOPOROSH, APO 60 ETOS, APO 2 MHNES KAI APO 10 GRAMM
Gemma-2	OSTEOPOROSH, ARTHROSITIS, ETOVIR
Phi-3	OSTEOPOROSH, XAROSTHROMA, ALPHA-BISFIOVITINI, 2018, DIATHRHSH, DIA
gpt-4o	OSTEOPOROSH, ANEMIA
gpt-3.5-Turbo	OSTEOPOROSH, GASTREKTOMH, EMFISIMA, YDRONERFOSI, PSIXROS.

Table 3: Mean performance metrics of the classifier for synthetic data sets, with standard deviation. Performances that are closer to 0.5 are considered better. The bold and underlined values represent the best and second-best performances, respectively.

LLM	F1	Precision	Recall	Accuracy
Llama-3	<u>0.875 ± 0.021</u>	<u>0.881 ± 0.020</u>	<u>0.875 ± 0.020</u>	<u>0.875 ± 0.020</u>
Aya-23	0.945 ± 0.005	0.947 ± 0.004	0.945 ± 0.005	0.945 ± 0.005
Mistral	**0.848 ± 0.012**	**0.856 ± 0.001**	**0.849 ± 0.011**	**0.849 ± 0.011**
Gemma-2	0.928 ± 0.005	0.930 ± 0.005	0.928 ± 0.005	0.928 ± 0.005
Phi-3	0.927 ± 0.009	0.932 ± 0.008	0.927 ± 0.009	0.927 ± 0.009
GPT-4o	0.906 ± 0.014	0.912 ± 0.012	0.907 ± 0.014	0.907 ± 0.014
GPT-3.5-Turbo	0.940 ± 0.013	0.944 ± 0.011	0.940 ± 0.013	0.940 ± 0.013

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LLNewsBias: A Multilingual News Dataset for Lifelong Learning

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Abstract

The rise of digital media enhances information accessibility but also introduces challenges related to the quality and impartiality of news reporting, particularly regarding biases that influence public perception during key global events. In response, this study introduces *LLNewsBias*, a dataset designed to detect and analyze political bias in multilingual news headlines, covering four major events from 2019 to 2022 — Brexit, COVID-19, the 2020 U.S. election, and the Ukraine-Russia war. With over 350,000 headlines in 17 languages, annotated with bias labels, this dataset is compiled using Media Bias/Fact Check and Event Registry. Our contributions include a structured framework for data collection and organization, enabling event-wise and year-wise analysis while supporting lifelong learning. We also highlight potential use cases that demonstrate the dataset's utility in advancing bias prediction models, multilingual adaptation, and model robustness. Additionally, we discuss the dataset's limitations, addressing potential biases, sample size constraints, and contextual factors. This work provides a valuable resource for improving bias detection in dynamic, multilingual news environments, contributing to the development of more accurate and adaptable models in natural language processing and media studies. For code and additional insights, visit: https://github.com/Swati17293/LLNewsBias

Keywords

Dataset, News, Bias, Multilingual, Headline, Low-resource, Media Bias, News Bias, Continual Learning, Lifelong Learning

1 Introduction

The rapid growth of digital media has greatly enhanced the accessibility of information, but it has also introduced significant challenges concerning the quality and impartiality of news reporting. Political bias in news content is particularly concerning, as it has the potential to influence public perception and shape societal narratives, especially around key global events. Understanding and predicting such biases, particularly in multilingual contexts where biases can manifest differently across cultural and linguistic boundaries, is essential for promoting fair and balanced journalism. Traditional approaches to bias detection often rely on monolingual datasets and static models that may not effectively capture the evolving nature of news content [6]. These limitations underscore the need for more robust datasets and methodologies that can adapt to the dynamic and multilingual landscape of modern news reporting.

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In this study, we address these challenges by introducing a novel dataset *LLNewsBias* specifically designed for the detection and analysis of political bias in multilingual news headlines. Our dataset spans four major global events from 2019 to 2022: Brexit, COVID-19, the 2020 U.S. election, and the Ukraine-Russia war, capturing a wide range of political discourse across 17 languages. To collect this dataset, we use Media Bias/Fact Check for the assignment of bias labels, and Event Registry [2] for the extraction of relevant headlines and metadata. The resulting dataset is not only comprehensive in its linguistic diversity but also structured to support both event-wise and year-wise analyses, with an emphasis on lifelong learning.

1.1 Contributions

Our study makes the following contributions:

- **Multilingual bias-annotated dataset:** We introduce a multilingual bias-annotated dataset containing over 350,000 news headlines in 17 languages, each annotated with political bias labels.
- **Data collection and organization framework:** We present a structured framework for data collection and organization, enabling event-wise and year-wise analysis while ensuring adaptability for lifelong learning.
- **Potential use-cases:** We outline several potential applications of our dataset, highlight its potential for advancing lifelong learning models, particularly in bias prediction, multilingual adaptation, and model robustness.
- **Discussion of limitations:** We identify and discuss the dataset's limitations, such as biases in data collection, sample size constraints, and contextual influences, offering a transparent assessment of its applicability.

In summary, our paper introduces a comprehensive dataset and a framework for the study of political bias in multilingual news headlines. By focusing on key global events and providing support for lifelong learning, our study contributes to the ongoing effort to develop more accurate and adaptable models for bias detection in diverse linguistic and cultural contexts.

2 Related Work

Several datasets focus on news articles and political bias [5], but there is a notable scarcity of multilingual, bias-annotated datasets designed for lifelong learning [4]. While resources like the *media bias chart* by Ad Fontes Media and PolitiFact provide insights into bias, they are often limited to English-language sources or specific fact-checked claims, lacking the continuous, event-centric data necessary for broader analysis. GDELT [3], a large-scale event-oriented news dataset, covers multiple languages but focuses on location, network, and temporal attributes rather than political bias or the event-outlet relationship. Existing multilingual datasets are often domain-specific [1], limiting

their utility for general bias analysis. In contrast, LLNewsBias dataset fills these gaps by offering a generalized, multilingual, and bias-annotated data designed for event-wise and year-wise analyses, particularly suited for lifelong learning models.

3 Dataset Description

In this section, we introduce our dataset *LLNewsBias* and describe the framework used for its collection and organization. We begin by detailing the primary data sources that form the foundation of this dataset. Following this, we present a comprehensive overview of the data collection process, with a focus on the methodologies employed to ensure robustness and reliability. Finally, we provide an in-depth overview of the dataset's structure, including its directory organization, file contents, and the various ordering methods applied to facilitate detailed analysis. Our dataset is documented in accordance with the FAIR Data Principles.

3.1 Primary Data Sources

In this section, we outline the two primary data sources used in our study: Media Bias/Fact Check (MBFC) and Event Registry (ER). MBFC serves as the bias rating portal, providing bias labels for selected media outlets, while ER is used to extract the headlines and corresponding metadata from articles published by these outlets.

3.1.1 ***Media Bias/Fact Check.*** For bias labeling in this study, we utilized Media Bias/Fact Check (MBFC), a well-established platform known for its comprehensive coverage and frequent updates. Although other platforms like allsides.com and adfontes-media.com also provide bias ratings, MBFC was selected for its reliability and particular focus on low-resource languages. MBFC assigns bias labels based on political orientation and evaluates outlets for credibility and factual accuracy. These labels are determined by a team of contractors and volunteers who follow a standardized methodology, ensuring that the ratings are both consistent and dependable for our analysis.

3.1.2 ***Event Registry.*** In this study, we use Event Registry [2] platform as the primary source for collecting multilingual news headlines. It aggregates content from over 150,000 news sources across more than 60 languages, making it an ideal resource for analyzing bias in diverse and low-resource languages. Apart from the headlines, it allows access to numerous metadata such as publication date, news category, and political bias. By leveraging its Python API, we efficiently filtered and extracted headlines relevant to our study. This ensured a comprehensive dataset that supports the analysis of bias in a lifelong learning setup, exploring how emerging events and domain shifts influence the performance of bias prediction models over time.

3.2 Data Collection Framework

Our data collection framework as depicted in Figure 1, is designed to support both event-wise and year-wise analyses, with the additional capability of facilitating lifelong learning.

For data collection, we begin by defining two sets: a set of significant global events ($E = \{e_1, e_2, ..., e_n\}$), and a set of years ($Y = \{y_1, y_2, ..., y_m\}$), where n and m represent the total number of events and years, respectively. We then use the Media Bias/Fact Check (MBFC) platform to select media outlets ($O = \{o_1, o_2, ..., o_p\}$) and determine their respective political bias, with p as the total number of outlets. To maintain data reliability, we exclude outlets labeled as questionable and assign each remaining outlet $o_i \in O$ a bias label $b_i \in B$, where $B = \{b_1, b_2, ..., b_q\}$ represents the set of bias labels, with q representing the number of distinct bias labels.

Next, we define a temporal query Q_t to extract article headlines ($H = \{h_1, h_2, ..., h_r\}$), where r represents the total number of headlines retrieved from the Event Registry (ER). The query Q_t is formulated as:

$$Q_t = \{Q_e, Q_o, Q_{cat}, Q_{dt}\} \tag{1}$$

where Q_e, Q_o, Q_{cat} specify the event, media outlet, and news categories (limited to those classified as 'news' by ER $Q_{cat} = \{$'*politics*', '*business*', '*sports*', '*arts and entertainment*', '*science*', '*technology*', '*health*', '*environment*'$\}$), respectively. The time constraint is represented as $Q_{dt} = [Q_{sd}, Q_{ed}]$, where Q_{sd} and Q_{ed} denote the start and end dates. To scrape all the article headlines (H), we utilize Q_t to query ER.

We then associate the extracted headlines H with the corresponding bias labels in B and structure the dataset according to two classification types: event-wise and year-wise. To organize the data, we define an event-based order O_{event} and a year-based order O_{year} as follows:

$$O_{event} = \{e_1 \rightarrow e_2 \rightarrow ... \rightarrow e_n\} \tag{2}$$

$$O_{year} = \{y_1 \rightarrow y_2 \rightarrow ... \rightarrow y_m\} \tag{3}$$

For lifelong learning, we design the dataset to be extendable, allowing for the integration of new events and years as they emerge, denoted by $E' \subseteq E$ and $Y' \subseteq Y$, where E' and Y' represent the sets of newly added events and years.

We designed the dataset with a flexible framework that allows for the seamless integration of new events and years as they emerge, represented as $E' \subseteq E$ and $Y' \subseteq Y$, where E' and Y' denote the newly added events and years. This structured approach ensures scalability for continuous learning without requiring major restructuring and supports the training of adaptive models capable of integrating new information effectively. Unlike standard multi-year datasets, our dataset includes annotations that facilitate contextual understanding, enabling models to learn from historical data while adapting to evolving trends and patterns in news reporting. This ensures that the models remain relevant as new information becomes available.

Finally, we split the dataset into training and test sets using a stratified sampling approach to ensure the preservation of bias label distributions across both events and years. We perform this step as it is critical for maintaining the integrity of the model training process in a lifelong learning context.

3.3 Data Synopsis and Structure

In this section, we present an overview of the data and explain how it is systematically organized, making it easier to understand both the content and format of our dataset.

3.3.1 ***Data Synopsis.*** The dataset features 356,060 headlines on four major events from 2019 to 2022: *Brexit*, *COVID-19*, *the election*, and *the Ukraine-Russia war*. These headlines, sourced from 45 unique news outlets in 17 different languages, are annotated with 3 political bias labels: *Left Centre*, *Least Biased*, and *Right Centre* covering diverse topics such as *politics*, *business*, *arts and entertainment*, *sports*, *science*, *technology*, *health*, and *environment*. The dataset is structured into 7 distinct columns within .csv files. Table 1 presents a comprehensive summary of the dataset statistics.

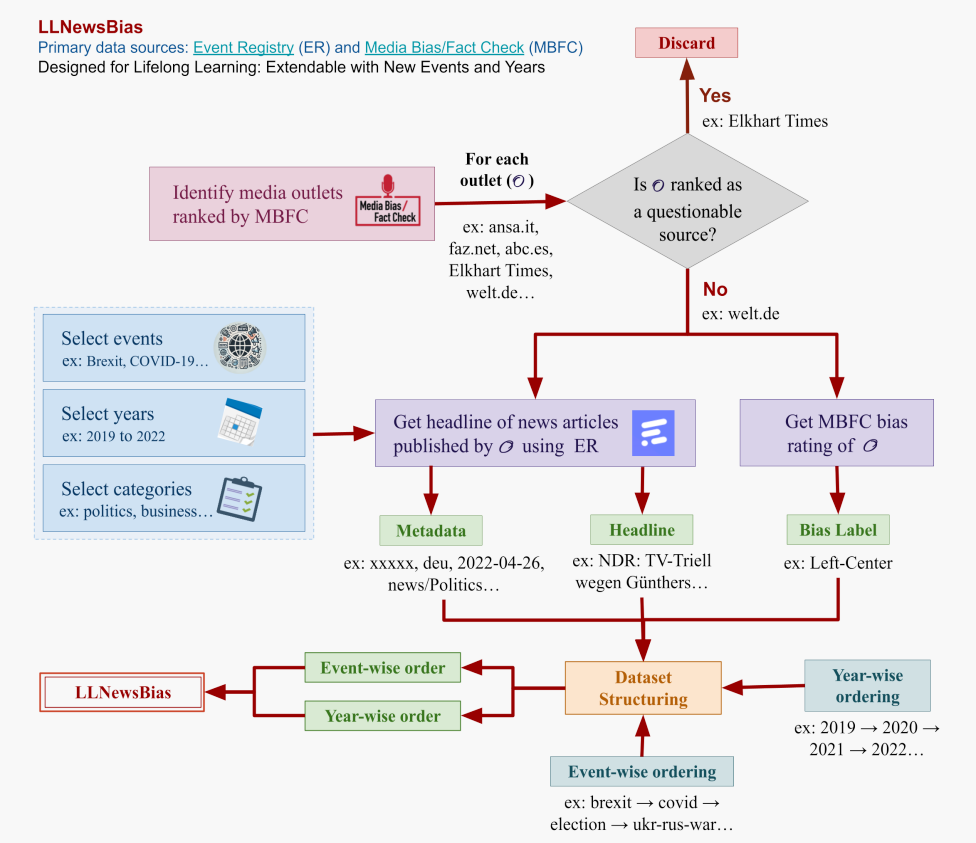

Figure 1: Data Collection Framework. The framework uses MBFC for bias labeling and ER for headline retrieval.

Table 1: Summary of Dataset Statistics.

Language-wise Distribution			
Catalan	882	Romanian	17,038
Croatian	13,929	Russian	10,511
Czech	1,876	Slovak	5,642
Danish	4,330	Spanish	83,940
Dutch	10,905	Swedish	6,441
Finnish	1,512	Ukrainian	10,616
French	85,007	Italian	48,450
Hungarian	105		
Event-wise Distribution			
Brexit	32,286	COVID	309,329
Election	3,829	Ukraine	10,616
Year-wise Distribution			
2019	20,664	2021	4,638
2020	258,871	2022	71,887

3.3.2 ***Directory Structure.*** The dataset is organized in a main 'data' directory with subdirectories categorized by events ('brexit', 'covid', 'election', 'ukr-rus-war') and years (2019-2022). Additional subdirectories consolidate data across all events (ordered_events) and all years (ordered_years). Each subdirectory contains .csv files for training and testing, structured across the following columns.

- **news outlet**: The name of the news outlet.
- **article_ID**: A unique identifier for the raw news article in the Event Registry platform from which the headlines are extracted.
- **language**: The source language of the published news article.
- **date**: The date on which the news was published.
- **headline_text**: The text of the news headline.
- **news_category**: The category assigned by Event Registry.
- **political_bias**: The political bias of the news outlet as provided by the bias rating portal Media Bias/Fact Check.

The dataset is annotated with bias labels: Left Centre (LC), Least Biased (LB), and Right Centre (RC). To ensure model robustness across varying data distributions, we concatenate and shuffle files for each event and year in four distinct random orders. This prevents overfitting to specific sequences and helps evaluate generalization across diverse configurations. While chronological order is ideal for practical use, this randomized approach tests broader performance, with the original event and year splits provided for user flexibility.

Event-wise Ordering:

(1) brexit → covid → election → ukr-rus-war
(2) election → covid → ukr-rus-war → brexit
(3) brexit → ukr-rus-war → election → covid
(4) covid → brexit → ukr-rus-war → election

Year-wise Ordering:

(1) 2019 → 2020 → 2021 → 2022
(2) 2021 → 2020 → 2022 → 2019
(3) 2019 → 2022 → 2021 → 2020

(4) 2020 → 2019 → 2022 → 2021

The dataset captures the distribution of headlines related to various events over the years, reflecting the temporal dynamics of news coverage and the evolving reporting on these events. The differences in coverage levels reveal important patterns in media attention, which are essential for developing datasets that support lifelong learning models.

4 Potential Use-Cases

Our dataset introduced in this study has a wide range of potential use-cases, particularly in the fields of natural language processing and media studies. It is particularly valuable for research and applications that require understanding and predicting news bias in a continual, multilingual environment. Below we list some potential use cases:

- **Lifelong learning for news bias prediction:** Our dataset is ideal for developing and testing lifelong learning models. It allows models to adapt to new events and evolving entities. With its year-wise structure from 2019 to 2022, the dataset addresses the challenges of emerging events and domain shifts (e.g., Brexit, COVID-19, Ukraine-Russia War), providing the data needed to develop and evaluate robust models.

- **Domain Adaptation in Multilingual Contexts:** Our dataset enables researchers to investigate domain adaptation techniques in a multilingual context, featuring headlines in 17 languages. This facilitates the development of models that generalize across languages and adapt to various cultural and political contexts, ensuring accurate bias prediction. It addresses the challenges faced by generic models in the news domain, which often struggle with topic and language diversity.

- **Sparse Experience Replay for Continual Learning:** Our dataset is particularly well-suited for the news domain, supporting efficient experience replay by allowing the selection of specific topics and categories. With its event-wise and year-wise classifications, our dataset enhances memory utilization, improves generalization, reduces catastrophic forgetting, and ensures that models remain accurate and up-to-date in real-time applications.

In a nutshell, our dataset serves as a valuable resource for advancing news bias prediction, particularly in the context of lifelong learning, by providing a flexible framework for integrating new events and years. Unlike many news-based datasets with timestamps, it offers structured annotations and contextual information that enhance the understanding of evolving trends in news coverage, making it particularly suitable for lifelong learning applications. It supports a range of research activities, from model development and evaluation to the exploration of new techniques for handling dynamic and multilingual news environments.

5 Limitations

Several limitations are associated with the dataset presented in this article and should be carefully considered in any further research or analysis:

- **Data Collection Issues:** The dataset was gathered using Media Bias Fact/Check (MBFC) and the paid version of Event Registry (ER). MBFC is publicly accessible, while ER provided comprehensive but limited coverage, potentially missing relevant articles. The use of ER's paid version also restricted the extent of data collection.
- **Sample Size:** The dataset is constrained by its focus on four major events over a span of four years. This limited number of events and time frame may not fully capture the broader spectrum of news and media biases, affecting the diversity of the samples.
- **Biases:** Selection bias is a significant factor, as only news outlets labelled by MediaBiasFactCheck were included. This restriction may limit the number of languages and perspectives represented in the dataset, thereby influencing the overall analysis.
- **Contextual Factors:** The dataset is limited by its temporal scope, covering only four specific events over four years. While it reflects the dynamic nature of news media, it does not account for all future events and years to come.

6 Conclusions

In this study, we present LLNewsBias, a comprehensive dataset designed to tackle the challenges of detecting and analyzing political bias in multilingual news headlines. By spanning four major global events from 2019 to 2022 across 17 languages, this dataset provides a valuable resource for research in natural language processing and media studies. Our framework supports both event-wise and year-wise analysis, emphasizing lifelong learning and enabling models to adapt continuously to new data. The dataset's potential use cases include enhancing bias prediction models, facilitating domain adaptation in multilingual contexts, and improving model robustness. While LLNewsBias offers significant contributions, we also acknowledge limitations such as potential biases in data collection, sample size constraints, and contextual factors. Addressing these challenges in future work will be crucial for maximizing the dataset's impact, ultimately contributing to fairer and more balanced journalism.

7 Acknowledgments

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Creating Local World Models using LLMs

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Abstract

A key limitation of state-of-the-art large language models is their lack of a consistent world model, which hinders their ability to perform unseen multi-hop reasoning tasks. This paper addresses this by extracting local world models from text into a systematic first-order logic framework, enabling structured reasoning. Focusing on the educational domain, we present a multi-step approach using Prolog to represent and reason with these models. Our method involves segmenting educational texts, generating Prolog definitions, and merging them into a comprehensive knowledge graph. We successfully extracted several small models and manually verified their accuracy, demonstrating the potential of this approach. While promising, our results are currently limited to small-scale models.

Keywords

Large language models, local world models, knowledge representation, educational technology, structured reasoning, knowledge graphs

1 Introduction

In recent years, Large Language Models (LLMs) have revolutionized the field of Natural Language Processing (NLP), offering unprecedented capabilities in understanding, reasoning over, and generating human-like text. Despite their impressive performance across various language tasks, a significant limitation persists – the absence of a consistent and coherent world model within these systems [8]. This limitation hampers their ability to perform advanced reasoning tasks that require not only textual understanding but also logical consistency and structured knowledge representation.

While current LLMs are powerful, they are inherently constrained by their reliance on statistical correlations within vast datasets, often resulting in shallow and contextually inconsistent reasoning. To address this limitation, we propose an approach for extracting local world models, i.e., small, context-specific representations of knowledge that capture the relationships and rules governing a particular domain or scenario. The approach is multi-step. First, the input text is segmented into manageable parts. Each segment is analyzed to extract key concepts and their interrelationships, which are then represented as Prolog definitions. Then, the definitions are merged into a comprehensive knowledge graph that reflects the structure and content of the input text.

We focus specifically on the educational domain, where the ability to generate and utilize local world models could significantly enhance the effectiveness of AI-driven educational tools, e.g. by providing LLMs a framework for responding with logically consistent and pedagogically sound explanations. Moreover, by modifying some of the components, the approach can also be applied to other domains, such as industry, finance, and law.

The remainder of the paper is as follows: Section 2 presents the related work on LLMs and creating world models. Next, the proposed approach is described in Section 3. The experiment setting is presented in Section 4, followed by the experiment results in Section 5. We discuss the results in Section 6 and conclude the paper in Section 7.

2 Related Work

The recent surge in large language models, such as GPT-3 [3] and GPT-4 [1], has significantly advanced natural language processing, showing emergent reasoning abilities across various tasks. However, despite their impressive performance, LLMs are often criticized for lacking factual consistency, interpretability, and logical coherence, especially in complex, multi-hop reasoning tasks [8]. To address these shortcomings, efforts have been made to integrate LLMs with structured knowledge frameworks, like knowledge graphs (KGs) and ontologies, to enhance reasoning and knowledge flow between structured data and language models [9].

In the field of ontology and KG development, early initiatives like Cyc [6] laid the groundwork for large-scale structured knowledge representation. More recent efforts [8, 5] have explored using LLMs to assist in ontology generation and KG construction. While LLMs can automate parts of the ontology development process, they struggle with ensuring logical consistency and managing complex domain-specific knowledge [5, 2]. Complementary approaches, like using LLMs for ontology learning [2] and structured knowledge extraction [10], highlight the need for human validation and formal methods to ensure accuracy.

Our work builds on these insights by focusing on using LLMs to extract structured local world models in the form of Prolog-based representations. This approach addresses the limitations of LLMs in handling complex reasoning and provides a more robust, logically consistent framework for educational applications.

3 Methodology

This section introduces the approach for creating local world models by generating and utilizing structured data in Prolog. The methodology is designed to systematically identify and map the concepts and their interrelationships within a given educational document, such as a textbook, facilitating the generation of a knowledge graph.

3.1 Document segmentation

To manage the document's complexity and ensure accurate concept extraction, the source material was divided into several shorter parts, each up to 10 pages long. This segmentation was crucial in allowing us to focus on smaller, more manageable sections of the content, enabling a thorough analysis and avoiding problems that come with long-context LLM outputs. The length of each part was determined based on the natural divisions within

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https://doi.org/10.70314/is.2024.sikdd.22

the text, such as chapters or major sections, to maintain the coherence of concepts within each segment.

3.2 Generating Prolog definitions

For each segmented part, we created a prompt to generate Prolog definitions of the concepts and their relationships. The prompt was carefully crafted to guide the extraction of educational content in a structured format. It consisted of three main components: the context, the predicates and the structured output.

Context. A description of the educational context and a brief narrative to position the content within a learning scenario. This helped to align the LLM-extracted concepts and relationships with our downstream tasks. The following is an example of the prompt used:

> *You are a teacher and an expert in natural language processing (NLP). You wrote a chapter in an NLP textbook and would like to convert the content of the chapter into a classroom lesson. You would like to step into the shoes of a student in order to understand their learning process of this material. You need to understand which concepts are being taught and their relationships.*

Predicates. List of predicates and their descriptions, which were essential for identifying concepts (`isConcept(A)`), prerequisites (`isPrerequisiteOf(A, B)`), and sections (`isSection(S)`). These predicates were used to simulate the learning process, where concepts are linked to sections. A concept may have prerequisite concepts or sections that must be understood before a student can advance to learning the concept.

Structured output. Clear instructions to output the extracted predicates in the form of a Prolog program. The LLM responding in a structured format a crucial part of our approach, as it has been shown that structured responses can improve LLM reasoning and generation quality [13].

In summary, this prompt allowed us to extract detailed summaries of the concepts taught and their relationships, which were then represented in Prolog. Each segment was processed independently to generate a corresponding Prolog program.

3.3 Merging Prolog definitions

After generating the Prolog definitions for each segment, the next step was to merge them into a single cohesive program. To achieve this, we created a prompt, which was nearly identical to the first, but with instructions to combine the disjoint parts into one integrated Prolog program added to the end of the prompt:

> *Now you need to combine the parts into a single Prolog program. Make sure to include all the concepts and relationships, but also properly connect them. Merge concepts from different sections where necessary and make sure to include all the sections and their relationships.*

3.4 Use of the knowledge graph

The generated knowledge graph, represented by the Prolog program, was then used to recommend the next steps in the learning process. Using the structured output, we created a detailed concept map that helped identify key learning paths and prerequisites. Prolog (specifically SWI Prolog [11]) was chosen for this task because it can handle structured data, is widely used (increasing the likelihood that LLMs have encountered it during training), and can be executed and analyzed immediately.

4 Experiment Setting

This section outlines the experiment setting for evaluating our approach to extracting local world models from educational texts and generating structured Prolog representations. We describe the data sources, the large language model used, and the evaluation framework.

4.1 Data sources

We evaluated our approach on two widely used textbooks in deep learning and natural language processing. These texts were chosen because they are relevant to both structured reasoning tasks and the representation of complex, multi-step concepts. The following chapters were selected for analysis:

Deep Learning Preliminaries from the book *Dive into Deep Learning* [12]. This chapter provides foundational knowledge of deep learning, covering key concepts such as linear algebra, calculus, and probability, which are essential for understanding the field. The textbook's teaching approach is highly hands-on, with a significant portion devoted to code. It is open-sourced, and we used the Markdown files provided on their GitHub page[1].

Chapter 2: Regular Expressions, Tokenization, and Edit Distance from *Speech and Language Processing* [4]. This chapter introduces basic NLP techniques, focusing on regular expressions and tokenization, which are pivotal in text preprocessing tasks.

4.2 Used large language model

We employed GPT-4o via the ChatGPT interface to extract concepts and their interrelationships. We leveraged the model's multimodal capabilities, allowing it to process text and PDF documents.

4.3 Evaluation Framework

We developed an evaluation framework to assess the performance of our approach based on three primary aspects: accuracy, completeness, and consistency. To validate the results, we manually reviewed the extracted knowledge graphs and compared them with the source texts. We ensured that the extracted concepts were accurate, complete, and logically consistent.

Assessment Criteria. The following criteria were used to evaluate the effectiveness of our approach:

- *Accuracy.* This aspect examines how accurately the approach extracted the concepts and their relationships from the text. We evaluated the correctness of each Prolog definition against the source material.
- *Completeness.* This evaluates whether the system captured all the key concepts from the educational material. The assessment ensured that no significant concepts or relationships were omitted during extraction.
- *Consistency.* This aspect assesses the extent to which the extracted models maintained logical coherence across different

[1] https://github.com/d2l-ai/d2l-en

segments of the text. This was crucial in determining whether the segmented Prolog definitions could be merged into a cohesive KG.

5 Results

In this section, we review the knowledge graphs of the two tested texts generated by our model.

5.1 *Dive into Deep Learning*

The selected chapter covered six sub-chapters in the following order: Data Manipulation, Data Preprocessing, Linear Algebra, Calculus, Automatic Differentiation, and Probability and Statistics. The results are represented by the graph in Figure 1.

The system accurately identified three major independent branches of the chapter – Linear Algebra, Calculus, and Probability and Statistics – which reflects the structure of the source material. The extracted knowledge graph also logically restructured the content in ways that differed from the original organization but made sense pedagogically. This restructuring highlights the logical flow of how data handling techniques naturally feed into more abstract mathematical concepts despite differing from the original structure.

However, some omissions and reassignments were noted, particularly within the Linear Algebra section. Concepts such as vectors and matrices were omitted, likely due to the high-level nature of the extraction process. Additionally, matrix multiplication, though identified, was separated from Linear Algebra basics and Tensor operations. This disjunction represents a slight deviation from the expected conceptual hierarchy.

Similarly, in the Calculus section, the extracted model restructured the sequence of topics. This restructuring captured the relationship between fundamental calculus concepts and their practical applications in machine learning. Furthermore, the system included concepts like Gradient Descent and Backpropagation which were only briefly mentioned in the source material.

5.2 *Speech and Language Processing*

The Regular Expressions section, seen in Figure 2, was extracted accurately, capturing the core concepts effectively. However, a noticeable limitation was the loss of the original sequencing of the concepts presented in the textbook. While the key ideas were identified, the pedagogical flow, which is essential for gradual learning, was somewhat disrupted in the extraction process.

For the other sections, including Tokenization and Edit Distance, the model extracted only the most prominent concepts, omitting many important details. As a result, these sections are less comprehensive than they need to be for in-depth understanding. Despite this, the overall connections between sections in the knowledge graph were logically structured, showing that the system was still able to create a coherent representation of the material at a high level.

It is important to note that this textbook is significantly more information-dense and longer compared to the *Dive into Deep Learning* book. This added complexity exposed some limitations in the current approach, mainly when dealing with texts that require detailed extraction of concepts and their interrelationships. The model's ability to handle such dense material is limited by its tendency to focus on top-level ideas while losing much of the depth and sequencing provided in the source text. Additionally, there were rare occasions where the output required manual interventions to fix inconsistent formatting of the Prolog variable names.

6 Discussion

Our approach to extracting local world models from educational texts demonstrated strong performance in generating logically coherent knowledge graphs from high-level concepts, but certain limitations were identified. The synthetic data generation effectively captured core concepts from both textbooks, particularly in structuring major branches such as Linear Algebra, Calculus, and Probability from *Dive into Deep Learning*. However, some restructured sections, while logical, differed significantly from the source material's flow.

In the *Speech and Language Processing* textbook, the Regular Expressions subsection was extracted with sufficient accuracy. Other sections, such as Tokenization and Edit Distance, suffered from detail omissions, where only top-level concepts were extracted. This issue was more prominent due to the higher information density of the NLP textbook, exposing limitations in handling detailed, densely packed content.

Regarding the evaluation framework, the model generally performed well on metrics like accuracy and consistency but struggled with completeness in more detailed sections. The model's tendency to restructure content logically, though sometimes deviating from the original, suggests that while it captures core relationships, further refinements are needed to preserve pedagogical flow and details.

6.1 Potential improvements

To address the limitations, improving the prompt engineering could lead to more detailed extractions while maintaining the structure of the source material. Additionally, enhancing the model's ability to handle complex, dense information would mitigate the loss of key concepts. Future iterations may benefit from automated post-processing checks to ensure logical consistency and reduce manual interventions. Overall, while the approach shows promise, refining it to handle finer details and complex sequences more effectively will be essential for broader applications.

7 Conclusion and Future work

In this paper, we proposed a novel approach to extracting local world models from educational texts by generating structured Prolog representations. Our methodology demonstrated the ability to capture core concepts and their interrelationships in a logical and coherent manner, especially in the *Dive into Deep Learning* textbook. However, the results from the more information-dense *Speech and Language Processing* text revealed limitations, particularly in handling detailed content, large knowledge graphs, as well as preserving pedagogical flow.

The use of Prolog proved effective in organizing educational material, allowing for structured reasoning and enabling applications in AI-driven educational tools. Despite these successes, certain challenges remain, such as the omission of detailed concepts and the system's occasional tendency to deviate from the original sequence of topics.

Future work will address these limitations by improving the prompt engineering and enhancing the system's ability to handle complex, information-dense material. Additionally, we plan to explore automating the segmentation process and scaling up the

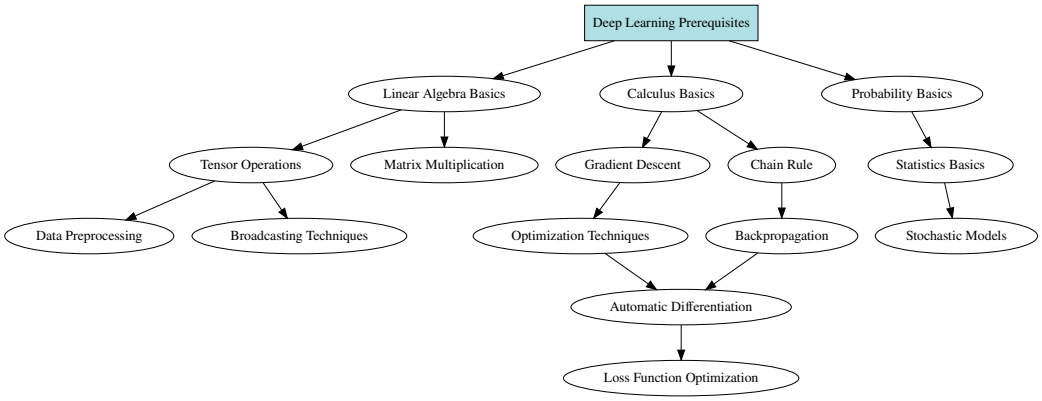

Figure 1: Knowledge graph of the *Preliminaries* section from *Dive into Deep Learning*.

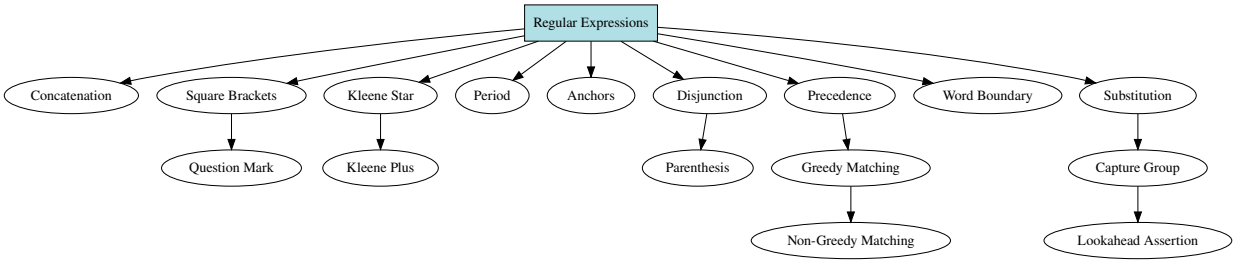

Figure 2: Knowledge graph of the *Regular Expressions* section from *Speech and Language Processing*.

model to generate larger, more intricate knowledge graphs. Other potential directions include integrating retrieval-augmented generation [7] to enrich knowledge extraction and comparing generated world models across different texts to evaluate their pedagogical alignment. Self-evaluation and correction mechanisms could also be introduced to improve accuracy and completeness.

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Semantic video content search and recommendation

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Abstract

The rapid growth of video streaming platforms has intensified the demand for personalized content recommendations. However, current solutions often rely on historical user data, leading to challenges like the cold start problem and overlooking users' immediate preferences. We present a conversational recommendation system that leverages large language models (LLMs) to generate keyword-based content and query descriptions. By integrating Retrieval-Augmented Generation (RAG), our system efficiently retrieves relevant content, independent of prior user interactions, and ensures consistent performance across languages. Preliminary testing shows our system outperforms the RAG baseline by up to 24% in less descriptive queries and demonstrates consistent performance across three languages. While the results are promising, further evaluation focusing on user interaction and satisfaction is necessary. Our approach can potentially be extended to other recommendation systems, offering broader applicability and enhanced content personalization.

Keywords

large language models, recommendation system, search system, retrieval augmented generation

1 Introduction

The surge in video streaming platforms has accelerated the demand for personalized content recommendations. As these platforms expand their libraries and user bases, the challenge of delivering precise, user-specific recommendations intensifies. In this dynamic environment, streaming services must quickly adapt to provide accurate recommendations, which are crucial for maintaining user engagement and ensuring satisfaction.

Existing recommendation systems primarily rely on historical user interaction data, such as viewing history and ratings. This dependence leads to significant challenges, such as the cold start problem, where new users or newly added content lack sufficient data for accurate recommendations. Additionally, these systems often fail to account for users' immediate preferences, which can change dynamically due to various factors such as mood, viewing context (e.g., watching alone or with a group), or recent events in the user's life. This gap highlights the need for more adaptive and responsive recommendation mechanisms.

Recent advancements in Large Language Models (LLMs) present an opportunity to address these limitations. LLMs offer significant potential due to their emergent reasoning abilities, their capacity to extract high-quality representations of textual features, and their ability to leverage the vast external knowledge encoded within them [10], [7]. By harnessing LLMs, it is possible to create a recommendation system that interacts with users to capture their immediate preferences, thereby overcoming the cold start problem and enhancing the relevance of recommendations. Additionally, ensuring consistency in the quality of recommendations across different languages is increasingly important as many streaming services operate globally.

Our approach utilizes LLMs to generate keyword descriptions for both content and user queries. These keywords serve as the basis for recommendations, with a Retrieval-Augmented Generation (RAG) [6] model efficiently retrieving relevant content. By crafting query keywords using LLMs, the system adapts to user preferences in real time, providing relevant and language-consistent recommendations.

This paper makes the following contributions: **(1) Development of a Keyword-Based Recommendation System:** We introduce a novel approach that utilizes LLMs to generate keyword-based descriptions for content and user queries, enabling more personalized and adaptive recommendations. **(2) Exploration of Two User Interaction Models:** We propose and evaluate two distinct interfaces for user interaction—a conversational chat-based model and a structured question-answering model, where the system refines recommendations through a series of targeted yes/no questions generated by the LLM. **(3) Comprehensive Evaluation Strategy:** We outline a detailed plan for evaluating the system's performance in a production environment, focusing on its ability to deliver consistent, high-quality recommendations across different languages and user contexts.

2 Related Work

Recommender systems have progressed from techniques such as collaborative filtering and matrix factorization to more complex models that incorporate deep learning. The advent of large language models (LLMs) has enabled innovative methods for interacting with these systems [11], particularly when combined with retrieval techniques [9]. One of the most promising advancements in this area is the use of Retrieval-Augmented Generation (RAG) models, which integrate the powerful text generation capabilities of LLMs with retrieval-based methods to improve recommendation accuracy and relevance [6].

Recent advancements in conversational recommender systems have focused primarily on integrating LLMs with traditional recommender systems or fine-tuning LLMs using user-item interaction data [9], [10], e.g., [8], [4], and [5]. These approaches, while effective, often rely heavily on historical user data, leading to challenges such as the cold start problem. This reliance underscores the need for novel methods that reduce dependency on past interactions and leverage real-time retrieval mechanisms to enhance content recommendations [2].

To address these challenges, recent work by Di Palma et al. (2023) [2] introduced a Retrieval-Augmented Recommender System, which combines the strengths of LLMs and retrieval-based methods. Their approach employs LLMs both at the conversational layer and the backend retrieval process, thereby improving recommendation relevance, particularly in scenarios with sparse data or new users. Their experimental results demonstrated that

*All authors have contributed equally.

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this RAG-based framework performs comparably to state-of-the-art systems, even in zero-shot scenarios, underscoring the potential of such an approach to mitigate cold start and hallucination problems inherent in LLMs.

Our approach builds on the strengths of RAG-based models by introducing a keyword-based recommendation system that operates within a RAG framework. This system ensures consistent performance across multiple languages and adapts to real-time user preferences without relying on historical user data.

3 Data

The data used in this study was provided by our partner United Cloud, who operate a multinational streaming service in the Balkan region, EON TV[1]. The EON platform encompasses a variety of content, such as video-on-demand (VOD) movies and TV shows, as well as live TV channels. We focused exclusively on VOD movie data, although our approach is capable of accommodating multiple content types.

The VOD movies data set comprises nearly 5000 movies in various languages. Each movie is accompanied by a brief description averaging around 460 characters (5-6 sentences) in multiple languages. In cases where multiple translations were available, we opted for the original language of the movie; otherwise, we chose the first available translation.

4 Methodology

4.1 Recommendation Mechanism

The core of our recommendation system is the generation of textual representations of content. Instead of using movie descriptions directly, we employ the LLM to generate a set of English keywords and related movies. This approach prevents the model from overemphasizing less relevant details, such as specific plot points, that may not be central to the user's query. User queries follow a similar approach, where the LLM generates a set of relevant keywords, as well as any possibly relevant movies.

One of the key advantages of this method is its ability to abstract core concepts from user queries using the LLM, aligning better with the keywords generated from movie descriptions. The LLM-generated keywords from both the movie descriptions and user queries are designed to encapsulate the essential topics and themes. By aligning the keywords generated from movie descriptions with those derived from user queries, our system enhances the relevance of the recommendations. This alignment is crucial in ensuring that the retrieved movies resonate with the user's expressed interests, even when these interests are not articulated well. Furthermore, the use of in-context learning allows the system to maintain its performance without extensive fine-tuning [3], making it both efficient and effective.

The rest of the recommendation system follows the Retrieval-Augmented Generation (RAG) [6] pipeline (see Figure 1). The RAG pipeline operates by first generating textual representations of movies, which are then embedded into a vector space. These embeddings are stored in a vector database, allowing for efficient similarity searches. When a user submits a query, the system generates a corresponding representation, embeds it into the same vector space, and retrieves the top k most similar movie embeddings from the database. This process ensures that the recommendations are both contextually relevant and semantically aligned with the user's input.

[1]No EON user data was used.

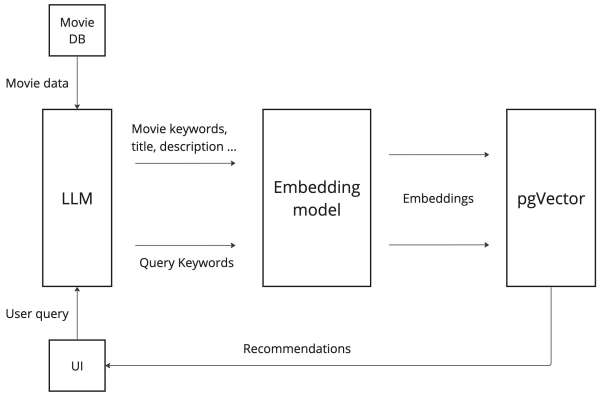

Figure 1: Overview of the Recommendation Pipeline.

4.2 User Interface

Our proposed user interface designs (see Figure 2) offer two main ways for users to interact with our recommendation core. Besides a direct search, where the user submits a query and receives recommendations in a single step, we propose: **(a)** A chatbot, which assists users in narrowing down their options through a conversational interface. The chatbot provides recommendations at each response, allowing for a multi-step interaction that refines the search results progressively. **(b)** An inquisitive method, where an agent asks the user a series of Yes/No questions to narrow down the search. Keywords are generated based on the user's responses, making it particularly useful for users who are uncertain about what they want to watch. This approach shifts the burden of knowing what to query from the user to the system, streamlining the recommendation process.

Each of these designs aims to enhance user engagement and satisfaction by providing tailored interactions that cater to different user preferences and needs.

5 Evaluation

We have developed a twofold approach for addressing the evaluation of our model:

First, to gauge the effectiveness of our keyword-based approach for recommendation, we curated a small multilingual evaluation dataset to test our core recommendation mechanism. This dataset includes queries in various languages along with their expected recommendations. We compared the performance of our mechanism with a baseline RAG system that directly embedded user queries and movie descriptions.

Second, to assess the efficiency and user satisfaction of our system in real-world situations, we have devised an evaluation plan to test our system in production. This strategy utilizes a structured A/B testing framework to conduct precise comparisons between our semantic recommendation system and conventional search, addressing distinct aspects of user experience and system performance.

5.1 Evaluation dataset

To create our evaluation dataset, we carefully selected 25 movies across multiple languages, including both well-known and lesser-known titles. For each movie, we formulated two types of queries to assess the system's retrieval accuracy: *Descriptive* and *General* queries.

The *Descriptive* queries were designed to simulate scenarios where the user knows exactly what they are looking for. For instance, a query for the movie *Messi (2014)* might be, "I am looking for inspirational documentaries about famous athletes, such as Lionel Messi and his rise through football." In contrast, the *General* queries were intended to test situations where the user has only a rough idea of what they want to watch, which is likely more common in real-world environments. An example of a general query for the same movie might be, "soccer movies that will inspire me."

To evaluate the system's performance across different linguistic contexts, we manually translated these queries into English, Serbian, and Slovenian. We then compared the performance of our keyword-based retrieval mechanism against a baseline RAG model that directly used user queries and movie descriptions without generating keywords.

5.2 Experiment Design

We have divided our user base into four distinct groups to facilitate a detailed comparative analysis, aligned with our proposed user interface designs:

Baseline Group: This control group doesn't use our system, but instead finds movies and receives recommendations based on the traditional recommendation methods, a common practice in the industry.

Direct Semantic Search Group: This control group interacts with a straightforward search interface. Users submit a query and receive recommendations in a single step. This approach provides immediate suggestions based on the user's input, mimicking traditional full-text search practices.

Chatbot Group: Participants in this treatment group use a conversational interface (interface **a**), where a chatbot assists in narrowing down options. The chatbot provides recommendations at each response, enabling a multi-step interaction that progressively refines the search results. This design enhances engagement by simulating a natural conversation.

Inquisitive Method Group: Users in this group engage with an agent that asks a series of Yes/No questions to narrow down the search (interface **b**). Keywords are generated based on the user's responses.

The evaluation will be conducted continuously, starting with a focused initial phase over the first month post-implementation to address immediate usability and performance issues, followed by ongoing monitoring to capture long-term user engagement and satisfaction.

By implementing this structured evaluation framework, we aim to comprehensively understand the impact and effectiveness of our semantic recommendation system, guiding further refinements and ensuring that the system meets user needs and expectations.

5.2.1 Metrics We would like to measure how users interact with our system in two main ways: First, we would like to know how engaged and satisfied they are with our recommendations, i.e., do users find our system frustrating to navigate, and whether they watch movies recommended by our system. The second set of metrics will aim to capture how different demographics interact with our system, as a major goal is to remove any biases such as language or age.

Engagement and Satisfaction Metrics: These include Click-Through Rate (CTR), which measures the percentage of clicked recommendation links, and Watch Time to gauge the duration users engage with recommended content. Additionally, immediate user reactions are captured through Like/Dislike Ratios, while more detailed user feedback is collected via surveys administered after interactions.

Behavioral Metrics: We analyze User Interaction Patterns, such as search frequency and refinement actions, and System Usage Frequency to determine how different demographics utilize the system and to identify any potential biases in system engagement. We also record the search time and number of queries needed for a decision.

6 Results

The outcomes presented in Table 1 showcase the performance of both models in various query types and languages, as measured by accuracy at the top 5 and top 10 recommendations.

The results reveal that the baseline model surpasses (or matches) the performance of the keyword mechanism in the case of *Descriptive* queries, particularly in terms of Accuracy@5. However, in terms of Accuracy@10, the two models demonstrate relatively similar performance. Conversely, the keyword model shows significant performance enhancements for *General* queries, particularly in Accuracy@10, indicating its capacity to adapt to non-specific content descriptions. Additionally, the keywords model consistently performs well across different languages, whereas the baseline model shows fluctuations of up to 28% across languages.

In summary, the keywords model allows for more general and multilingual queries, while the baseline model excels at retrieving very specific content.

Table 1: Evaluation results on the descriptions and general queries data sets. LLM embeddings were generated using OpenAI's *text-embedding-3-large* model. The Keywords model used *GPT-4o*.

	Accuracy@5		Accuracy@10	
	Keywords	Baseline	Keywords	Baseline
Descriptive Queries				
English	60%	**64%**	**68%**	**68%**
Serbian	56%	**80%**	72%	**84%**
Slovenian	56%	**80%**	72%	**84%**
General Queries				
English	**44%**	28%	**68%**	44%
Serbian	44%	**52%**	**68%**	52%
Slovenian	44%	**56%**	**72%**	56%

6.1 User Interface Implementation

We implemented our proposed interface design using Flutter, which guarantees functionality across a variety of devices, including iOS, Android, Windows, and web browsers. This cross-device compatibility is crucial as it ensures that all users, regardless of their preferred platform, have access to our application. The support for mobile devices is particularly useful in our interrogation design, where users can easily navigate through options by swiping cards left or right.

Additionally, we integrated Tipko [1], a Slovenian transcription service, to facilitate voice-to-text capabilities. This feature

enhances user convenience by enabling voice communication with our chat bot, removing the necessity for typing.

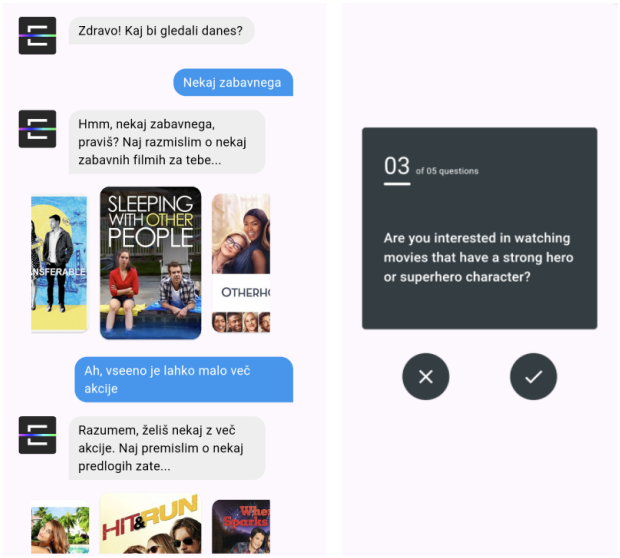

Figure 2: Implementations of our *(a) Chatbot* (left) and *(b) Inquisitive* (right) user interface designs.

7 Discussion

This report introduces a new content recommendation mechanism and three ways to interact with it. Table 1 demonstrates the success of our keyword retrieval model in understanding general user preferences while still performing well when searching for specific content. Moreover, its consistency across languages and its ability to retrieve content using specific descriptions as well as general themes make it well-suited for a diverse user base. Additionally, the keyword model allows seamless integration with both the *Chatbot* and *Inquisitive* methods. Moreover, our system could be extended to dynamically adjust keyword generation based on user-specific factors such as viewing history, local time, weather, and current mood indicators. This personalization ensures that the recommendations are not only relevant to the content but also tailored to the user's immediate context and preferences.

Our approach has some limitations, including the cost per query, which is higher than traditional search, although not exorbitant. Furthermore, our model's performance is commendable given our limited knowledge about the movie content but relies on the assumption that the language model may have more information about a movie than our dataset. It's worth noting that, in the short term, it appears that models are continually improving, becoming faster, more knowledgeable, and more cost-effective.

Lastly, as with any chat application that involves user inputs, security is a crucial consideration. While improvements can be made through better prompting and fine-tuning, ongoing monitoring is essential when the system is in production.

8 Future work

In future work, we plan to further explore methods for improving user experience and personalization. Our initial experiments have involved incorporating the user's time, location, and weather to enhance results. Moving forward, we aim to explore additional integrations, such as the user's calendar. We also intend to expand our user interface by introducing new forms of interaction, such as movie trailers and multiple-choice questions.

To overcome the limitations of our movie information, we are interested in delving deeper into the content by analyzing subtitles using a local language model. Additionally, we aim to broaden our database to include other types of content, such as live channel content and special time-limited events like Eurovision, Eurobasket, and the FIFA World Cup.

Finally, we are interested in the integration of a traditional recommendation models that utilize historical watch data or ratings to re-rank our recommendations.

Acknowledgments

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Continuous Planning of a Fleet of Shuttle Vans as Support for Dynamic Pricing

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ABSTRACT

This paper solves the problem of estimating the number and type of required resources for pickup and delivery of passengers at some time in the future. By combining optimization and sampling methods, as well as making plans based on several statistical samples, we estimate the real values for the required resources and show how the sample values converge towards the real values. Our approach combines machine-learning based demand predictions, for the number of passengers, and a route optimization engine that assigns the passengers into shared shuttle vehicles. In order to validate our method we create a baseline data that is representative of the real values. We test our approach using this baseline data, and we obtain statistically significant results.

KEYWORDS

statistical samples, demand predictions, route optimization engine, sampling techniques, optimization technique

1 INTRODUCTION

The effective allocation of resources is a critical topic in the mobility industry. Anticipating the number and type of resources required can significantly enhance a company's ability to plan accurately for the future. Our work addresses this challenge by focusing on how to estimate the number and type of vehicles needed for passenger pickup and delivery at a future time. The input to our problem consists of machine learning-based demand predictions, which provide estimates of the number of passengers across various routes offered by the company. These predictions are provided daily and further broken down into hourly estimates for each day.

*Both authors contributed equally to this research.

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Once we receive these predictions, our goal is to simulate reservations based on this data. For instance, if the predictions indicate that 12 passengers will travel from Ljubljana to Koper on October 20, 2024, we would simulate reservations using sampling techniques. One particular example is creating four separate bookings—one for five passengers, one for three, and two for two passengers each. We will introduce the sampling techniques used in this process in greater detail later on.

After generating these reservations, the next step is to input them into the Route Optimization Engine to generate a plan for that day. This plan will specify the number of vehicles required and the specific reservations each vehicle will serve.

The main hypotheses that our approach explores and experimentally tests are the following:

- H1: We can accurately estimate the number of required resources using optimization methods based on predicted passenger numbers.
- H2: Monte Carlo sampling of historical distributions can effectively model uncertainty in demand predictions, leading to stable resource estimations.
- H3: Creating plans based on several sample values will converge towards the actual number of required resources.

On the other hand, the key assumptions and limitations that underline our research are:

- Prediction Accuracy: We assume that the predictions effectively estimate the number of future passengers.
- Passenger Distribution: We assume that the number of passengers follows a Poisson distribution and that the distributions on different routes are independent.
- Independence: We assume that the passenger distribution and the window type distributions are independent to each other.
- Concept Drift: We assume there is no concept drift in the data, meaning the underlying data patterns do not change over time.

2 RELATED WORK

The problem of resource allocation in the mobility industry, particularly in the context of vehicle routing and passenger demand prediction, has been extensively studied. Traditional methods for vehicle routing often rely on static models that assume known and deterministic demand. However, recent advances in machine learning and optimization have enabled more dynamic approaches that can account for uncertainty and variability in demand. [3][4] For instance, predictive analytics has been employed to forecast passenger demand using historical data, which can then be fed into optimization algorithms to determine the optimal allocation of vehicles. Monte Carlo simulation is another technique commonly used to model uncertainty in demand predictions, providing a probabilistic framework for decision-making under uncertainty. [2] Moreover, dynamic vehicle routing approaches, have demonstrated the benefits of real-time adjustments to routing plans based on updated demand information. [1] The integration of these methodologies into a continuous planning framework is relatively novel and addresses the limitations of static planning approaches, particularly in highly variable and uncertain environments. [1][5]

3 METHODOLOGY

Our methodology begins with demand predictions for the number of passengers, and the ultimate goal is to determine the number and type of vehicles required, as well as the reservations each vehicle will serve. The figure below provides a detailed overview of this process.

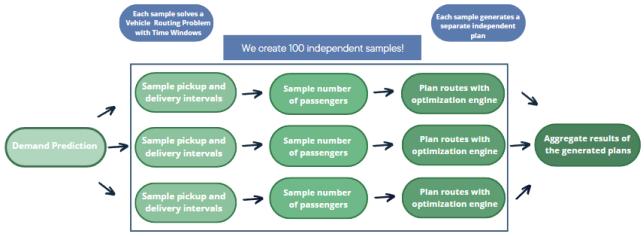

Figure 1. Methodology

Starting with the demand predictions, we apply sampling techniques to simulate reservation data. Specifically, we take the predicted number of passengers for different routes at various times and generate reservations through sampling. This reservation data follows a specific format, including fields such as ID, start location, end location, pickup time, and more. Key attributes include the number of passengers per reservation and the window type, which reflects travel preferences. For instance, some passengers may prefer a private vehicle (VIP), while others are open to sharing the ride. Additionally, the window interval is crucial—it can be a specific time or a more flexible period, affecting both the service pricing and overall experience. These factors will be incorporated into the dynamic pricing model later on.

The process begins with demand predictions and culminates in the generation of reservation data. Critical steps include sampling the number of passengers per reservation, the window type, and the window length. Sampling is done from probabilistic distributions derived from historical data, with the distributions illustrated below.

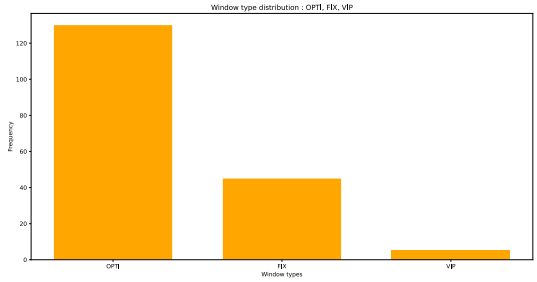

Figure 2. Window type distribution

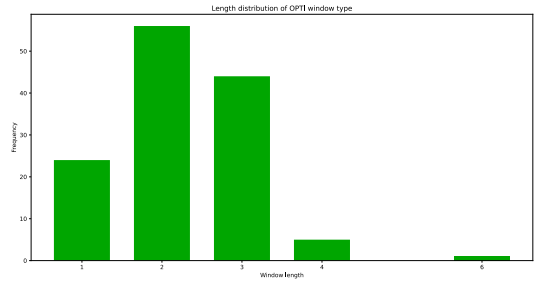

Figure 3. Window length distribution

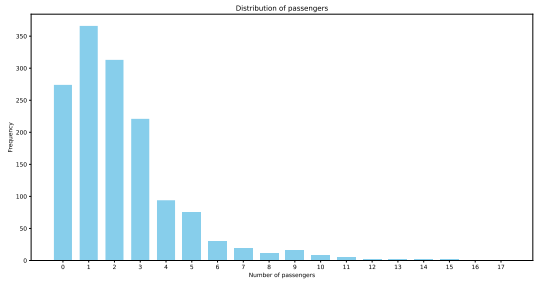

Figure 4. Number of passengers distribution

Please note that from a single demand prediction input file, we generate 100 independent samples of reservation data. This approach introduces uncertainty through probabilistic sampling. Each independent sample is then submitted as a separate job to the Route Optimization Engine, where it solves a vehicle routing problem with time constraints. The output for each job is a plan corresponding to the reservation data. Our final objective is to aggregate these results and analyze the insights they provide.

4 RESULTS

After solving all 100 jobs, we obtained 100 independent plans and began analyzing the results. As shown in the figure below, the distribution of the number of passengers yielded a mean value of 325.87 with a standard deviation of 16.85. For the number of vehicles, the mean was 38.01 with a standard deviation of 3.06. It's notable that the passenger data exhibits significantly more variance compared to the vehicle data. This is expected, as passengers are grouped into visits, and visits are then allocated to vehicles, resulting in less variation in the vehicle count.

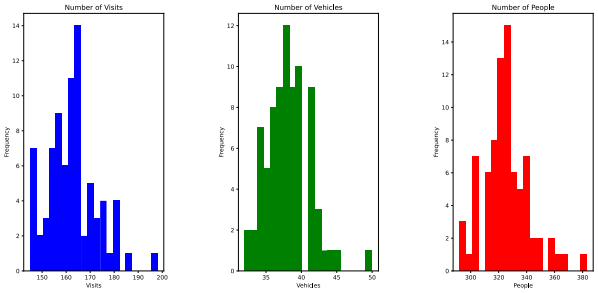

Figure 5. Sampled data: visits, vehicles and passengers distributions

To further validate our approach, we created a baseline using the same data from which the demand predictions were generated. We generated 100 samples from this baseline and submitted them as independent jobs. Upon completion, we compared the baseline results with those of our sampled data. The mean number of vehicles from the baseline was 37.81 with a standard deviation of 3.01, which closely aligns with the values from our sampled data. You can observe the comparison on the figure below.

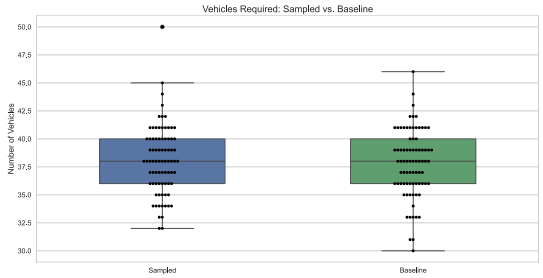

Figure 6. Comparison of required vehicles between sampled and baseline data

We also analyzed the error distribution for the number of vehicles between the baseline and sampled data, finding a mean absolute error of 3.16. This suggests that the difference between the two sets is minor, considering the sampling of data, and it is indicating a good alignment. Additionally, the average number of vehicles in both the sampled and baseline data is quite similar. While the mean absolute error reflects some variability in the sampled values, this is acceptable given the overall similarity to the global mean, and the sampling of values. Thus, despite the variance, the sampled values converge towards the actual values. This error distribution is displayed on the figure below.

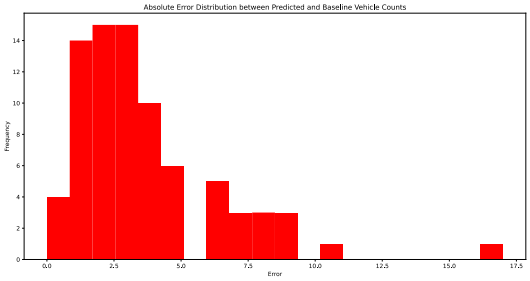

Figure 7. Required vehicles - error distribution

To statistically test whether the sampled and baseline data have the same mean number of vehicles, we conducted a Welch's t-test. The results showed a test statistic of 0.59, a p-value of 0.55, and a 95% confidence interval ranging from -0.64 to 1.23. Given the p-value, we fail to reject the null hypothesis, meaning there is no statistically significant difference between the sampled and baseline vehicle counts. Additionally, the range of the mean difference of vehicles between the sampled and the baseline data, which is from - 0.64 to 1.23, falls within our practical significance threshold of up to 2 vehicles, further supporting the similarity between the two datasets. This indicates that we can effectively estimate the number of required resources by applying optimization techniques on top of the demand prediction values.

We also analyzed the mean number of vehicles and observed that this value converges toward the actual values as the number of samples increases. This is shown on the figure below.

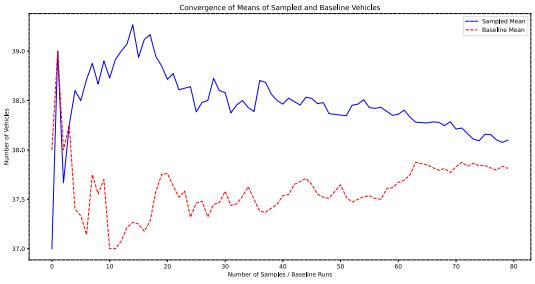

Figure 8. Convergence of means of sampled vehicles

Finally, after obtaining both the number of passengers and the number of vehicles, we decided to fit a linear regression to explore whether we could simplify the process and avoid the detailed approach previously described. As illustrated in the figure below, the regression line serves as a reasonable estimator for the number of vehicles based on the number of passengers. However, this model struggles to capture the non-linear relationships influenced

by various optimization types, window lengths, and travel modes, resulting in considerable variance around the regression line. While it is generally true that a higher number of passengers correlates with an increased number of vehicles, this relationship can be misleading. Different travel types can accommodate more passengers per vehicle, which can disrupt the linear relationship, especially in cases where these travel types dominate. Consequently, although the linear regression provides a solid approximation, it overlooks essential non-linear factors that are critical to our analysis. Our approach, which integrates these factors, demonstrates greater robustness and effectiveness. The linear regression line and the data correlation are presented in the figure below.

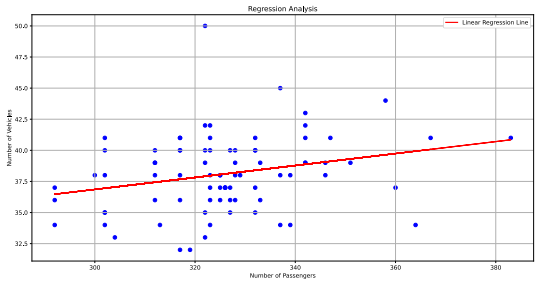

Figure 9. Regression Analysis

5 CONCLUSION

In conclusion, our findings demonstrate that we can effectively estimate the number of required resources by employing optimization methods based on predicted passenger numbers. As the number of samples increases, the sampled values consistently converge toward the actual resource requirements, reinforcing the reliability of our approach. Alternative methods, such as linear regression, fail to adequately address the non-linear complexities inherent in resource allocation, such as varying optimization types and window lengths. Our method, which incorporates these factors, proves to be a far more accurate and effective solution for resource estimation in the mobility industry.

ACKNOWLEDGMENTS

Our research is part of a broader, multi-partner initiative called CONDUCTOR. The primary objective of this project is to design, integrate, and demonstrate advanced, high-level traffic and fleet management systems. These systems aim to optimize the transport of passengers and goods efficiently on a global scale, ensuring seamless multimodality and interoperability. The CONDUCTOR project is co-funded by the European Union's Horizon Europe research and innovation programme under the Grant Agreement No 101077049.

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Knowledge graph Extraction from Textual data using LLM

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ABSTRACT

The advent of Large Language Models (LLMs), such as ChatGPT and GPT-4, has revolutionized natural language processing, opening avenues for advanced textual understanding. This study explores the application of LLMs in developing Knowledge graphs from textual data. Knowledge graphs offer a structured representation of information, facilitating enhanced comprehension and utilization of unstructured text. We intend to construct Knowledge graphs that capture relationships and entities within diverse textual datasets by harnessing LLMs' contextual understanding and language generation capabilities. The primary goal is to explore and understand how well LLMs can identify and extract relevant entities and relationships from textual data using prompt engineering while contributing to structured knowledge representation.

KEYWORDS

Knowledge graph, Large Language Models, prompt engineering, information extraction, textual data

1 INTRODUCTION

In an era where data is ubiquitous, efficient organization, retrieval, and interpretation of textual information are crucial. Knowledge graphs, representing facts and relationships in structured forms, play a pivotal role in various AI applications, from enhancing search engines to powering recommendation systems. However, the construction of these graphs is often hindered by the complexity and variability of human language. This paper explores the potential of Large Language Models, like GPT-4, to revolutionize this process. By leveraging their advanced natural language understanding capabilities, we aim to automate and refine the extraction of knowledge from textual datasets. The fundamental purpose of this research is to understand the extent to which LLMs can identify and extract relevant entities and relationships from textual data and then build a Knowledge graph using the extracted information.

The motivation behind this study stems from the growing need to effectively manage and utilize the vast amounts of textual data generated daily. Knowledge graphs offer a structured and intuitive way to represent information, but their construction is often labor-intensive and requires expert knowledge. However, constructing Knowledge graphs from unstructured text is intricate and depends on sophisticated natural language processing (NLP) methods, including named entity recognition (NER) and relation extraction. The advancement of LLMs like GPT-4 presents an opportunity to automate and improve this process as illustrated in Figure 1. Utilizing LLMs can lead to more efficient, scalable, and accurate Knowledge graph construction, thereby unlocking new possibilities in information management and AI applications.

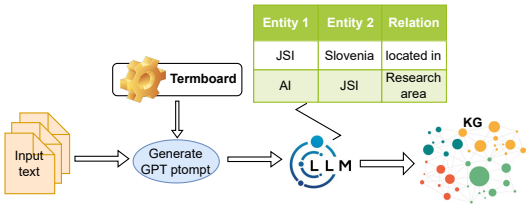

Figure 1: Overview of proposed approach where input text is processed through a Termboard to generate a structured prompt for LLM, creating an entity-relation table to build a Knowledge graph (KG).

2 BACKGROUND

An overview of recent research in Large Language Models and Knowledge graphs is provided in this section, which also emphasizes the potential for their integration.

2.1 Large Language Model (LLM)

Large Language Models are advanced AI systems pre-trained on extensive data, enabling them to comprehend and produce human language. Their recent surge in popularity is due to their proficiency in various language-processing tasks, including text completion, translation, summarization, and answering questions. These models, primarily based on transformer architecture, utilize self-attention mechanisms through encoder-decoder modules. Encoders transform input text into numerical embeddings that reflect the context and meaning, while decoders use these embeddings to generate coherent and pertinent textual output. The large language models feature a decoder-only architecture and, thus, make a prediction of the target output text using only the decoder module. The training paradigm for these models is to predict the next word in the sentence. Generally, large-scale decoder-only LLMs such as ChatGPT [7] and GPT-4 [2], focus on human-like language output, predicting subsequent words based on the preceding text for tasks like text generation.

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Table 1: Simplified comparison between Large Language Models (LLMs) and Knowledge graphs (KGs)

Feature	LLM	KG
Knowledge type	Broad, general knowledge	Structured, domain-specific knowledge
Data handling	Flexible, can process varied inputs	Requires structured data
Accuracy	May lack precision in understanding	Highly accurate with structured data
Understanding	Can interpret and generate language	Designed for specific queries and relationships
Adaptability	Adapts to new information by retraining	Adaptable when updated with new data
Transparency	Often seen as "black boxes" with unclear reasoning	Clear decision-making pathways
Error rate	Can make mistakes due to broad generalizations	Can be prone to errors if data is incorrect or missing
Complexity	Handles complex language tasks	Manages complex relationships and attributes
Usage	Broad applications in text generation, translation, etc.	Used for specific tasks like recommendations, search optimization
Scalability	Scales with computational power	Scales with the amount of structured data available

2.2 Knowledge graph (KG)

Knowledge graphs are structured representations of information that depict the relationships between entities in a specific domain. They are used extensively in various applications, such as search engines, recommendation systems, and question-answering systems. These graphs use detailed connections between data to help with smart thinking, finding specific information easily, and running applications that use knowledge. Hence, allows us to better understand and use information across multiple fields.

Knowledge graphs provide a structured way of representing interconnected knowledge. They are precise and consistent, aiding in decisive and informed decision-making. KGs are particularly valuable for their interpretability and explainability due to the explicit representation of entities and relationships. They can capture domain-specific information accurately and evolve to incorporate new data. However, KGs may suffer from incompleteness and may not always reflect the most recent or unseen facts. They also typically cannot understand natural language in an unstructured format [3][6]. Moreover, KGs are preferred in scenarios where explainability and interpretability are crucial, as they provide structured knowledge representation.

2.3 Combining LLM and KG

The comparison between Large Language Models and Knowledge graphs (Table 1) can be supported by various references that highlight their respective strengths and weaknesses [4]. Large Language Models like ChatGPT [7] are celebrated for their generalizability and ability to process diverse text data, allowing them to perform various language-related tasks without extensive task-specific training. They can act as reservoirs of general knowledge, aiding in information synthesis and research. Their proficiency in language processing is useful in tasks like natural language understanding and sentiment analysis. However, they can suffer from hallucinations, where they generate plausible but factually incorrect information. Their "black-box" nature makes it difficult to understand the internal decision-making processes, and they can be indecisive, producing uncertain responses to ambiguous inputs. Additionally, while they have vast general knowledge, they may not be up-to-date with domain-specific or the latest information. Critics of LLMs argue that these models lack transparency and interoperability.

Recent research [3] [4]efforts are, however, improving LLM's interpretability through techniques like attention mechanisms and model introspection. KGs also present advantages over LLMs by providing knowledge about long-tail entities, thus improving recall for knowledge computing tasks. However, both LLMs and KGs can perpetuate biases present in their training data or construction methodologies. In conclusion, both LLMs and KGs have their unique strengths and challenges. While LLMs excel in general language processing and knowledge extraction from vast corpora, KGs provide a structured and interpretable way to organize explicit knowledge. These differences underscore the potential benefits of integrating LLMs and KGs to create more robust AI systems that leverage the strengths of both approaches.

3 PROOF OF CONCEPT: ANALYSIS AND KNOWLEDGE GRAPH GENERATION

This section demonstrates how to process and analyze textual data to build a Knowledge graph using LLM. It is important to mention that prompt engineering [5] is of great importance when it comes to the results generated from ChatGPT. Since it is a generative model, small variations in the input sequence can create large differences in the produced output as demonstrated below. We use two different textual files containing contextual data: (i) APRIORI proposal (containing project details, job description, potential candidate skills, hosting organizations, etc.) and (ii) ADRIA Motorhome instruction manual (containing textual as well as tabular data). Moreover, building KG out of the ADRIA instruction manual has potential applications for the manufacturing industry.

3.1 Using ChatGPT Prompts:

We compare ChatGPT-3.5 and GPT-4 extracted entities and relations using the same prompts. We use Termboard[1] which offers customized ChatGPT prompts to create terms, entities, and relations to visualize larger graphs from the provided text.

Prompt: Extract an ontology and create a table of relations with 3 columns in this order: source, target, and relation name. Also Create a table with 2 columns: put in the first column the name of the term and in the second column an elaborate definition of the term. Use this text as a basis: ¨APRIORI¨- (contains textual data about the job description, candidate skills, project description, hosting organization, etc).

Observing the Knowledge graphs generated by ChatGPT-3.5 (Figure 2) and GPT-4 (Figure 3); we notice, that it didn't extract all entities and relations and missing terms/concepts. For this reason, we ran the second prompt, where we redefined a more detailed prompt to ask GPT-4 to explicitly generate a comprehensive ontology including all entities and relations from the provided text, categorize entities into types like Persons, Organizations,

[1]https://termboard.com/

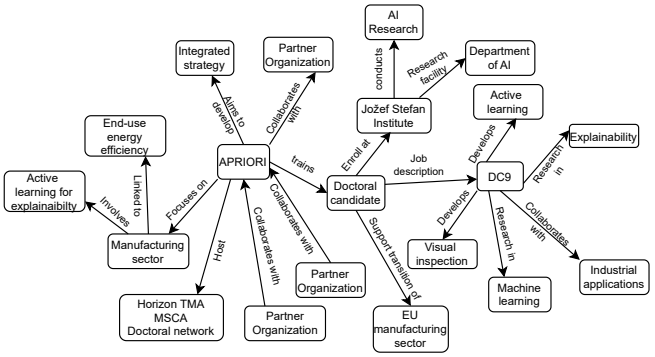

Figure 2: The KG generated using ChatGPT-3.5 contains 20 entities. It was able to extract entities and link them to relations, but it failed in abstracting concepts and specifying entities (i.e. partner organizations, location, etc.).

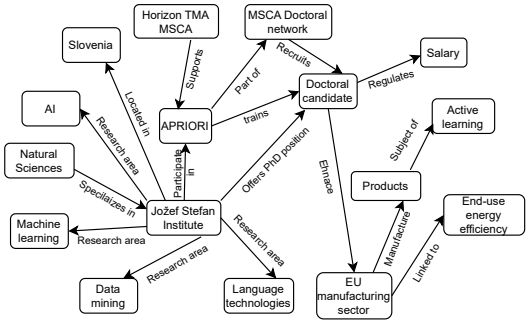

Figure 3: The KG generated by GPT-4 contains 16 entities. It was able to identify abstract concepts, and geographic entities that ChatGPT-3.5 doesn't. Extracted more elaborated entities with relations.

and concepts, and Geographic Locations, and then identify the relations between these entities. Providing additional information to GPT-4 resulted in an improved Knowledge graph (Figure 4). However, ChatGPT-3.5 didn't produce a quality graph (Figure 5) compared to Figure 2.

3.2 Python Implementation

We use a free, open-source library called spaCY [2] for advanced NLP in Python. We employ the named entity recognition technique to identify named entities from a given text using the spaCY model (en-core-web-sm). We used a chunk of textual data from the ADRIA Motorhome manual for experiment purposes. Table 2 compares entities, relations, and triplets extracted from the raw texts. The table shows that the number of triplets extracted by algorithms is similar–(Figure 6 and Figure 7). However, the number of entities that spaCY extracts are larger but not every pair of entities is connected by meaningful relation, leading to fewer triplets. Thus defeating the purpose of creating a Knowledge Base. When using spaCy for entity extraction, the entities are typically recognized based on the named entities present in the text. Named entities are often specific nouns, such as names of people, organizations, locations, dates, or product names. spaCy might not identify it as a specific entity by default. So to extract specific entities, it might need to customize spaCy's NER model

[2]https://spacy.io/models

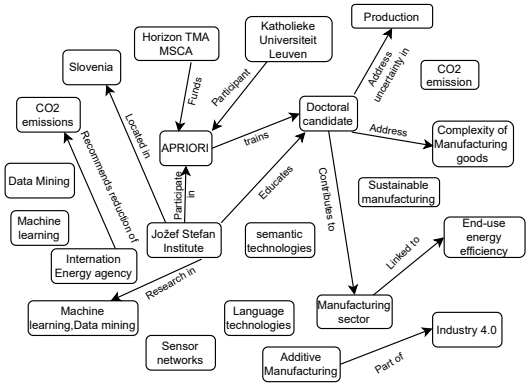

Figure 4: The KG generated by GPT-4 contains 22 entities. It Identified more key entities and relevant concepts and identified suitable relations to connect them (i.e. participant-Katholieke Universiteit Leuven). However, it didn't cover all relations and classes (i.e. skills). We also notice a few duplicated entities(i.e. data mining, CO2 emission, etc.) and some independent entities (i.e. sustainable manufacturing).

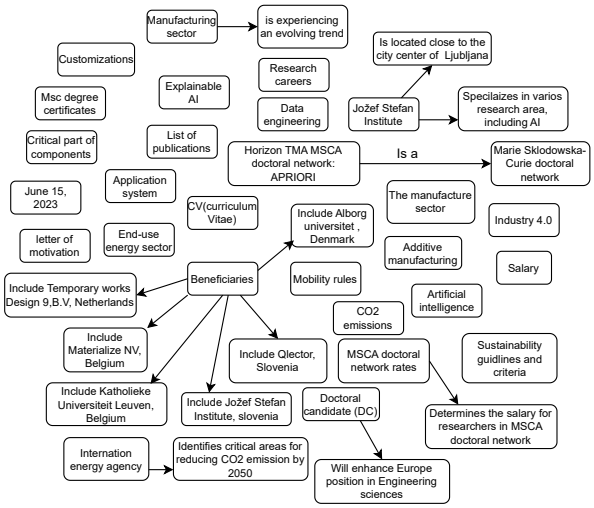

Figure 5: ChatGPT-3.5 was able to extract a larger number of entities but it was not successful at abstracting concepts and missing relations. Entities and relations found frequently represented complete sentences rather than concepts. This occurs because ChatGPT is a conversational model trained on a task to create responses to a given prompt and is not particularly trained to recognize entities and relations

or provide additional context for better recognition. Hence results can be improved by pre-processing data into a structured format.

4 EVALUATION

When there is no ground truth data available, creating an automated evaluation metric for a Knowledge graph becomes challenging. In such cases, the evaluation relies on qualitative principles to assess the results. Based on the practical framework defined in the study [1], the following principles were identified:

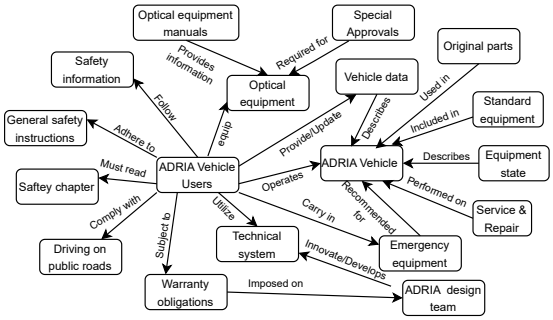

Figure 6: The KG generated by GPT-4 contains 18 entities using the ADRIA motorhome instruction manual. It extracted concepts relevant to ADRIA users and vehicle instructions, their functions, and how they are connected.

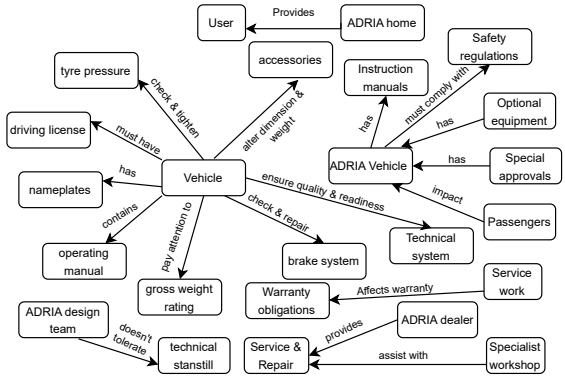

Figure 7: The KG generated by ChatGPT-3.5 contains 24 entities. Extracted more entities relevant to ADRIA vehicles but relations between entities are more generic and entities are duplicated.

- Triplets should be concise.
- Contextual information of entities should be captured.
- The Knowledge graph does not contain redundant triples.
- Entities should be densely connected.
- Relations among different types of entities should be included.
- Knowledge graphs should be organized in structured triples for easy processing by machine.
- For tasks specific to a particular domain, it's essential that the Knowledge graph is tailored and relevant to that specific field

According to these principles, in our use case, we manually inspected the Knowledge graphs generated above, and we can conclude that the ChatGPT-3.5 approach provides a more detailed Knowledge graph without abstract concepts compared to the GPT-4. However, to create these Knowledge graphs, a few steps of refining the answers from ChatGPT are needed. Sometimes the produced output is incorrect and needs to be corrected before proceeding. When we redefined the prompt, GPT-4 identified more specific entities, and concepts compared to ChatGPT-3.5. Even though ChatGPT extracted a larger number of entities, it failed to provide abstract concepts and entity-relation.

In the second part of the experiment, we employed the NER method to extract relations and entities from the given text (i.e. ADRIA). We analyzed that extracted entities are duplicated and relations have some noise and incomplete information. If you have specific patterns or structures in mind that you want to extract entities and relations based on, you may need to customize the relation extraction logic. Alternatively, more advanced natural language processing techniques or pre-trained models designed for relation extraction tasks might provide better results. Also, we analyzed half of the relations-entities extracted by spaCY and ChatGPT are overlapped.

Table 2: Knowledge extraction comparison. (ADRIA motorhome manual dataset)

Algorithm	Entities	Relations	Triplets
GPT-4	18	20	20
ChatGPT-3.5	24	18	18
spaCY	22	14	17

5 CONCLUSION

The proposed exploration of using LLMs for Knowledge graph extraction holds promise for advancing our understanding of how advanced language models can contribute to structured knowledge representation. This paper explores using LLMs to generate Knowledge graphs out of source documents. We utilized ChatGPT-3.5 and GPT-4 models to generate the Knowledge Graphs for two different textual data and compared the structure of the KGs. GPT-4 performed better as it successfully identified more abstract concepts and key entities compared to ChatGPT-3.5. Therefore, it provides insights into the practical application of LLMs in developing structured knowledge from unstructured textual data, with potential applications in knowledge-based AI applications, paving the way for more effective information processing and utilization. In future studies, we intend to use a more formal framework to evaluate the quality of created Knowledge graphs. Such a framework will allow us to efficiently analyze the quality of KG and provide a standardized method to forecast missing linkages between concepts and relationships within a given domain.

ACKNOWLEDGEMENTS

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Solving hard optimization problems of packing, covering, and tiling via clique search

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Abstract

In the paper we propose to convert NP-hard combinatorial optimization problems of packing, covering, and tiling types into maximum or k-clique problems. The key step is to come up with a tactically constructed auxiliary graph whose maximum or k-cliques correspond to the sought combinatorial structure. As an example, we will consider the problem of packing a given cube by copies of a brick. The aim of the paper is two fold to illustrate (i) the modeling power and (ii) the feasibility of the clique approach. Since theoretical tools are not readily available to study the effectiveness of the solution of the resulting clique problems we will carry out carefully conducted numerical experiments.

Keywords

mathematical programming, k-clique problems, combinatorial optimization

1 Introduction

One can see graphs as a mathematical models that can describe various fields of interest. Like numbers, functions, or Linear Programming graph based approach can model interesting problems and aid us in solving them. Some of these approaches are quite straightforward like cliques of people in a social interaction graphs or shortest path problem in a road map. Other approaches are less obvious but still easily constructed, like conflict graphs in a set of codewords where a maximum independent set represents a maximum set of suitable error correcting codes [9].

But the approach of modeling and solving various problems by graphs are more versatile. Namely, we can see graphs as a language for mathematical programming – if certain combinatorial problems can be solved by constructing a suitable auxiliary graph and finding a maximum or k-clique of this graph gives the solution. The authors have already used this approach in connection with mathematical conjectures [1], hyper graph coloring [11], subgraph isomorphism [2], scheduling problems [12], graph coloring problems [13] and protein docking problems in chemistry [8].

Here we would like to give an example, where a hard combinatorial optimization problem can be solved by this approach. For this we chose a simple to understand but numerically hard to solve problem of brick packing popularized by M. Gardner. We will focus on different approaches of how to construct an auxiliary graph in order that to translate this problems into a clique search problem. We will try to investigate how these different approaches – based on packing, covering and tiling– affect the solving time and if they have other consequences as well. First, we describe the basic problem, then we present theoretical discussion of different reformulations, and finally we describe the results of numerical experiments. The emphasis is on the modeling aspect of the computation and not on reaching new records, as the proposed problem was solved in theoretical manner within months of its formulation. Here we use it as a prototype of similar problems, and our aim to show the versatility of our approach, that is model a problem by a graph.

Graphs in this paper will be finite simple graphs. Further all graphs we use will not have loops or double edges. A finite simple graph G can be described with its set of nodes V and a subset E of the Cartesian product $V \times V$. The subset E can be identified by the set of edges of G.

Let $G = (V, E)$ be a finite simple graph. A non-empty subset C of V is called a k-clique if each two distinct nodes of C are adjacent in G and in addition C has exactly k elements. If C has only one element, then we consider it a 1-clique. The 2-cliques of G are the edges of G. A k-clique C of G is called a maximum clique if G does not have any $(k+1)$-clique. For each finite simple graph G there is an integer k such that G contains a k-clique but G does not contain any $(k+1)$-clique. This well defined integer k is called the clique number of G. We state two clique problems formally.

Problem 1. *Given a finite simple graph G and an integer k. Decide if G has a k-clique.*

Problem 2. *Compute the clique number of a given finite simple graph.*

Problem 1 is a decision problem, it is referred as the k-clique problem, and it is an NP-complete problem included in the original list of 21 NP-complete problems by Karp [7]. Problem 2 is an optimization problem and referred as the maximum clique problem, and as the decision problem belongs to the NP-complete class it follows that it belongs to the NP-hard class.

We color the nodes of a finite simple graph G with the colors $1, 2, \ldots, k$ such that each node receives exactly one color and adjacent nodes never receive the same color. Such a coloring of the nodes of G is called a well coloring, a proper coloring, or a legal coloring (the terminology is not unified). The set of nodes of G receiving the color i is called the i-th color class. Clearly, a color class is an independent

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set of G, that is, two nodes from a fixed color class are never adjacent.

If the nodes of a finite simple graph can be legally colored using k colors, then we say that G is a k-partite graph. The reason is that in this situation the nodes of G form a union of k independent sets and these sets are pair-wise disjoint.

In this paper we will focus on the following clique problem.

Problem 3. *Given a finite simple graph G whose nodes are legally colored using k colors. Decide if G has a k-clique.*

Problem 3 is a k-clique problem particularized to case of k-partite graphs. This problem is still an NP-complete problem, as the graph coloring problem can be reduced to such question as shown in [13], and should not be confused with the problem of complete graphs.

The problem class we will be focusing on in the present paper consists of packing, covering, or tiling problems. Obviously many real world and mathematical problems fall into this class, and here we would show some ideas how such problems can be modeled by a suitably constructed auxiliary graph where a k-clique search would solve the original problem.

2 Packing, covering, and tiling

First, we describe the problem class in question. Second, we draw up some basic concepts how these problems can be modeled by graphs.

Let U be a finite ground set and let

$$A_1, \ldots, A_m \tag{1}$$

be subsets of U. A family of subsets

$$B_1, \ldots, B_n \tag{2}$$

with $\{B_1, \ldots, B_n\} \subseteq \{A_1, \ldots, A_m\}$ is called a packing of U if the members of the family (2) are pair-wise disjoint. A family of subsets (2) is called a covering of U if the union of (2) is equal to U. Phrasing it differently, a family of subsets (2) is a covering of U if each element of U belongs to at least one member of the family (2). If a family of subsets (2) is a packing and a covering of U in the same time, then it is called a tiling of U. A tiling of U some times referred as exact covering of U.

A packing of U is called a k-packing if it consists of k subsets of U. Similarly, a covering of U is called a k-covering if it consists of k subsets of U. Finally, a tiling of U is called a k-tiling if it consist of k subsets of U. For a given ground set U and for its given subsets (1) there is an integer k such that U has a k-packing using subsets of the family (1) but there is no any $(k+1)$-packing of U using members of the family (1). This well defined integer k is the packing number of U with respect to the family (1). If the packing number of U is equal to k, then each k-packing of U is called maximum packing of U.

For a given ground set U and for its given subsets (1) there is an integer k such that U has a k-covering using subsets of the family (1) but there is no any $(k-1)$-covering of U using members of the family (1). This well defined integer k is the covering number of U with respect to the family (1). If the covering number of U is equal to k, then each k-covering of U is called minimum covering of U.

We state five problems related to packings, coverings, and tilings in a formal manner. Given a finite set U and its subsets (1).

Problem 4. *Decide if U has a k-packing using the members of the family (1).*

Problem 5. *Decide if U has a k-covering using the members of the family (1).*

Problem 6. *Decide if U has a k-tiling using the members of the family (1).*

Problem 7. *Compute the packing number of U with respect to the family (1).*

Problem 8. *Compute the covering number of U with respect to the family (1).*

Problem 4 can be reduced to Problem 1. We construct a finite simple graph G. The nodes of G are the members of the family (1). Two distinct nodes A_i and A_j are adjacent in G whenever A_i and A_j are disjoint. A k-clique in G corresponds to a k-packing of U.

Problem 5 can be reduced to Problem 3. We sketch the main points of this reduction. We construct a finite simple graph G. The first type of nodes of G are ordered pairs (B, x), where $B \in \{A_1, \ldots, A_m\}$, $1 \leq x \leq k$. The intuitive meaning of the pair (B, x) that the subset B is the x-th member of a k element family of (1). To the node (B, x) we assign the color x. Two nodes receiving the same color will be non-adjacent in G. Therefore the first type nodes of G are legally colored with k colors.

We are adding second type nodes to G. Namely, we are adding the ordered pairs (A, u), where $A \in \{A_1, \ldots, A_m\}$, $u \in U$ and in addition $u \in A$ holds. The intuitive meaning of the pair (A, u) is that the element u is covered by set A. To the node (A, u) we assign u as a color. Two nodes receiving the same color will not be adjacent in G. Thus the second type nodes of G are legally colored using $t = |U|$ colors. Now if we are locating a $(k+t)$-clique in G, then we select exactly k subsets from (1) and each element of U will belong to at least one of these subsets. The missing part of the construction, what we left for the reader, is how the first and second types of nodes are connected by edges.

Problem 6 can be reduced to Problem 3. As a tiling is a packing and covering at the same time, we can add the packing restrictions, namely not connecting two sets if they intersect, to the second type of nodes. On the other hand – in case of equal size sets –, we do not need to count the used sets, so we won't need the first type of nodes, they can be omitted.

The computational difficulties of the k-packing, k-covering, and k-tiling problems are different. It seems that the covering problems are the computationally most demanding and the tiling problems are the most manageable.

3 Gardner's bricks problem

We picked Gardner's problem because it is intuitive and easy to comprehend among such problems that can be reduced to Problem 3 and so it serves as a good illustration of the kind of clique modeling we are dealing with. We do not claim any originality in connection with the problem. We do not prove any new results. Each of the facts we use are known from the folklore and we present them only

for the reader convenience. The problem was raised by Foregger in March 1975 [10], popularized by Gardner in February 1976 [5], and solved by Foregger and Mather in November 1976 [3].

Let us consider a brick B of dimensions $1 \times 2 \times 4$. The brick B is a union 8 unit cubes whose edges are parallel to the coordinate axis. From some reason unknown for us the brick B is referred as canonical brick. Suppose we have a large supply of congruent copies of B and we want to pack as many as possible into a $7 \times 7 \times 7$ cube C. The cube C is a union of 343 unit cubes. Let us divide 343 by 8 with remainder. As $343 = (42)(8) + (7)$, 43 copies of B cannot be packed into C. M. Gardener advanced the question if 42 copies of B can be placed into C. One can place a copy of B into C in any possible rotated position as long the edges of B are parallel to the coordinate axis. (The answer to this question is actually: No, one cannot place 42 bricks into a cube of size $7 \times 7 \times 7$.)

Gardner's problem can be expressed in terms of computing the clique number of a suitable constructed graph G. In other words, Gardner's problem can be reduced to an instance of the maximum clique problem. Let us denote the set of the 343 unit cubes forming C by U. An 8 elements subset v of U is a vertex of G if the union of the elements of v is a congruent copy of B. As it turns out G has 1008 nodes. Two distinct nodes v and v' of G are adjacent in G if v and v' are disjoint. If G contains a (42)-clique, then 42 congruent copies of B can be packed into C. During our numerical experiments a greedy coloring procedure provided a legal coloring of the nodes of G using 42 colors. Note that this is just a coincidence, it could've happened otherwise. Thus we are facing with a particular case of the k-clique problem stated in Problem 3. The nodes of G are legally colored with 42 colors and we are looking for a (42)-clique in G. Phrasing it differently, we are looking for a k-clique in a k-partite graph, where $k = 42$.

We introduce a coordinate system whose origin coincides with a corner of the cube C.

Observation 1. *If* 42 *congruent copies of the brick* B *can be packed into* C*, then there is such a packing which contains the congruent copy of* B *whose one corner is the origin. Further the edges of lengths* 1*,* 2*,* 4 *are parallel to the first, second and third coordinate axis, respectively.*

Proof. As $343 = (42)(8) + (7)$ holds, 7 unit cubes of C are not contained by any bricks of the packing. The cube C has 8 corners and so at least one of the corners must be contained by a brick. At this point we introduce a coordinate system whose origin is this corner of C. Then we introduce the first, second, and third coordinate axis to satisfy our requirement. □

The cube C can be sliced into 7 slabs using planes perpendicular to the first coordinate axes. Each slab is a $1x7x7$ slice of the big cube, that is a union of 49 unit cubes. The centers of these cubes are in a plane perpendicular to the first coordinate axis. The 7 unit cubes of C, that are not contained by any brick of the packing, are referred as unpacked unit cubes.

Observation 2. *Two distinct uncovered unit cubes of* C *cannot be in the same slab.*

Proof. Note that a fixed slab can contain only 0, 2 or 4 unit cubes from any brick of the packing. The point is that the numbers 0, 2, 4 are all even. Each slab consists of an odd number of unit cubes. Therefore, each slab must contain an odd number of unpacked unit cubes. The number of slabs is 7 and so each slabs must contain exactly one unpacked unit cube. □

We can also form slabs by slicing C with planes perpendicular to the second coordinate axes. Each of these 7 slabs contains exactly one unpacked unit cube. Finally, slicing C by planes perpendicular to the third axes we get that each of these slabs contains exactly one unpacked unit cubes. These constraints on the uncovered unit cubes are independent, but can also be checked independently during an extended search, and as such can reduce the search space well.

4 Numerical experiments

Gardner's brick packing problem can be turned into various clique search problems and we carried out numerical experiments with them. We will observe that the same geometric problem will lead to very different clique search problems. When we try to pack 42 congruent copies of the canonical brick B into the the big cube C, we get a k-clique problem. When we notice that the nodes of the auxiliary graph can be legally colored using 42 colors we get a k-clique problem in a k-partite graph which is a more tractable search problem. When we try to pack 42 congruent copies of the brick into the cube C together with 7 unit cubes we get tiling problem. When we try to pack 42 congruent copies of the brick into the cube C together with 7 unit cubes and in addition we distinguish the unit cubes among each other we get yet another version of the tiling problem.

In the first approach the auxiliary graph G_1 had 1008 vertices. The nodes of G_1 were legally colored using 42 colors and we tried to locate a (42)-clique in G. Note, that although this graph can be colored with 42 colors it was just a coincidence. There is no theoretical background to this fact. Of course the expectation was that G_1 do not have any (42)-clique.

Let us assume that it is possible to pack 42 congruent copies of the $1 \times 2 \times 4$ canonical brick B into the $7 \times 7 \times 7$ cube C. By Observation 1, we may assume that a brick appear in the packing such that one of the corners of the brick coincides with the origin of the coordinate system and the edges of lengths 1, 2, 4 are along the 1-st, 2-nd, 3-rd coordinate axis. This information can be interpreted such that there a (42)-clique C_2 in G_1 which has a specific node. Namely, the vertex v_1 of G_1 that corresponds to the special corner brick is a node of the of C_2. This suggests to restrict the graph G_1 to the neighbors of the vertex v_1 to get a new graph G_2. Then we are looking for a (41)-clique in G_2. Plainly, the nodes of G_2 are legally colored using 41 colors. This coloring is inherited from the coloring of the nodes of G_1. Since the graph G_2 has fewer vertices than G_1 (actually 960) and we are looking for a smaller clique in G_2 than in G_1. The new clique problem probably requires less computational effort because the graph is smaller, and because we introduced a symmetry breaking to it.

The problem of packing 42 bricks into a bigger cube can be viewed as a tiling problem. Namely, we try to tile the

$7 \times 7 \times 7$ cube C by 42 copies of the canonical brick and 7 additional copies of a unit cube. Thus we are facing to a tiling problem using two different types of tiles and the number of the tiles is given. To ensure that we use 42 bricks we numerate the small cubes as $\{1, \ldots, 7\}$ and ensure in the graph that each small unit cube is used once, that is we do not connect nodes where the unit square is covered by the same small cube. This tiling problem can also be reduced to a clique search problem. We denote the corresponding graph G_3. Tiling problems are more manageable compared with packing problems as during the search back-tracking can be anticipated earlier. However, the graph associated with the tiling in our case has more vertices than the graph associated with the packing, namely it has 10 465 nodes. Therefore only computations can reveal which approach is preferable.

Obviously, in this case we can also fix a brick in the corner. This version will be the G_4 graph.

In the last clique search equivalent of Gardner's problem we construct a graph G_5. In this construction we handle a mixed tiling problem but we utilize the extra information that no two distinct unit cube can appear in the same slab. By Observation 2, this may be assumed. This is done by not connecting two nodes associated with unit cubes if those unit cubes lay in the same slab. This graph is the same size as G_3, as we only delete some edged from it. Also, we can fix a brick in the corner in this case as well, that shall be the G_6 graph.

Once again only numerical experiments can guide us in judging the merits of the possible clique search equivalents of the problems. Further, the preconditioning methods perform differently on the graphs G_1, G_2, G_3, G_4, G_5, G_6 and this adds an extra layer of difficulty to the numerical work. We used a computer with AMD EPYC 7643 processors, `C++`, and gcc v12.1 with settings `-O3 -arch=znver3`.

We made all six graphs and performed k-clique search on them after preconditioning as described in [12, 13]. The preconditioning run for 1-2 hours for the bigger graph, and reduced it by half, namely to around 6 000 nodes for G_3, G_4; and to around 4 000 for G_5, G_6, that is the graphs where we allow only one small cube in a slab. For the smaller graphs (G_1, G_2) the preconditioner runs for a couple seconds but cannot significally reduce the graph. Three of the six graph could be solved after preconditioning: G_2, G_5, and G_6.

The solution time of G_2 (the original graph with fixed brick in the corner) was 50 days. The solution of G_5 was a bit faster, 29 days. Finally, the graph G_6 could be solved more effectively. The running time was 123 484 seconds, that is 34 hours. This clearly show us the importance of the extra information of slabs.

5 Conclusions

We detailed several k-clique search reformulations of a certain combinatorial problem in terms of constructing suitable auxiliary graphs. We do not claim, that these methods result more efficient practical computations than other approaches. The point we are trying to make is that the clique reformulations open up a possibility to use well tuned clique solvers, including preconditioning, to handle different combinatorial problems in a unified manner as a general solver.

The results presented here have interesting consequences and suggest further research problems. First, and as anticipated, different auxiliary graphs lead to very different search space sizes. And although the usual concept in our research is that bigger graphs usually tend to be harder, that is not always the case. Remarkably, numerical results indicate that the size of the auxiliary graph alone is not as important as the type of the reformulation. Namely, the tiling type auxiliary graphs required less computational effort for clique search even if they were not the smallest graphs. Second, there are additional constraints that can be added to some reformulations while they seemingly cannot be incorporated into others. An example to such a constraint is the fact described after the proof of Observation 1. Namely, that no two distinct uncovered unit cubes can appear in the same slab in Gardner's brick packing problem. That kind of restriction could be incorporated into the tiling version of reformulation, and possibly not applicable to the packing reformulation. Taking advantage of the extra constraint made possible to solve the brick packing problem in reasonable time.

There are other problems that can be solved using similar approaches as detailed in the paper. Authors could solve smaller instances of the Golomb ruler problem or the Salem-Spencer set problem. The results, that lay outside the scope of the present paper, obtained with those instances open up even more interesting considerations.

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Zbornik 27. mednarodne multikonference

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Zvezek D

Proceedings of the 27th International Multiconference

INFORMATION SOCIETY – IS 2024

Volume D

Miti in resnice o varovanju okolja
Myths and Truths About Environmental Protection

Uredniki / Editors

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Information Society Multyconference 2024
Conference on Myths and Truths of Environmental Protection
Opening address

V veliko zadovoljstvo in čast nam je, da vas lahko ponovno pozdravimo na letošnji konferenci o okolju v okviru zdaj že tradicionalne Multikonference Informacijska družba. Zahvaljujemo vam, da ste se tako številčno odzvali na naš poziv z vašimi prispevki in predstavitvami.

Tema letošnje konference je kmetijstvo in gozdarstvo v luči nove evropske zakonodaje na teh področjih. Pri tem pa gre za mnogo širše probleme v povezavi z varstvom okolja in podnebnih sprememb, zato je nujno vključiti v razpravo tudi poročila s teh drugih področij, posebej energetike. Ravno tako se ni mogoče izogniti razpravi o nekaterih teoretičnih vidikih, ki so osnova ukrepov za preprečevanje in blaženje posledic podnebnih sprememb.

Podnebne spremembe so postale modni dodatek razpravam, človeški vpliv pa je razglašen za poglavitni vzrok in krivca za vse probleme, ki so se pojavili v zadnjih desetletjih.

Med tem ko spremembe namembnosti zemljišč zagotovo vplivajo na lokalne podnebne razmere, tega pa z enako znanstveno strogostjo ni mogoče trditi za vpliv ispustov toplogrednih plinov na globalni ravni. Med tem ko izpuste toplogrednih plinov spremljamo z nesorazmerno veliko pozornostjo, resne okoljske škode povzročene z drugimi onesnažujočimi dejavniki komaj kdaj omenjamo.

It is a great pleasure and honour to be able to welcome you all once again on behalf of the editorial board of the Information Society Multiconference, and to thank you for your submission of articles and presentations at the Conference on Myths and Truth of Environmental Protection.

This year's main theme is agriculture and forest management in the light of the latest European legislation on this subject. However, as this is just a segment of the much broader problem of both environmental protection and climate change, we have included a number reports on related topics of energy supply and consumption, as well as some theoretical basis for assessing the necessity to mitigate climate change.

Climate change has become a fashion issue during the last couple of decades, and the anthropogenic influence on it has been declared the main cause and a guilt for almost every aspect of problems that have recently emerged in the modern society.

While land use change certainly affects local climate to some extent, the influence of greenhouse gases emissions on global climate has been determined to a much lower certainty than the scientific rigor requires. The question of greenhouse gases has received a disproportionate attention; the question of environmental damage by other pollutants has been discussed only marginally.

Med tem ko je človekov vpliv na podnebje še vedno do določene mere znanstveno vprašljiv, vsaj glede vzrokov ekstremnih vremenskih pojavov, je za večino medijev in politično elito znanost dorečena in je čas za ukrepanje. Podnebna znanost je postala močno politizirana.

Po besedah Rimskega kluba, vplivnega idejnega podnebnega združenja ter svetovalnega telesa Organizacije združenih narodov:

"*Skupni sovražnik človeštva je človek. Pri iskanju novega nasprotnika, ki naj bi nas poenotil, smo prišli do spoznanja, da so onesnaževanje, ogrožajoče podnebne spremembe, pomanjkanje vode in hrane, ter življenja nasploh, ustrezni dejavniki nevarnosti, ki jih s svojim delovanjem povzroča človek. Le s spremembami naravnanosti in obnašanja lahko te nevarnosti prebrodimo. Resnični sovražnik je človeštvo samo.*"

"*Človeštvo je odprlo vrata pekla*", je v svoji nedavni konferenci za novinarje povedal generalni sekretar Združenih narodov Antonio Guterres.

Po drugi strani pa najnovejše Šesto poročilo IPCC v poglavju 11 na strani 1520 oznanja:

"*Pogostost prihodnjih sicer redkih, toda udarnih dogodkov povezanih s podnebnimi skrajnostmi je na splošno povezana z nizko verjetnostjo, čeprav jih ni mogoče izključiti, zlasti ob globalnem segrevanju nad 4°C.*"

In še na strani 1608:

"Če povzamemo; *posamezne povezave med spremembami povprečnih in skrajnih pogojev so močno odvisni od opazovanih dejavnikov ali pojavov. Na lokalni ravni so spremembe povprečnih in skrjnih temperatur površja močno povezane, med tem ko je povezava sprememb povprečnih in skrajnih padavin pogosto šibka. Oboje, spremembe povprečnih in skrajnih pogojev, se močno razlikujejo med različnimi območji zaradi učinkov lokalnih in regionalnih procesov.*"

While the science of human influence on climate is still controversial to some extent, at least in regard to its impact on the frequency and intensity of extreme weather events, for the mass media and most of the political elite the science is settled and it is now time for action. Climate science has become highly politicized.

In the words of the Club of Rome, a premier environmental think-tank, consultants to United Nations:

"*The common enemy of humanity is men. In searching for a new enemy to unite us, we came up with the idea that pollution, the threat of global warming, water shortages, famine, and the life, would fit the bill that dangers are caused by human intervention. It is only by changed attitudes and behaviours that they can be overcome. The real enemy is humanity itself.*"

"*Humanity Has Opened the Gates of Hell*" is one of the recent statements at a press conference by the UN Secretary General Antonio Guterres.

On the other hand, the latest IPCC Sixth Assessment Report acknowledges in Chapter 11, page 1520:

"*The future occurrence of low-likelihood, high-impact events linked to climate extremes is generally associated with low confidence, but cannot be excluded, especially at global warming levels above 4°C.*"

And on page 1608:

"*In summary, the specific relationship between changes in average and extreme conditions strongly depends on the variable or phenomenon being considered. At the local scale, average and extreme surface temperature changes are strongly related, while average and extreme precipitation changes are often weakly related. For both variables, the changes in average and extreme conditions vary strongly across different places due to the effect of local and regional processes.*"

V zanjem času so podnebne spremembe povzročile tudi problem uveljavljana zakonov. Predlagane rešitve za omilitev domnevnih groženj pogosto ustvarijo več novih problemov, rešujejo pa jih malo ali nič. Predlagana zakonodaja pa pogosto povzroča ravno nasprotne učinke, kar je postalo očitno zlasti pri vplivih na avtomobilsko in drugo težko industrijo, kot tudi na poljedeljstvo in gospodarjenje z gozdovi.

Največji problem pa verjetno leži v popolnem pomanjkanju komunikacije in dialoga med vladami in prizadetimi deležniki. Zato je to prvo kar moramo spremeniti, če želimo uveljaviti realne rešitve za realne probleme.

Upamo, da bo ta konferenca korak v to smer.

Konferenčni uredniški odbor
Ljubljana, 9. Oktobra, 2024

Lately the question of climate change has become also an executive problem. Solutions suggested to mitigate the alleged problems often produce more new problems, while solving little or nothing. And the proposed legislation is often counterproductive, which has become evident mostly in its impact on automotive and other heavy industry, as well as on agriculture and forest management.

Probably the greatest problem is a complete lack of communication and dialogue between the governments and the affected parties, and this needs to change first, if we are to establish real solutions to real problems.

Hopefully this conference will be a step in that direction.

Conference editorial board
Ljubljana, October 9th, 2024

PROGRAMSKI ODBOR / PROGRAMME COMMITTEE

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LCA data conforms to Benford's law
Podatki LCA se ujemajo z Benfordovim zakonom

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Abstract

Life cycle assessment (LCA) has been established as the standard method for evaluating environmental impacts of products, and processes. However, ISO standards depicting the application of these standards are tailored more towards LCA practitioners and less on the data acquisition and quality. The data acquisition process lacks robustness, with significant decision-making and quality control entrusted to practitioners. Given the lack of incentives for industry participants to submit high-quality data, the integrity of LCA databases may be questionable. Moreover, in some cases, participants may be incentivised to protect their data from competition. To address these concerns, data is carefully studied by external experts to verify their credibility. However, it is not entirely clear how these experts are chosen, nor how trust is established. In this paper, we apply a well known method Law of anomalous numbers, commonly referred to as Benford's law in order to test the conformity of commonly used LCA databases. Our results on testing Ecoinvent, one of the most widely used LCA databases, show that LCA data strongly conforms to Benford's law. Moreover, our analysis includes 5 additional publicly available LCA databases, which also conformed with the exception of Bioenergiedat, which is likely due to the low number of observations. Finally, we tested individual properties given by Ecoinvent and establish that very few columns (<5%), which pass the criteria for Benford's analysis, are non-conforming. Although interesting, these results call for a more fine-grained analysis as future work.

Abstract

Življenjski cikel izdelka (LCA) se je uveljavil kot standardna metoda za ocenjevanje okoljskih vplivov izdelkov in procesov. Vendar pa so standardi ISO, ki določajo uporabo teh metod, bolj prilagojeni strokovnjakom za LCA in manj usmerjeni v pridobivanje kakovost podatkov. Proces pridobivanja podatkov ni zelo robusten, saj je veliko odločitev in nadzora nad kakovostjo prepuščenih izvajalcem. Glede na pomanjkanje spodbud za udeležence iz industrije, da oddajo kakovostne podatke, je lahko integriteta baz podatkov LCA vprašljiva. Poleg tega so udeleženci v nekaterih primerih lahko motivirani, da zaščitijo svoje podatke pred konkurenco. Da bi naslovili te pomisleke, podatke natančno preučijo zunanji strokovnjaki, da bi preverili njihovo verodostojnost. Vendar ni povsem jasno, kako so ti strokovnjaki izbrani in kako se vzpostavlja zaupanje. V tem prispevku uporabljamo dobro znano metodo "zakon anomalnih števil", pogosto imenovano Benfordov zakon, da bi preizkusili skladnost podatkov, ki se uporabljajo v najpogosteje uporabljenih bazah podatkov LCA. Naši rezultati preizkusa Ecoinventa, ene najpogosteje uporabljenih baz podatkov LCA, kažejo, da se podatki LCA močno ujemajo z Benfordovim zakonom. Poleg tega naša analiza vključuje še pet drugih javno dostopnih baz podatkov LCA, ki so prav tako skladne, z izjemo Bioenergiedata, kar je verjetno posledica majhnega števila podatkov. Nazadnje smo preizkusili posamezne lastnosti, ki jih ponuja ecoinvent, in ugotovili, da zelo malo stolpcev (manj kot 5 %), ki izpolnjujejo kriterije za Benfordovo analizo, ni skladnih. Čeprav so rezultati zanimivi, ti kličejo po podrobnejši analizi v prihodnosti.

Keywords

LCA, Benford's Law, Anomaly Detection

Keywords

LCA, Benfordov zakon, odkrivanje anomalij

1 Introduction

Life Cycle Assessment (LCA) is a systematic methodology for evaluating the environmental impacts of a product, process, or service throughout its entire life cycle. This encompasses all stages from raw material extraction, production, use, and disposal or recycling. The main goal of LCA is to identify opportunities for improving environmental performance and making informed decisions regarding sustainability.

(1) Goal and Scope Definition**:** Establishing the purpose, boundaries, and scope of the assessment.
(2) Inventory Analysis (LCI): Compiling an inventory of relevant energy and material inputs and environmental releases.
(3) Impact Assessment (LCIA): Evaluating the potential environmental impacts associated with the inputs and releases identified in the inventory analysis.
(4) Interpretation: Analyzing results to make informed decisions, identify significant issues, and suggest improvements.

Life Cycle Assessment (LCA) is used in various industries and sectors to promote sustainable practices, reduce environmental footprints, and support regulatory compliance. It is recognized as a crucial tool for environmental management and policy-making [6]. Considerable effort has been made over the past decade in an attempt to alleviate early criticism about data quality and trustworthiness [1]. Over the last few years many different tools have been made to assess these problems, but there is still not standard that could be used on all LCA datasets [4]. It was shown that results of LCA for same processes were variable over time which makes it hard to find statistical tool that could easily assess the trustworthiness and reliability of the data. [11] This is the reason why we decided to use Benford's law as a good indicator. It is also known as first-digit law and is very often used for fraud

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https://doi.org/https://doi.org/10.70314/is.2024.env.1

detection [8]. It was perfect choice for our research since it did not require a lot of domain specific knowledge and is not influenced by variability over time. For this purpose we have decided to analyze Ecoinvent database as it has established itself as one of the most used databases due to the amount of data, and tooling provided. More details about databases available in the literature [10, 17, 9].

2 Literature review

We have checked many sources that motivated us to check how good Benford's law would be for detecting inconsistencies in data. It is estimated that less than 20% of papers related to LCA conducted any kind of uncertainty analysis. [2]

Research conducted by Aalto University, Finland [16], compared numbers from five different LCA databases to compare amount of green house gases produced during the creation of the buildings. The findings indicate that the databases exhibit comparable patterns in the evaluation outcomes, with consistent disparities in scale across the reference buildings observed across all databases. Additionally, it was disclosed that there are significant disparities in the numerical values across the databases at some locations, and these disparities come from several data fragments.

Early research offered a comparative analysis of 26 sulfate pulp mills in Sweden, focusing on the quantified emissions released into the air and water between 1986 and 1993. The analysis revealed significant variations in annual emission variables across a group of companies. The emission parameters for most water emissions were not influenced by the annual production rates of pulp. [11]

A more recent study statistical analysis of elemental flows in commonly used LCA and LCIA databases and software was analysed [7]. The main conclusions of the study signaled considerable shortcomings in flow clarity, consistency, and extensibility in elementary flows. However, no common method of identification was proposed.

Moreover, the objectiveness of the evaluators responsible for data integrity has been highlighted as crucial to LCA database quality [13]. While this may be self-evident, a bigger concern would be when objectiveness is not guaranteed.

3 Methodology

The first-digit law is an observation about the frequency distribution of leading digits. It is also known as the Newcomb–Benford law or Benford's law. It has been apparently first discovered by polymath Newcomb and published in [14] and later rediscovered by physicist F. Benford and presented in [3]. The Benford's law [15] defines a fixed probability distribution for leading digits of any kind of numeric data with the following requirements:

- Data with values that are formed through a mathematical combination of numbers from several distributions.
- Data that has a wide variety in the number of figures (e.g., data with plenty of values in the hundreds, thousands, tens of thousands, etc.)
- Data set is fairly large, as a rule of a thumb at least 50 – 100 observations [12].
- Data is right skewed (i.e., the mean is greater than the median), and the distribution has a long right-tail rather than being symmetric.
- Data has no predefined maximum or minimum value (with the exception of a zero minimum).

The distribution of digits is presented in Figure 1; the digit 1 occurs in roughly 30 % of the cases, and the other digits follow in a logarithmic curve. It has been shown that this result applies to a wide variety of data sets [15], including electricity bills, street addresses, stock prices, house prices, population numbers, death rates, and lengths of rivers. The equation for the distribution of the first digits of observed data is given in Equation 1.

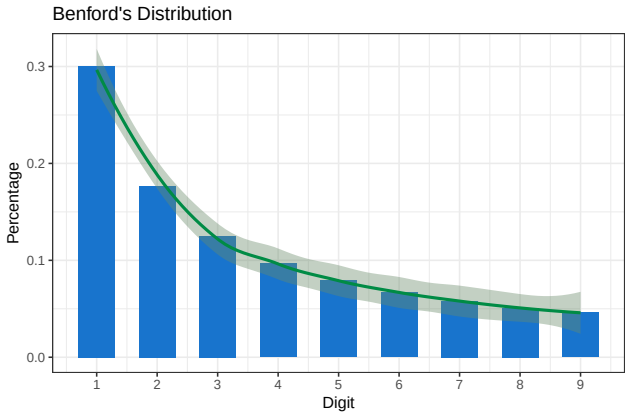

Figure 1: A graphical representation of the Benford's distribution

$$P(d) = log_{10}(d+1) - log_{10}(d) = log_{10}(1 + \frac{1}{d}) \quad (1)$$

We utilized the benford.analysis package [5] in R for our research. There were no instances of missing values denoted by "NA" in the form, although there were numerous occurrences of zeros. The Benford function automatically disregarded any zero values, eliminating the necessity for their removal. We needed to extract a subset of the data that includes only columns containing numerical values. The Benford function was modified to accommodate negative numbers as well, as the sign was irrelevant for our specific investigation. The Ecoinvent dataset comprises 2654 columns, of which 2648 are numeric and were utilized in the analysis. Within the 2648 columns, we have identified a total of 1190 distinct chemical substances. These substances have been categorized into five classes according to their place of release: Air, Water, Soil, Natural Resources, and Inventory Indicator.

4 Results

We have demonstrated that a significant proportion of the columns in the Ecoinvent database conform to Benford's law, specifically 2193 out of 2648. The majority of non-conforming cases had a significant number of missing values, resulting in an insufficient amount of data for analysis. Only 70 columns met the criteria of having sufficient observations and not conforming. Figure 2 shows proportion of columns that conform and those that do not. We can see that our R package also divides conformity into four levels: close conformity, acceptable conformity, and marginally acceptable conformity. For our research we have counted all levels of conformity as the same since we can't expect data to conform perfectly in real life.

In order to show that LCA data generally conforms to Benford's law, in addition to Ecoinvent, which underwent individual column testing, other databases were examined as a whole using the Benford method. These databases are open source and available online, and even though they are not as big and detailed as

Database	ChiSq	ChiSqP	MantissaArcTest	MantissaArcTestP	MADConformity	MAD	Number of Observations
Ecoinvent	247.684	0	0.033	0	Close conformity	0	49031793
Worldsteel	44.56	0	0.039	0	Close conformity	0.002	73044
OzLCI2019	63.034	0	0.036	0	Close conformity	0.002	178940
Greendelta	29.375	0	0.032	0	Close conformity	0.001	205344
Needs	150.271	0	0.034	0	Close conformity	0.001	808382
Bioenergiedat	29.626	0	0.053	0	Nonconformity	0.018	834

Table 1: Statistical indicators of Benford's conformity for LCA databases studied.

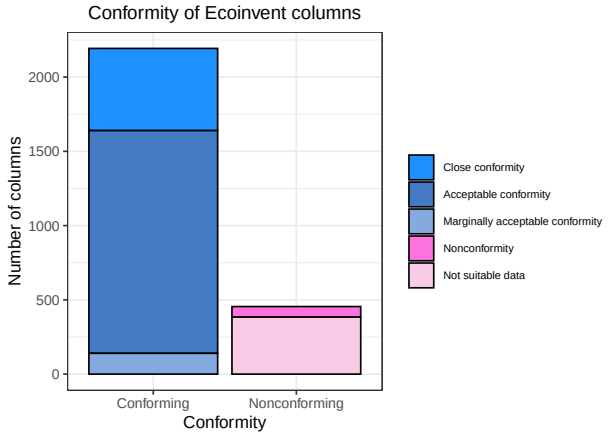

Figure 2: Conformity of Ecoinvent columns

Ecoinvent, they also conformed. From the Figure 3 we can see that all of these databases conformed with the testing, except for one that was outdated and lacked sufficient data. By visual inspection, the last database appears acceptable, however, from a statistical standpoint, it does not meet the required criteria. Table 1 shows all statistical values produced by our Benford function. As aforementioned, the Bioenergiedat [1] stands out as the only non-conforming LCA database due to the low amount of observations (n=834), the credibility of this statistical test is questionable. For other databases, all statistical conformity tests signal strong conformity with the expected distribution, which results into a Close conformity according to commonly used MAD conformity test. All open source databases were found on OpenLCA Nexus website [2]. Worldsteel [3] presents comprehensive worldwide and regional Life Cycle Inventory (LCI) data for 16 different steel products, ranging from hot rolled coil to plate, rebar, sections, and coated steels. This study was conducted using the worldsteel LCI methodology report and ISO standards 14040 and 14044. It is considered the most extensive and precise LCI dataset for steel products worldwide. OzLCI2019 [4] is a free LCA database created by The Evah Institute in Australia. The database covers the supply of goods from the Australasian area, including imports, and was created using openLCA. Greendelta [5]is focused on providing secondary data for Product Environmental Footprints (PEFs) within the openLCA software. The objective is to address the environmental effects of products, such as carbon emissions, by creating a standardized European approach for evaluating and categorizing items. Needs [6] database was established by the NEEDS (New Energy Externalities Developments for Sustainability) project and contains life cycle inventories of future energy supplies in Europe. The dataset includes life cycle inventory (LCI) information related to upcoming transportation services, power, and material supply in the industrial sector. Bioenergiedat was developed as part of the German BioEnergieDat project and was finalized in February 2013. The objective of the project was to establish supply chains for bioenergy alternatives, with a particular focus on the German context. The primary focus was on bioenergy derived from wood and wastewood, wheat, and biowaste.

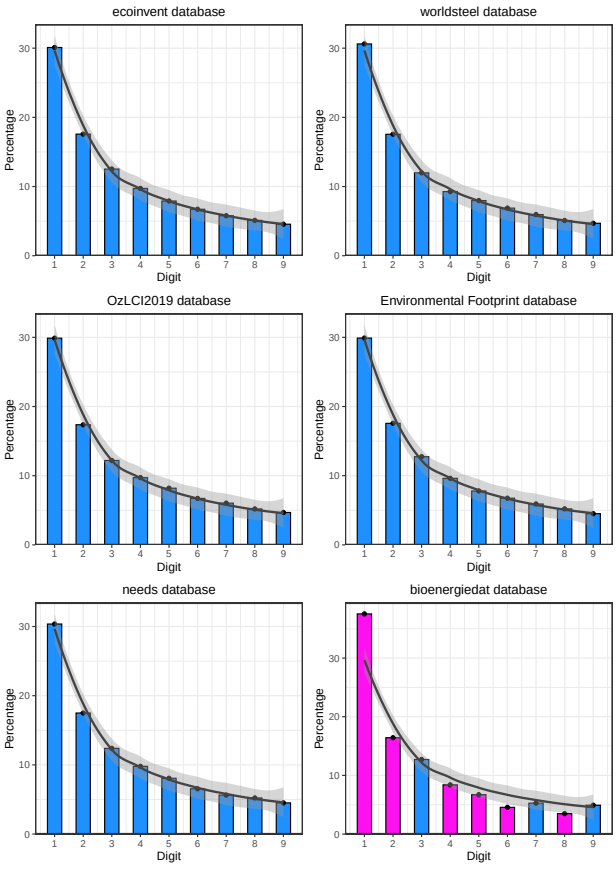

Figure 3: Comparison of first digit distribution between different databases

[1]https://bioenergiedat.de/
[2]https://nexus.openlca.org/
[3]https://worldsteel.org/
[4]http://www.evahnaturepositive.com/
[5]https://www.greendelta.com/

[6]https://nexus.openlca.org/database/NEEDS

5 Conclusion and future work

Our analysis has determined that, generally, LCA data should conform to Benford's law. The results were consistent with expectations and demonstrated that this straightforward statistical approach can be employed to evaluate first assessments of data reliability. We anticipated that the entire LCA dataset would conform, while we acknowledged the possibility that certain minor components would not. Non-conformity in the results does not imply the inaccuracy or fabrication of the data; rather, it indicates the necessity for expert verification. Establishing general conformity is a stepping stone, as the method can be used to reliably test for database anomalies quickly and efficiently. However, nonconformity would still require expert assessment to determine the reasons. Typically, anomalies might be statistically undetectable in large number of observations. This is commonly addressed by sub-sampling the data. By testing individual parameters, we have shown that for Ecoinvent, almost all are conforming (>95%). Future work should include other sub-sampling techniques such as geographic location, compartment (Air, Water, Soil, Natural Resources, and Inventory Indicator), and others. These approaches might provide a more granular view and possibly be able to detect anomalies in individual sub-samples, thereby making subsequent analysis easier and more accurate.

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Liquid Neural Network in Modelling Rainfall-Runoff

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ABSTRACT

This study explores the use of Liquid Neural Networks (LNNs) to predict runoff for one, three, and six days ahead, highlighting their superior performance compared to traditional models such as Artificial Neural Networks (ANNs), Model Trees (MTs), and Long Short-Term Memory (LSTM) networks. LNNs leverage a dynamic reservoir of neurons, enabling them to capture complex temporal dependencies inherent in the rainfall-runoff process. The study employs a case analysis of the Sieve River basin, using historical hydrological data to train and evaluate the models. The results demonstrate that LNNs consistently outperform other models across all prediction horizons, achieving the lowest Root Mean Square Error (RMSE) and Normalized Root Mean Square Error (NRMSE) values, and the highest Coefficient of Efficiency (COE). This indicates that LNNs are highly effective for both short-term and long-term hydrological forecasting, offering significant potential for enhancing water resource management and flood prediction strategies.[1]

KEYWORDS

Liquid Neural Networks, Runoff Prediction, Hydrological Forecasting, Temporal Dependencies, Machine Learning, Rainfall-Runoff Modeling

POVZETEK

Ta študija raziskuje uporabo Liquid Neural Network (LNN) za napovedovanje odtoka vode (runoff) en, tri in šest dni vnaprej. LNN je vrsta rekurentne nevronske mreže, ki ohranja dinamično stanje nevronov, kar omogoča zajemanje kompleksnih časovnih vzorcev v podatkih.

Raziskava se osredotoča na bazen reke Sieve v Toskani, Italija, in vključuje podatke o padavinah, evapotranspiraciji in odtoku v obdobju treh mesecev. Rezultati kažejo, da LNN dosledno presega tradicionalne metode, kot so Artificial Neural Networks (ANN), Model Trees (MT) in Long Short-Term Memory (LSTM) omrežja, pri vseh napovedovalnih horizontih (1, 3, 6 dni). LNN se je izkazal za najučinkovitejšega pri obvladovanju tako kratkoročnih kot dolgoročnih napovedi, kar nakazuje na njegov potencial pri izboljšanju hidroloških napovedi in upravljanju z vodnimi viri.

KLJUČNE BESEDE

Liquid Neural Networks, napovedovanje odtoka, hidrološko napovedovanje, časovne odvisnosti, strojno učenje, padavinsko-odtočno modeliranje

1 Introduction

Rainfall-runoff models are essential tools in hydrology used to simulate the transformation of rainfall into runoff, a process critical for water resource management, flood forecasting, and environmental protection. These models help understand and predict how precipitation translates into river discharge, which is vital for designing infrastructure, managing water resources, and mitigating the impacts of extreme weather events.

Traditionally, rainfall-runoff models have employed a variety of algorithms ranging from empirical and conceptual models to more sophisticated data-driven techniques. Among the data-driven approaches, Artificial Neural Networks (ANNs) and Model Trees (MTs) have been extensively used due to their ability to capture complex nonlinear relationships between rainfall and runoff [1, 2]. ANNs, inspired by the human brain, consist of interconnected nodes (neurons) that process input data to produce an output. They are highly effective in identifying patterns and making predictions based on historical data [3]. On the other hand, Model Trees are decision tree-based models that combine linear regression at the leaves, offering a more interpretable approach while maintaining good predictive performance (Quinlan, 1992).

In addition to ANNs and MTs, Long Short-Term Memory (LSTM) networks and other recurrent neural networks (RNNs) have gained popularity for rainfall-runoff modeling. LSTMs are a type of RNN specifically designed to capture long-term dependencies in sequential data by addressing the vanishing

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gradient problem common in traditional RNNs [4]. LSTMs and similar architectures like Gated Recurrent Units (GRUs) have shown promise in modeling time series data due to their ability to maintain and update a memory state over long sequences, making them well-suited for hydrological forecasting [1].

While these methods have proven effective for short-term and moderately long-term predictions, their performance tends to degrade over even longer lead times. This limitation is partly due to the static nature of these models, which may struggle to capture the dynamic temporal dependencies inherent in the rainfall-runoff process. Consequently, there is a growing interest in exploring more advanced neural network architectures that can better handle temporal data.

2 Modelling

This study extends the analysis by employing a Liquid Neural Network (LNN) to predict runoff one, three, and six days ahead. LNNs are a type of recurrent neural network that maintain a dynamic reservoir of internal states, allowing them to capture complex temporal patterns in data. Unlike traditional neural networks, which rely on static weights and activations, LNNs leverage a constantly changing network of neurons, making them particularly suitable for modeling temporal data.

The results of this study indicate that the LNN can effectively capture the temporal dependencies in the rainfall-runoff transformation process. By leveraging the dynamic behavior of neurons, the LNN can model short-term and medium-term dependencies and provide accurate predictions for runoff one day, three days, and even six days ahead. This promising approach offers significant potential for improving hydrological forecasting over longer lead times, essential for effective water resource management, flood prediction, and planning.

3 Liquid Neural Networks and Their Architecture

3.1 Introduction to Liquid Neural Networks

Liquid Neural Networks (LNNs) represent an advanced approach to recurrent neural network design. LNNs maintain a reservoir of dynamic states, enabling them to capture complex temporal dependencies and patterns in data. This feature makes LNNs particularly well-suited for tasks involving time-dependent data and dynamic systems [5, 6].

3.2 Key Concepts and Mechanisms

Dynamic Reservoir: LNNs consist of a reservoir of interconnected neurons with time-varying states. The reservoir's dynamic nature allows it to process and retain information over varying time scales, making it effective for modeling temporal dependencies.

Temporal Processing: The temporal processing capability of LNNs allows them to capture and model the evolution of time-series data more effectively than static neural networks.

Training: LNNs typically involve training only the output layer, while the reservoir dynamics are left untrained but fixed, which simplifies the learning process and allows for efficient handling of temporal data [7].

3.3 Architecture of Liquid Neural Networks

Neurons: Dynamic Neurons: Neurons in LNNs have time-dependent states that evolve based on their interactions with other neurons in the reservoir.

Synapses: Adaptive Synapses: Synapses in LNNs can adapt based on the input data, allowing the network to learn temporal patterns.

Network Topologies: Reservoir Computing: LNNs employ a fixed, randomly connected recurrent network (the reservoir) to project input signals into a higher-dimensional space, facilitating the capture of temporal patterns [5].

3.4 Advantages of Liquid Neural Networks

Temporal Dynamics: LNNs naturally handle time-series data and dynamic processes, making them well-suited for tasks such as speech recognition, event detection, and time-dependent predictions [6].

Energy Efficiency: Due to their dynamic nature, LNNs can be more energy-efficient than traditional neural networks, as they maintain a dynamic equilibrium rather than constantly recalculating static weights.

Biological Plausibility: By mimicking the brain's dynamic processing of information, LNNs provide insights into biological neural processes and can be used to study and model neural behavior.

3.5 Challenges and Future Directions

Training Complexity: Training LNNs can be challenging due to the complex dynamics of the reservoir. Researchers are exploring various approaches to optimize training and improve performance [7, 8].

Computational Resources: Although LNNs are theoretically efficient, simulating large-scale LNNs can be computationally intensive. Advances in neuromorphic hardware aim to address these challenges by providing specialized hardware for efficient LNN simulation [9].

4 Case Study

The study focused on the Sieve River basin, situated in the Tuscany region of Italy, with a drainage area of 822 km². The Sieve River, a tributary of the Arno River, extends for 56 km

through predominantly hilly and mountainous terrain. The climate in this basin is temperate and humid.

For this analysis, three months' worth of hourly data on discharge (Q), precipitation (R), and evapotranspiration (E) were available, covering December 1959 to February 1960 and comprising 2,160 data points. This dataset includes a variety of hydrological conditions, with flow rates spanning a wide range.

5 Result and Discussion

This document provides a detailed overview of the implementation of a Fluid Neural Network (FNN) for predicting rainfall-runoff processes. The aim is to forecast runoff for one, three, and six days ahead using historical data. The model leverages PyTorch for the neural network implementation and integrates a dynamic adjustment mechanism to optimize the number of active units in the fluid cells, enhancing its ability to handle varying input data complexity.

5.1 Data Preparation

The dataset includes various hydrological parameters such as precipitation, evapotranspiration, and river discharge. The features (inputs) and target variables (outputs) are extracted and normalized to ensure that all variables contribute equally to the model training process. StandardScaler from Scikit-Learn is used to standardize the features by removing the mean and scaling to unit variance.

5.2 Model Architecture

The core of this approach is the Fluid Neural Network, a variant of the LSTM (Long Short-Term Memory) network designed to dynamically adjust the number of active units based on the input variance. This fluid behavior optimizes the model's performance, especially for time-series data with varying temporal dependencies.

1. **Fluid LSTM Cell**: This cell dynamically adjusts the number of active units based on the variance of the input data. High variance input activates more units, allowing the model to capture complex patterns, while low variance input activates fewer units to prevent overfitting and reduce computational load.

2. **Fluid LSTM Network**: The network consists of multiple layers of Fluid LSTM cells. Each layer processes the sequential data and passes the hidden states to the next layer. Dropout is applied to prevent overfitting.

3. **Fully Connected Layer**: After processing through the Fluid LSTM layers, the final hidden state is passed to a fully connected (linear) layer that maps the high-dimensional output to the desired number of outputs, which in this case are the runoff predictions for one, three, and six days ahead.

5.3 Training the Model

The training process involves the following steps:

1. **Data Loader**: The training data is loaded in batches using PyTorch's DataLoader to facilitate efficient training and allow the use of GPUs for acceleration.

2. **Loss Function and Optimizer**: Mean Squared Error (MSE) is used as the loss function to measure the difference between the predicted and actual runoff values. The Adam optimizer is chosen for its efficiency in handling sparse gradients and adaptive learning rate.

3. **Training Loop**: The model is trained over several epochs. In each epoch, the model processes each batch of data, computes the loss, performs backpropagation to calculate gradients, and updates the model parameters using the optimizer. The average loss per epoch is monitored to track the training progress.

5.4 Model Evaluation and Predictions

After training, the model is evaluated on the test set to measure its performance. The test loss is computed to assess how well the model generalizes to unseen data. Additionally, the trained model is used to make predictions, which are then compared to actual runoff values to validate the model's accuracy.

5.5 Results

The Fluid Neural Network demonstrated superior performance in predicting runoff compared to traditional models, particularly for longer lead times. For the six-day prediction horizon, the model showed significant improvements in accuracy, attributed to its ability to dynamically adjust to the temporal dependencies in the data. Results are presented in Table 1.

6 Discussion and Conclusion

6.1 Discussion

The comparison of the models' performance across different prediction horizons (Day 1, Day 3, and Day 6) reveals significant insights into their efficiency and accuracy.

Artificial Neural Network (ANN):

For short-term predictions (Q_{+1}), ANN demonstrates reasonable accuracy with an RMSE of 5.175 m^3/s, an NRMSE of 0.106 m^3/s, and a COE of 0.9886.

However, as the prediction horizon extends to Q_{+3} and Q_{+6}, the performance of ANN deteriorates, with RMSE values increasing to 11.353 m^3/s and 19.402 m^3/s, respectively. Correspondingly, COE values decrease, indicating reduced model efficiency.

M5 Model tree:

The MT model exhibits superior performance compared to ANN for short-term predictions, with an RMSE of 3.612 m^3/s, an NRMSE of 0.074 m^3/s, and a COE of 0.9944 for Q_{+1}.

For Q_{+3}, the RMSE rises to 12.548 m³/s, and the COE drops to 0.9331, demonstrating a noticeable decline in performance for medium-term predictions.

For Q_{+6}, the RMSE further increases to 21.547 m³/s, and the COE falls to 0.8028, indicating significant prediction errors and reduced model reliability for long-term predictions.

Long Short-Term Memory (LSTM):

LSTM models outperform both ANN and MT across all prediction horizons. For Q_{+1}, the RMSE is 3.200 m³/s, the NRMSE is 0.066 m³/s, and the COE is 0.9952.

Even for medium-term (Q_{+3}) and long-term (Q_{+6}) predictions, LSTM maintains relatively lower RMSE values of 10.500 m³/s and 18.000 m³/s, and higher COE values of 0.9550 and 0.8600, respectively.

Liquid Neural Network (LNN):

The LNN model consistently exhibits the best performance across all metrics and prediction horizons. For Q_{+1}, it achieves an RMSE of 2.800 m³/s, an NRMSE of 0.058 m³/s, and a COE of 0.9960.

Table 1: Results

Prediction	ANN:			MT:			LSTM:			LNN:		
	RMSE (m³/s)	NRMSE (m³/s)	COE	RMSE (m³/s)	NRMSE (m³/s)	COE	RMSE (m³/s)	NRMSE (m³/s)	COE	RMSE (m³/s)	NRMSE (m³/s)	COE
Q_{+1}	5.175	0.106	0.9886	3.612	0.074	0.9944	3.2	0.066	0.9952	2.8	0.058	0.996
Q_{+3}	11.353	0.234	0.9452	12.548	0.258	0.9331	10.5	0.216	0.955	9.5	0.195	0.96
Q_{+6}	19.402	0.399	0.8401	21.547	0.443	0.8028	18	0.37	0.86	16	0.329	0.88

For Q_{+3}, the RMSE and NRMSE are 9.500 m³/s and 0.195 m³/s, respectively, with a COE of 0.9600, demonstrating its robustness in medium-term predictions.

For Q_{+6}, LNN maintains its superior performance with an RMSE of 16.000 m³/s, an NRMSE of 0.329 m³/s, and a COE of 0.8800, indicating its effectiveness even in long-term predictions.

6.2 Conclusion

The comparative analysis of the ANN, MT, LSTM, and LNN models reveals that the Liquid Neural Network (LNN) consistently outperforms the other models across all prediction horizons (Day 1, Day 3, and Day 6). LNN achieves the lowest RMSE and NRMSE values and the highest COE values, indicating its superior accuracy and efficiency.

While ANN and MT models demonstrate acceptable performance for short-term predictions, their accuracy significantly declines for medium- and long-term predictions. On the other hand, LSTM models show better resilience and maintain relatively lower error rates and higher efficiency than ANN and MT models. However, LNN models are the most reliable, providing robust predictions with minimal errors and high efficiency across all tested horizons.

In summary, the LNN model's superior performance across all metrics and prediction horizons underscores its potential as the most effective model for time series prediction tasks, particularly in scenarios where both short-term and long-term accuracies are critical.

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The governance of cultural landscapes in the EU: A Comparative Analysis of the Nature Restoration Law and the LULUCF Regulations

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Abstract

This paper explores how the EU's evolving climate regime complex impacts cultural landscapes, focusing on the Nature Restoration Law (NRL) and the revised LULUCF Regulation. Using Multi-Level Governance (MLG) and regime complex theory, it analyses how these policies, now legally binding, influence governance across multiple levels. Through case studies on the transformation of the Habitats Directive into the NRL and the 2023 LULUCF revision, the study highlights the decisive role of NGOs in integrating climate, biodiversity, and land-use goals. The findings underscore the ongoing challenges in balancing EU-wide directives with local adaptation needs.

Keywords

EU Climate Policy ; Nature Restoration Law (NRL) ; LULUCF Regulation : Cultural Landscapes : Multi-Level Governance (MLG) ; Regime Complex Theory ; Environmental Governance ; NGO Influence ; Biodiversity Conservation ; Sustainable Land Use

1 The change of EU climate policy instruments

In recent decades, the EU moved from climate policies that are more 'symbolic' to legally binding targets. At the European level at a range of institutions has developed to deal with climate policies. Today, these institutions oversee a large toolbox of policy instruments [1]. Knodt even identified three modes of European climate governance, ranging from hard to softer governance models [2].

Changes of this magnitude to EU climate policies naturally impact cultural landscapes in the Union. This contribution sheds light on how the changes to EU governance shaped two EU policies: the Nature Restoration Law (NRL) and the Land Use, Land Use-Change and Forestry (LULUCF) Regulation. These two pieces of legislation are chosen due to their relevance for cultural landscapes across the EU. The NRL can transform the European landscape anew, and certainly in combination with other measures [3]. The LULUCF Regulation not only impacts landscapes and forests in its name, but it also plays a crucial role in the overall timetable of the EU in achieving carbon neutrality [4], [5]. In the case of the NRL, the study specifically refers to the experiences learnt from the older Habitats Directive in the Netherlands. At the same time, the LULUCF is seen as more general in the context of alpine and boreal areas since it is a newer piece of EU legislation. The analytical framework for the analysis is provided by multi-level governance (MLG) theory and regime complex theory. These two frameworks are applied to the two case studies respectively. The contribution ends with a discussion of the findings.

2 The analytical framework: Combining multi-level governance and regime complex theories

The study's analytical framework is divided into a macro and level analysis. On the macro level, MLG deals with the distribution of authority across different levels of government—local, regional, national, and international—where multiple actors and institutions interact to shape policy outcomes. By applying MLG, the study explores how the interplay between various governance levels and overlapping regulatory regimes shapes the two case studies [6], [7]. On the meso level, regime complexes refer to the loosely connected sets of institutions and norms that govern overlapping issue areas in global governance. Unlike a single, cohesive regime, regime complexes are characterised by their fragmented and sometimes conflicting regulations. The concept of regime complexes allows for the better analysis of the role of NGOs as they advocate for specific norms, providing expertise, and mobilizing public opinion, often bridging gaps between different governance levels and regimes [8], [9]. This look at the meso level is necessary as environmental and climate policies display a significant amount of NGO activity [10].

3 Case Study I: The evolution of the EU Habitats Directive into the NRL

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3.1. Multi-Level Governance

The Habitats Directive (92/43/EEC), adopted in 1992, is a cornerstone of EU biodiversity policy, aiming to protect natural habitats and species across Europe. It created the Natura 2000 network, which includes protected areas that member states must manage to conserve habitats and species of European importance. The Directive operates within an MLG framework, requiring coordination between the European Commission, national governments, and local authorities. This necessitates collaboration across multiple levels of governance to ensure that conservation objectives are met while considering national and local contexts. The Habitats Directive is, in this regard, the extension of the global climate policy framework into EU environmental and climate policies [11]. The Directive operates within an MLG framework, requiring coordination between the European Commission, national governments, and local authorities. Over time, it became evident that the Habitats Directive, while foundational, had limitations in addressing emerging environmental challenges. These included habitat degradation outside Natura 2000 sites and the lack of integration with broader land use and agricultural policies.

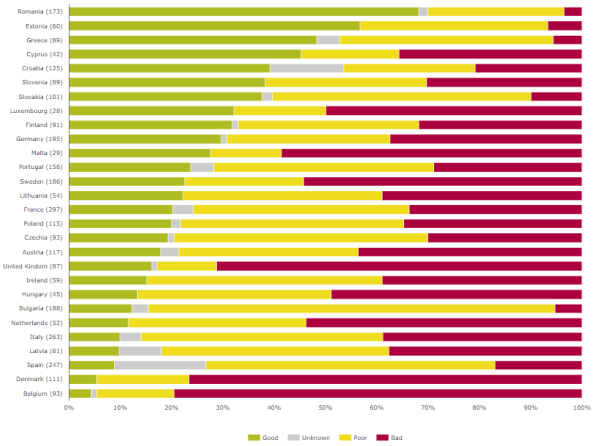

Figure 1: Conservation Status of habitats at Member State level, 2013-18 [12]

As the Figure 1 highlights, particular issues arose in the Low Countries. Especially the Netherlands faced significant issues with nitrogen emissions, largely due to intensive agriculture, which led to widespread habitat degradation. The crisis highlighted the inadequacies of the existing framework, where national policies were often misaligned with the original directive [13]. The Netherlands struggled to reconcile its intensive agricultural sector with the requirements of the Habitats Directive, leading to legal challenges and a halt in construction projects. In response, the Dutch government had to devise a comprehensive nitrogen reduction strategy involving collaboration across multiple governance levels, from local municipalities to the national government and EU institutions [14].

The NRL, proposed by the European Commission in 2022, can be seen as an evolution of the Habitats Directive, driven by the lessons learned from crises like that in the Netherlands. This new law aims to restore degraded ecosystems across the EU, with binding targets for habitat restoration beyond the protections offered by the Habitats Directive. The development of the NRL reflects an MLG approach, where the European Commission, influenced by member state experiences, proposed a more comprehensive framework. This framework integrates biodiversity restoration into broader land use and agricultural policies, addressing the gaps identified in the previous directive [15].

3.2. Regime Complexes

The regime complex surrounding the Habitats Directive is composed of various overlapping and interconnected regimes, including EU environmental policies (e.g., Habitats and Birds Directives), agricultural policies (e.g., Common Agricultural Policy), legal frameworks, and international biodiversity agreements (e.g., Convention on Biological Diversity).

In the Netherlands, NGOs were instrumental in bringing attention to the nitrogen crisis, particularly its impact on protected habitats under the Habitats Directive. Organisations such as Milieudefensie (Friends of the Earth Netherlands) and the Dutch Association for Nature Conservation (Natuurmonumenten) used legal avenues to challenge the Dutch government's failure to adequately address nitrogen pollution, leading to significant court rulings that halted construction projects and forced policy reconsiderations [16], [17], [18]. In response, the Dutch government revealed a plan to mitigate the impact of the consequences of the nitrogen crisis with the help of 24 billion EUR [19].

The persistent advocacy and legal actions by NGOs in the Netherlands were critical in demonstrating the limitations of the Habitats Directive in addressing complex, cross-sectoral environmental issues like nitrogen pollution. This helped build the case for more comprehensive legislation at the EU level. The Dutch experience provided a clear example how the NGOs could amplify the issues arising from the Habitats Directive, create public pressure and cause huge ramification for government and society. The leading to the proposal of the NRL. It sets ambitious quantitative targets in terms of both the areas to restore and the timeframe [20].

4 Case Study II: The impact of the EU Green Deal on the LULUCF Regulation

4.1. Multi-Level Governance

The LULUCF Regulation is primarily an EU-level policy designed to align with the EU's overall climate targets, including the European Green Deal and the Fit for 55 package, which aims to reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990. Member states are responsible for implementing the LULUCF Regulation. This requires each country to develop national forestry and land-use policies that align with the EU’s overarching goals. The 2023 revision introduced more stringent national accounting requirements, including higher carbon removal targets. The implementation at the regional and local levels involves managing forests, agricultural lands, and wetlands to maximise carbon sequestration while balancing economic and environmental

objectives. Local authorities and landowners are crucial in executing these policies, requiring close coordination with national governments.

In 2023, the LULUCF Regulation underwent a major revision to align it with the Green Deal targets. The new LULUCF Regulation introduced rigorous monitoring, reporting, and verification requirements (MRV). Member states must regularly report on their progress toward the targets, and the European Commission monitors compliance. It set binding targets for each member state regarding carbon removals in the LULUCF sector, and to ensure compliance, includes provisions for penalties and corrective actions if member states fail to meet their targets. [4], [5]. This creates a feedback loop where national actions are evaluated at the EU level. This marked a major shift in the vertical integration of LULUCF policies in the EU, including strengthening the compliance mechanism under the LULUCF Regulation by imposing a financial penalty of EUR 375 on Member States for each ton of CO2eq more than the annual national target in the given year after 2026.[21].

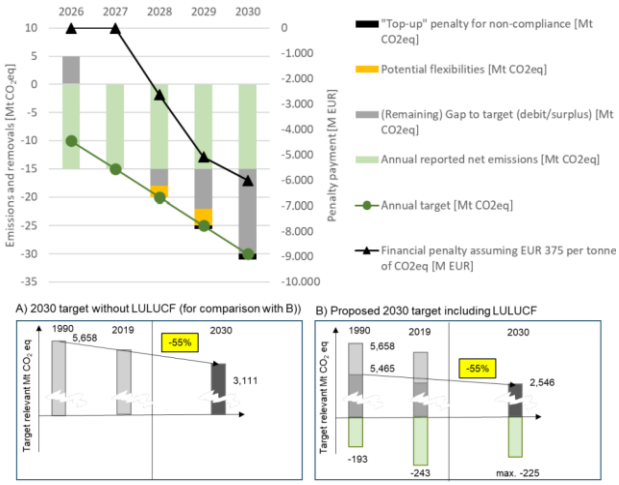

Figure 2: The newly introduced LULUCF compliance mechanism [21]

4.2. Regime Complexes

The LULUCF Regulation is situated at the intersection of several major international and EU regimes, including climate change (e.g., the Paris Agreement), biodiversity (e.g., the Convention on Biological Diversity), and agricultural policy (e.g., the Common Agricultural Policy - CAP). Each of these regimes has its objectives, norms, and governance structures, which sometimes overlap or conflict.

The 2023 revision of the LULUCF Regulation reflects efforts to harmonise these overlapping regimes. It seeks to integrate carbon sequestration goals with biodiversity conservation and sustainable land use, addressing the synergies and tensions between these regimes. NGOs have been instrumental in shaping the LULUCF Regulation by advocating for stronger links between climate and biodiversity regimes. NGOs often act as bridges between regimes, facilitating communication and coordination among different governance structures.

NGOs acted as norm entrepreneurs during the revision process by promoting the idea that land use should be managed for carbon sequestration and broader ecosystem services, including biodiversity and water regulation. This norm has been increasingly adopted within the LULUCF framework, particularly in the 2023 revision. The organizations lobbied for more stringent monitoring, reporting, and verification (MRV) processes to ensure that member states' contributions to carbon sequestration are transparent and verifiable. NGOs also pushed for accountability measures to address non-compliance, which were incorporated into the revised regulation. NGOs are crucial in monitoring the implementation of the LULUCF Regulation across the EU. Acting as watchdogs ensures that member states adhere to their commitments and that the interactions between different regimes remain aligned with overarching environmental goals. [22].

By acting across multiple regimes—climate, biodiversity, and agriculture—NGOs have helped to transform the LULUCF Regulation into a more comprehensive and coherent policy instrument.

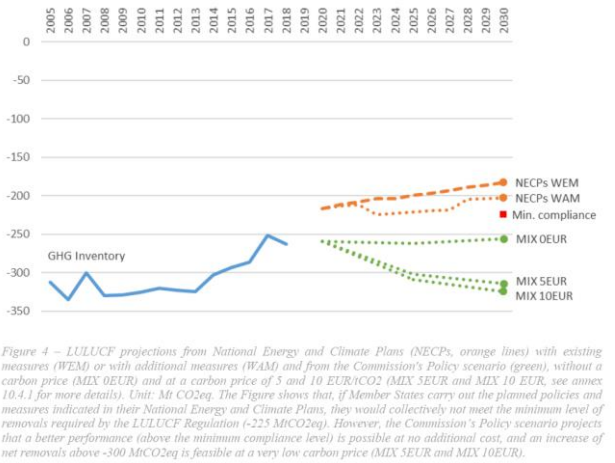

Figure 4 – LULUCF projections from National Energy and Climate Plans (NECPs, orange lines) with existing measures (WEM) or with additional measures (WAM) and from the Commission's Policy scenario (green), without a carbon price (MIX 0EUR) and at a carbon price of 5 and 10 EUR/tCO2 (MIX 5EUR and MIX 10 EUR, see annex 10.4.1 for more details). Unit: Mt CO2eq. The Figure shows that, if Member States carry out the planned policies and measures indicated in their National Energy and Climate Plans, they would collectively not meet the minimum level of removals required by the LULUCF Regulation (-225 MtCO2eq). However, the Commission's Policy scenario projects that a better performance (above the minimum compliance level) is possible at no additional cost, and an increase of net removals above -300 MtCO2eq is feasible at a very low carbon price (MIX 5EUR and MIX 10EUR).

Figure 3: Comparison of different LULUCF Projections [23]

5 Conclusion

The evolution of EU climate policy has shifted from symbolic measures to robust, legally binding targets, exemplified by the NRL and the 2023 revision of the LULUCF Regulation. These policies illustrate how the EU has strengthened its governance framework to address climate change, biodiversity, and land use challenges.

Using Multi-Level Governance (MLG) and regime complex theories, this study highlights the critical role of coordinated governance across multiple levels and the influence of NGOs. The NRL, shaped by the Dutch nitrogen crisis and the LULUCF Regulation, aligned with the European Green Deal, demonstrate how integrated approaches and NGO advocacy have transformed these policies into powerful tools for achieving EU climate and ecological goals. Yet, this transformation inherently curbed the ability of member states and local governments to shape their environmental and climate policies. Meanwhile, meta-studies highlight the necessity of adapting climate and environmental policies to local geography, regional preferences, and the needs of local communities [24].

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Resne napake v oceni toplogrednega učinka ozračja

Serious Errors in the Assessment of the Atmospheric Greenhouse Effect

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POVZETEK

Toplogredni učinek ozračja je osnovni proces na katerem Medvladni odbor za podnebne spremembe (*Intergovernmental Panel for Climate Change*, IPCC) v svojih poročilih (*Assessment Reports*, AR) analizira izhodiščno stanje in napoveduje pričakovane podnebne spremembe, ter njihove posledice. Po njihovih ugotovitvah je segrevanje ozračja, ki ga beležimo v zadnjih 150 letih pretežno posledica človekovih dejavnosti, predvsem izpustov toplogrednih plinov v ozračje. Na osnovi pričakovanih sprememb IPCC pripravlja priporočila vladam s katerimi ukrepi bi omilili podnebne spremembe in blažili njihove posledice, ter ustrezno prilagodili zakonodajo za uveljavljanje in izvajanje teh ukrepov, čemur so se s svojimi podpisi Pariškega sporazuma zavezale skoraj vse države članice Organizacije združenih narodov. Metodologija, ki jo uporablja IPCC za svoje analize in napovedi vsebuje vrsto napak. V tem prispevku se bomo omejili na nekaj resnih napak v oceni toplogrednega učinka v dokumentih IPCC, kar vzbuja močan dvom v pravilnost njihovih ugotovitev. Zaradi tega je človeški vpliv na podnebne spremembe in njihove pričakovane posledice močno precenjen, kar posledično zmanjšuje nujnost ukrepanja in sprejetja raznih predlaganih omejevalnih zakonov.

KLJUČNE BESEDE

Toplogredni učinek ozračja, podnebne spremembe, Stefan-Boltzmannov zakon, sevalno ravnovesje, povprečna globalna temperatura ozračja, vsebnost toplogrednih plinov.

ABSTRACT

The atmospheric greenhouse effect is the basis on which the Intergovernmental Panel for Climate Change (IPCC) in their Assessment Reports analyse the current climate and predict the expected climate changes and their consequences. In their estimate the atmospheric warming experienced during the last 150 years has been caused dominantly by human activities, mainly by greenhouse gases emissions. Following the expected changes the IPCC prepares recommendations to governments to mitigate the climate changes and reduce their consequences, as well as adapt their legislation to implement those measures in accordance with the Paris Agreement signed by almost all countries members of the United Nations Organization. The methodology used by the IPCC for their analyses and predictions contains a number of errors. Here we show only some serious errors in the way the greenhouse effect has been presented in the IPCC documents, which rises a strong doubt in the correctness of their analysis. Because of those errors the human influence on climate is overestimated, as are their expected consequences, therefore the relevance and the necessity to mitigate them is reduced, as well as the urgency to adopt the proposed restrictive legislation.

KEYWORDS

Atmospheric greenhouse effect, climate change, Stefan-Boltzmann law, radiative balance, average global air temperature, concentration of greenhouse gases.

1 Uvod v fizikalno ozadje

Termodinamika je področje fizike, ki opisuje procese prenosa toplote med obravnavanimi telesi in njeni zakoni veljajo tako na molekularni kot na makroskopski ravni. Toplotna energija se manifestira v elektromagnetih interakcijah med obravnavanimi telesi, kar pomeni, da obstajajo tesne povezave med notranjo energijo teles (v obliki kinetične energije, ki se izmenjuje ob trkih, ali pa kot lastne oscilacije in resonance zaradi vezalne energije med posameznimi atomi), ter absorbiranim ali emitiranim elektromagnetnim sevanjem, katerega energija (oziroma pripadajoča frekvenca) mora ustrezati določenemu molekularnemu rotacijsko-vibracijskemu kvantnemu stanju.

Za lažje razumevanje termodinamičnih procesov v ozračju je pomembno imeti v mislih dve spoznanji. Prvo je, da je energija fotonov (kvantov elektromagnetnega sevanja) kvantizirana in ustreza produktu Planckove konstante h in frekvence v:

$$E = hv \tag{1}$$

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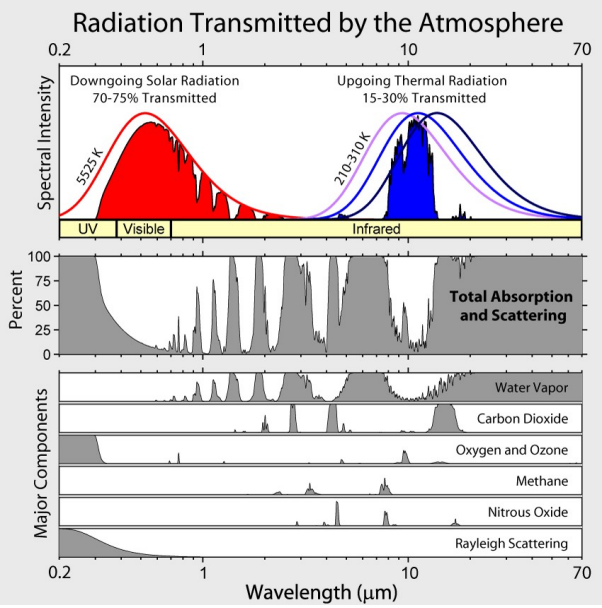
Pri tem lahko molekula lahko absorbira sevanje na ustrezni frekvenci le, če pripadajoče kvantno stanje ni zasedeno. Absorbirano energijo pa molekula čez čas spontano emitira spet v obliki fotona z enako frekvenco, če pred tem ni bila izpostavljena drugim interakcijam.

Za absorpcijo je tudi pomembna nesimetrična oblika molekule, ker s tem zunanjemu polju izkazuje električni dipolni moment. Dvoatomske molekule v ozračju (N_2, O_2) so vedno simetrične in zato nimajo nizko-energijskih interakcij s sevanjem. Drugače pa je s triatomskimi molekulami. Na pr., pri vodni molekuli, H_2O, tvorita atoma vodika glede na atom kisika kot 105°, zato je polje molekularnega naboja elektronskih orbital nesimetrično. Molekula ogljikovega dioksida, CO_2, pa ima simetrično obliko, atoma kisika tvorita z atomom ogljika dvojne vezi pod kotom 180°: O=C=O. Zato molekula CO_2 v osnovnem energijskem stanju nima dipolnega momenta in ne prihaja do interakcije s sevanjem. Po trku z neko drugo molekulo v ozračju pa se lahko del kinetične energije porazdeli med obe molekuli in se zaradi tega lahko vzbudi ena od možnih nihalnih in rotacijskih resonanc, odvisno od razpoložljive količine energije ob trku. Zaradi nihanja kisikovih atomov glede na ogljikov atom dobi molekula CO_2 za kratek čas nesimetrično obliko in nek določen dipolni moment in lahko absorbira foton ustrezne frekvence.

Na splošno imajo triatomske molekule več načinov nihanja, zato tudi več različnih resonančnih frekvenc, ki tvorijo karakteristični spekter posamezne molekule. V odvisnosti od rotacijskih osi pa resonance preidejo v ožji ali širši frekvenčni pas v okolici resonančne frekvence. Zato lahko te molekule zajamejo ali oddajo fotone z malenkostno drugačno frekvenco od osnovne. **Slika 1** prikazuje spektre molekul, ki jih vsebuje ozračje v različnih koncentracijah, v primerjavi s sevalnim spektrom sončevega in zemeljskega sevanja.



Slika 1: Absorpcijski spektri posameznih molekul v ozračju v primerjavi s sončnim in zemeljskim sevalnim spektrom.

Slika 1 je morda nekoliko zavajajoča, ker so spektri prikazani v odvisnosti od valovne dolžine. Energija sevanja pa je sorazmerna frekvenci in obratno sorazmerna valovni dolžini. Poleg tega pa je lestvica valovnih dolžin logaritemska, zato zgleda, kot da dolge valovne dolžine (nizke frekvence) nosijo več energije, v resnici pa je ravno obratno. Težava pa je tudi v tem, da so vsi prikazani spektri normirani na svoje maksimume, ki predstavljajo 100% učinka pri vrhu posameznega območja valovnih dolžin. Zato je primerjava učinkov med molekulami nekoliko otežena. Tretja težava pa nastopi zaradi različnih koncentracij molekul v ozračju, saj je verjetnost zajetja fotona odvisna tudi od koncentracije. Vse to je treba imeti v mislih kadar primerjamo posamezne spektre.

Poseben primer predstavlja vodna para, saj se posamezne molekule vode lahko povezujejo v različno velike aglomerate, od dveh molekul pa do makroskopskih kapljic. Posledično ima vodna para mnogo širši spekter in veliko število resonanc, mnogo večje od osnovnih šest za posamezno vodno molekulo.

Molekule CO_2 pa se med seboj ne povezujejo, ima pa ta molekula štiri izrazite resonance in sicer pri 1,9 μm, 2,8 μm, 4,2 μm, ter 15 μm. Prve tri se nahajajo v območju kjer je tako sončevo kot zemeljsko sevanje majhno, pa še delno se prekrivajo s spektrom vodne pare, katere koncentracija v nižjih plasteh ozračja je od 25 do 100 krat večja, zato je tam učinek CO_2 na segrevanje ozračja majhen. Dominanten učinek CO_2 je pri resonanci v območju okoli 15 μm, ki je tudi delno prekrito s spektrom vodne pare.

Drugo pomembno spoznanje za razumevanje termodinamičnih procesov je v verjetnosti zajetja ali izsevanja fotonov in pogostosti trkov med posameznimi molekulami.

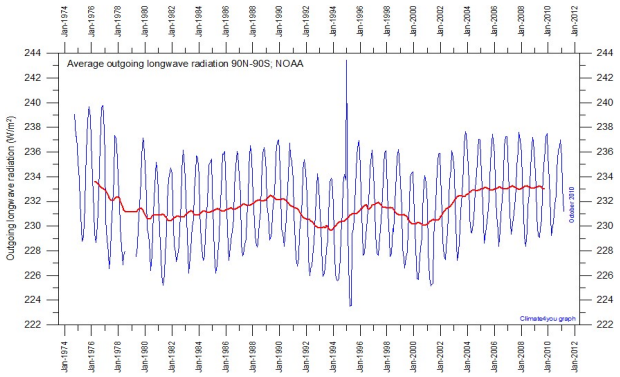
Če neka molekula zajame foton, ne more več zajeti drugega z enako frekvenco dokler se bodisi spontano ne znebi presežka energije z izsevanjem fotona z enako frekvenco, bodisi pa trči z neko drugo molekulo in se celotna energija obeh molekul porazdeli drugače, zaradi česar se prejšnje resonančno kvantno stanje sprosti. S tem pa tudi energija zajetega fotona preide v kinetično energijo molekul, kar pomeni povečano temperaturo ozračja, ponovna emisija fotona z enako frekvenco pa ni več možna. Tako zajeta energija ostane v ozračju dalj časa, saj se kinetična energija teh dveh molekul z nadaljnjimi trki porazdeli na vedno večje število molekul, nazadnje pa uide v vesolje kot sevanje pri valovnih dolžinah daljših od 50 μm.

Če pa molekula zajame foton in ga kmalu zatem spet odda, se v ozračju ni spremenilo nič bistvenega, le energija je na svoji poti proti vesolju imela zamudo za delček sekunde.

Ozračje ni enakomerno gosto, saj gostota pada z nadmorsko višino, prav tako tudi pritisk in temperatura, zato je verjetnost da pride do trka z drugo molekulo zelo velika v spodnjih plasteh ozračja, z višino pa se verjetnost trka zmanjšuje. Zaradi tega je tudi verjetnost zajetja in oddaje fotona v spodnjih plasteh ozračja majhna, toplotna energija se prenaša pretežno s trki in premikanjem zraka. V bližini tal je povprečna prosta pot fotona v območju IR sevanja okoli 22 m. Pri svetlobni hitrosti to pomeni povprečno življenjsko dobo okoli 65 ns.

Po drugi strni pa je povprečna hitrost molekul enaka zvočni hitrosti, okoli 340 m/s. Pri normalni gostoti zraka 1,2 kg/m^3, ter povprečni molarni masi 28,8 vsebuje en kubični meter zraka okoli $2{,}5\times10^{25}$ molekul, katerih povprečna razdalja znaša okoli 10^{-8} m in je povprečni čas med trki 3×10^{-11} s. To pomeni, da molekule le redko zajamejo foton, saj jih pri tem moti velika pogostost medsebojnih trkov. Teoretično izračunana verjetnost, da molekula odda odvečno energijo s sevanjem in ne s trkom je okoli 4%. Torej se toplotna energija v nizkih plasteh ozračja prenaša pretežno z molekularnimi trki.

Z višino se gostota zraka zmanjšuje, tudi pritisk in temperatura (hitrost, oziroma kinetična energija molekul), kar pomeni, da se postopoma povečuje verjetnost da molekula zajame foton, prav tako pa, da foton odda pred trkom z drugo molekulo. Približno na polovici gostote ozračja, to je na višini okoli 5,6 km, so razmere takšne, da je verjetnost spontane oddaje fotona približno enaka verjetnosti trka s drugo molekulo. Tam je povprečna prosta pot fotonov že okoli 2 km, kar pomeni da od tam fotoni lahko hitro uidejo izven ozračja. Zato s te višine tudi zaznamo največje število fotonov, oziroma največjo sevalno gostoto moči, kar merimo s sateliti kot sevanje Zemlje, **Slika 2**. To sevanje ima gostoto moči od okoli 232 W/m^2, temu pa po Stefan-Boltzmannovem zakonu ustreza absolutna temperatura okoli 253 K (ali −20°C), kot bomo videli v nadaljevanju.



Slika 2: Satelitske meritve gostote moči povprečnega dolgovalovnega izstopnega sevanja Zemlje med letoma 1974 in 2012. Sezonska nihanja so znatna, v dolgoročnem povprečju pa ni trenda. Vir podatki: NOAA, po <http://climate4you.com>.

Z opisanim smo si ustvarili sliko, ki bo osnova za razumevanje problema učinka tople grede.

2 Toplogredni učinek ozračja

Običajno se kot idejni oče toplogrednega učinka ozračja navaja francoski matematik *Jean Baptiste Joseph de Fourier* (1768 – 1830). Kot topniški general v Napoleonovi vojski se je zanimal za izboljšanje natančnosti streljanja s topovi in zato tudi za vpliv temperature na širjenje materiala. Kasneje pa je svoje raziskave razširil še na druge materiale in pojave. Tako je med drugim pri opisu toplogrednega učinka zapisal [1]:

»*... če preprečimo segretemu zraku, da se dviga in širi, ...*«

Potem pa v nadaljevanju:

»*Hkrati lahko opazimo zmanjšanje zajete stopnje toplote nad površino zemlje. Hitro gibanje zraka v vseh smereh, ki se tudi dviguje kadar se segreje, ter infra-rdeče sevanje v zraku, bosta zmanjšali intenziteto učinka, ki sicer nastane pod prozorno in gosto atmosfero, vendar to ne bo povsem izničilo tega učinka.*«

Iz tega je očitno, da je Fourieru bilo povsem jasno, da v odprtem ozračju toplogredni učinek ne more biti enako močan, kot je denimo pod steklenim pokrovom zaprte posode. Žal so kasneje drugi raziskovalci (*J. Tyndall*, *S. Arrhenius*, in drugi) to njegovo sporočilo nekako spregledali.

Tako danes obravnavamo toplogredni učinek ozračja kot posledico zakona o ohranitvi energije, ter temu primernega sevalnega ravnovesja [2]: vstopno sončno sevanje, zmanjšano za delež, ki se odbija z vrhov oblakov in poledenelih površin, ter nekaj malega z ostalih površin, segreva površje, to pa potem segreva ozračje, ozračje pa potem seva proti vesolju. Dolgoročno povprečje vstopnega in izstopnega sevanja mora biti enako, razlika nastane lahko le zaradi slabše prepustnosti ozračja za sevanje, pri čemur se temperatura spreminja dokler se ne vzpostavi novo ravnovesje.

Sončno sevanje, izmerjeno s sateliti v zemeljski orbiti znaša povprečno $S_0 = 1361$ W/m^2, kar imenujemo solarna konstanta, pa čeprav ni povsem konstanta. Zaradi sončeve aktivnosti se osončenost Zemlje spreminja v približno 11-letnih ciklih za okoli 0,2% (rekonstrukcija sončne aktivnosti zadnjih 400 let na podlagi sprememb koncentracije radioizotopov ^{14}C in ^{10}Be se zelo dobro ujema z zabeleženim številom sončnih peg); zaradi ekscentričnosti zemeljske orbite se spreminja za okoli 1,7%; zaradi premikanja težišča sončnega sistema glede na Sonce se spreminja za okoli 1%. Skupno znaša velikost sprememb blizu 3%, vendar se običajno domneva, da se vpliv večjih dveh sprememb v teku leta izravna. To pa ne drži povsem, saj je sprememba težišča odvisna predvsem od velikih planetov (Jupiter, Saturn), njuni orbitalni periodi pa se ne ujemata časovno z zemeljskim letom, posledično je ta vpliv s periodo 62 let odvisen od trenutne nagnjenosti Zemeljske rotacijske osi, saj južna polobla ima mnogo več oceanov kot severna, oceani pa veliko bolj absorbirajo toploto kot kopno.

Zato je neposreden vpliv spremembe v osončenosti na globalno povprečno temperaturo najbrž majhen, pa čeprav imamo zgodovinske dokaze, da nekakšen vpliv vendarle obstaja (srednjeveško toplo obdobje, mala ledena doba, predvsem pa Maunderjev in Daltonov minimum sončne aktivnosti se dobro ujemajo z zgodovinskimi podatki o lokalni klimi v Evropi).

Obstaja pa verjetnost, da Sonce vpliva na Zemljo posredno prek sprememb v sončevem magnetnem polju. Ob večji sončni aktivnosti je magnetno polje močnejše in bolj odklanja visokoenergetske kozmične delce, zaradi česar je v zemeljskem ozračju manj ionov in manj kondenzacijskih jeder okoli katerih se oblikujejo večje vodne kapljice oblakov. To teorijo zastopajo nekateri znani fiziki (*H. Svensmark*, Nobelovec *J. Clauser*, in drugi). Dejstvo je, da že zgolj 2% spremembe v oblačnosti ima podoben učinek kot učinek celotne količine CO_2 v ozračju (ne le človeškega deleža). Vendar ti vplivi niso tema tega članka in se z njimi tu ne bomo ukvarjali.

Kar pa nas tu zanima je način izračuna globalne povprečne temperature Zemlje. Zakonitost med sevanjem in temperaturo idealnega črnega telesa je prvi odkril fizik slovenskega rodu *Jožef Stefan* (1835 – 1893); ugotovil je, da je površinska gostota sevalne moči j^* sorazmerna četrti potenci absolutne temperature T (v Kelvinih), pomnoženi s Stefanovo konstanto σ:

$$j^* = \sigma T^4 \tag{2}$$

Pri tem je $\sigma = 5{,}67\times10^{-8}$ $\mathrm{Wm^{-2}K^{-4}}$, kar je bilo sprva empirično določeno, kasneje pa je Stefanov učenec in sodelavec *Ludwig Boltzmann* (1844 – 1906) izpeljal to konstanto teoretično iz drugih osnovnih fizikalnih konstant:

$$\sigma = 2\pi^5 k^4/(15c^2h^3) \tag{3}$$

kjer je Boltzmannova konstanta $k = 1{,}38\times10^{-24}$ Ws/K, svetlobna hitrost v vakuumu $c = 299792458$ m/s in Planckova konstanta $h = 6{,}626\times10^{-34}$ Ws/Hz.

Izraz (2) je zato znan kot Stefan-Boltzmannov zakon sevanja. Pripomniti je treba, da ta zakon velja za idealno črno telo segreto na temperaturo T, kar modeliramo kot sevanje majhne odprtine v veliki kavitaciji v termodinamičnem ravnovesju, tako da lahko izgubo energije skozi odprtino lahko zanemarimo. *Johann Heinrich Lambert* (1728 – 1777) je že leta 1760 ugotovil, da je gostota sevanja odvisna od kosinusa kota glede na normalo na določen površinski odsek, kar pomeni, da je sevanje maksimalno v smeri navpično na površino in nič v smeri vzporedno s površino. To je pomembno, ker sevanje po Stefan-Boltzmannovem zakonu računamo v pol-krogelnem prostorskem kotu 2π steradiana, za razliko od Planckovega zakona sevanja, ki ga ponavadi normiramo na kot enega steradiana. Dejansko je Stefan-Boltzmannov zakon integral Planckovega zakona po vseh možnih frekvencah. Planckov zakon nam podaja spektralno odvisnost sevanja (kot na **Sliki 1**).

Obrazec (2) nam omogoča izračun efektivnega sevanja zemeljskega površja, saj temperaturo lahko izračunamo iz povprečja meritev vseh svetovnih meteoroloških postaj v daljšem časovnem obdobju (Mednarodna meteorološka organizacija definira klimo kot povprečje vremena za najmanj 30 let). To povprečje znaša okoli 15°C, oziroma 288 K (kar je sicer zgolj statistični konstrukt, vendar sledimo metodi IPCC). Torej bo površinska gostota sevalne moči:

$$j^* = 5{,}67\times10^{-8} \times 288^4 = 390 \text{ W/m}^2 \tag{4}$$

Ta vrednost se močno razlikuje od vrednosti izmerjene s sateliti (**Slika 2**), kar pomeni, da se v ozračju del energije porabi za druge procese.

Če pa želimo določiti sevalno ravnovesje planeta, moramo upoštevati, da se del sončevega sevanja prav tako izgubi na svoji poti do tal. Znaten del sevanja se odbije od vrhnjih plasti oblakov in poledenelih površin (te imajo visoko odbojnost, *albedo*, za širok frekvenčni pas sončevega spektra), del pa se absorbira v ozračju (aerosoli, vodna para, itd.). Ocenjena povprečna vrednost albeda je 30%, oziroma $\alpha = 0{,}3$.

Poleg tega pa se del sevanja izgubi zaradi manjše emisivnosti tal. Vendar se za emisivnost večine snovi pri običajnih temperaturah jemlje vrednost med 0,95 in 1, zato naj bi ta vpliv bil majhen in se običajno ne upošteva (kar pa ni prav, saj je emisivnost odvisna tudi od razlike temperatur sosednih snovi).

Dnevna osončenost tal pa je seveda odvisna tudi od geometrije, saj imamo opravka s krogelno simetrijo planeta. Za kroglo pa je po Lambertu potrebno upoštevati kot sevanja v smeri sever-jug in vzhod-zahod, zato bomo imeli kvadrat kosinusa vpadnega kota. Če funkcijo $\cos^2\theta$ integriramo v pol-krogelnem območju kotov med ±90°, dobimo rezultat ½. Druga polkrogla planeta pa je v temi, zato imamo dodaten faktor ½. Skupno torej v dolgoročnem povprečju celotno površje Zemlje dobi ¼ sončevega sevanja, zmanjšanega za albedo. Za vstopno sevanje torej velja naslednja enačba:

$$j^* = S_0(1-\alpha)/4 \tag{5}$$

Ker pa mora veljati zakon o ohranitvi energije, lahko izraza (2) in (5) izenačimo in iz tega izračunamo teoretično povprečno temperaturo planeta:

$$T = [S_0(1-\alpha)/4\sigma]^{1/4} \tag{6}$$

Ko vstavimo ustrezne številke, dobimo $T = 255$ K, ali −18°C. To pa je zelo blizu vrednosti izmerjene s sateliti za sevalno območje na nadmorski višini 5,6 km, kjer smo ob **Sliki 2** izračunali −20°C. Lahko rečemo da gre le za višinsko razliko okoli 300m.

Iz tega pa pri IPCC izvlečejo naslednji (vprašljiv!) sklep: če je temperatura tal 288 K in sevalna temperatura planeta 255 K pomeni, da mora biti toplogredni učinek ozračja 33 K. Iz tega potem sledi, da mora biti klimatska občutljivost na vsebnost toplogrednih plinov zelo velika. Za to občutljivost (znano kot *equilibrium climate sensitivity*, ECS) ocenjujejo, da mora biti najverjetneje v območju med 2 in 5°C za vsako podvojitev koncentracije toplogrednih plinov.

Vendar pa laboratorijske meritve optične prepustnosti CO_2 v okolici dominantne resonance 15 μm valovne dolžine kažejo na le 1,1°C za vsako podvojitev koncentracije CO_2. Gre za logaritmično zakonitost, ki je bila empirično določena in ustreza relaciji $\Delta F = 5{,}35 \ln(C/C_0)$, kjer je ΔF sevalno »siljenje« (*forcing*, kar je pomanjkljivo imenovano, saj znak Δ pomeni spremembo), ln pa je naravni logaritem (po bazi e = 2,71828…) razmerja med novo koncentracijo C in začetno koncentracijo C_0; za podvojitev koncentracije pa velja $C/C_0 = 2$, torej bo:

$$\Delta F = 5{,}35 \ln(2) = 5{,}35 \times 0.693 = 3{,}7 \text{ W/m}^2 \tag{7}$$

Posledično za spremembo temperature velja relacija:

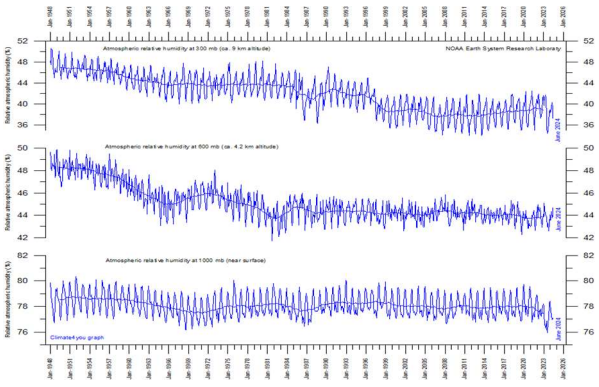
$$\Delta T_\mathrm{p} = \Delta F\{T_\mathrm{p}/[S_0(1-\alpha)]\} \tag{8}$$

kjer je temperatura površja $T_\mathrm{p} = 288$ K. Zato je sprememba temperature za podvojitev koncentracije CO_2 enaka le 1,1°C.

Ker se vrednosti za območje ECS ne ujemajo s ΔT_p, si pri IPCC pomagajo z domnevo o obstoju pozitivne povratne zanke prek

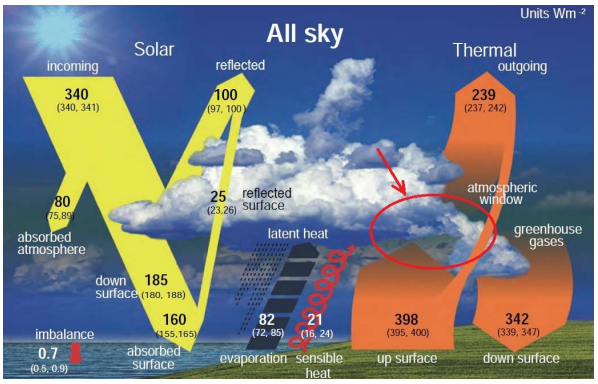
vodne pare, ki naj bi ojačala učinek CO_2 za približni faktor 3×. Razlaga gre nekako takole: ozračje, segreto zaradi povečanja vsebnosti CO_2, lahko sprejme več vlage (7% več za vsako 1°C po Clausius-Clapeyronovi relaciji), zato se zrak še bolj segreje, ter lahko sprejme še več vlage, in tako v krog, dokler se ne vzpostavi novo sevalno ravnovesje.

Vendar meritve zračne vlažnosti (relativne in absolutne) ne potrjujejo te domneve, kot je razvidno na **Sliki 3**, na kar je leta 2023 opozoril tudi Nobelovec John Clauser, pa je takoj doživel hude kritike z vseh strani, a povsem neupravičeno.



Slika 3: Satelitske meritve zračne vlažnosti na različnih višinah med januarjem 1948 in junijem 2024. Vir podatkov NOAA, povzeto po <http://climate4you.com>.

Na podlagi vseh predstavljenih formul so pri IPCC konstruirali sicer dokaj zapleten fizikalni model procesov v ozračju, kar pa zelo poenostavljeno prikazuje **Slika 4**:



Slika 4: Pretoki sevalne moči v zemeljskem ozračju. Številke predstavljajo gostote sevalnih moči posameznih procesov v enotah W/m^2. Vendar v območju označenem z rdečo elipso manjka pomemben podatek! Vir: IPCC AR6 [3].

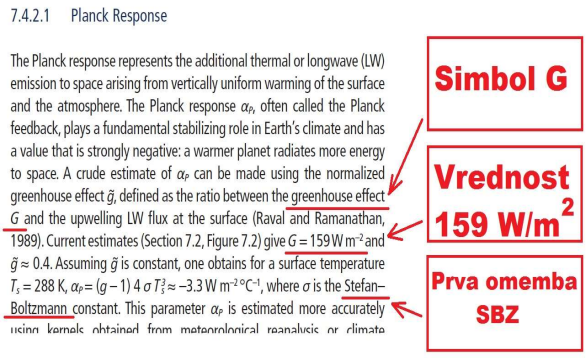
Parametre modela določa 12 števil (v oklepajih so navedene meje območja zanesljivosti), pri čemur vpadno kratkovalovno sončno sevanje na levi in izstopno dolgovalovno zemeljsko sevanje na desni približno ustrezata prej izračunanim številkam: četrtina sončnega sevanja (1361/4 = 340,25 W/m^2) zmanjšana za albedo, ter nekaj absorpcije v ozračju, segreva tla s kakšnih 160 W/m^2, zemeljsko površje izseva okoli 398 W/m^2 (mi smo izračunali 390), ozračje pa izseva kakšnih 239 W/m^2 v vesolje (sateliti sicer izmerijo le 232 W/m^2).

Dopustimo lahko, da senzorji satelitov ne zajemajo celotnega frekvenčnega območja, zato lahko nastopi znatna razlika med 232 W/m^2 na **Sliki 2** in 239 W/m^2 na **Sliki 4**. Precej nelogično pa se zdi, da se v sistemu pretaka veliko več energije kot v sistem vstopa in izstopa, saj zgleda kakor da bi hladno osrednje ozračje, ki je pri −18°C, z dobrimi 342 W/m^2 dodatno segrevalo tla, ki so na +15°C, pa čeprav efektivni pretok navzgor ustreza razliki med 398 in 342 W/m^2. Matematično se sicer številke ujemajo, toda fizikalno je nesmiselno, če sistem, ki naj bi bil v termodinamičnem ravnovesju z okolico, vsebuje precej več energije kot vanj priteka in odteka. To nakazuje, da z načinom izračuna, oziroma ocenami posameznih parametrov sistema, kot jih privzema IPCC, mora biti nekaj hudo narobe.

Vendar to ni edina težava. V **Sliki 4** na mestu označenem z rdečo elipso manjka trinajsti (nesrečni?) podatek. Označba *greenhouse gases*, oziroma toplogredni plini sicer naznanja, da se tam dogaja nekaj pomembnega in da ti plini sevajo nazaj proti tlom 342 W/m^2, ni pa podatka o razliki med sevanjem tal in sevanjem višjih plasteh ozračja proti vesolju, kar je dejansko **definicija toplogrednega učinka**!

Seveda to lahko izračuna vsakdo sam iz podatkov na **Sliki 4**: 398 − 239 = 159 W/m^2. Vendar te oznake v grafu ni, ker bi se kdo spraševal kako lahko 398 + 80 − 342 = 136 W/m^2 ustreza 159 W/m^2 ? Ker se namreč tistih 82 in 21 W/m^2 v resnici porabi za mehansko delo, transport toplega in vlažnega zraka navzgor.

Nekakšno razlago vendarle najdemo v besedilu poročila IPCC AR6 in sicer v poglavju 7.4.2.1 Planck Response, **Slika 5**:



Slika 5: Iz poročila IPCC AR6, leta 2021; vir [4].

Kot opozarja prof. *Howard Hayden* [4], je to prvič po več kot 30 letih delovanja IPCC, da so toplogrednemu učinku dali simbol G, mu določili vrednost, $G = 159$ W/m^2, ter prvič eksplicitno omenili Stefan-Boltzmannov zakon!

Pa poglejmo kako se izide izračun sevalnega ravnovesja. Ta določa, da mora biti izstopno sevanje zemlje, j_Z, enako vstopnemu sončnemu sevanju j_S:

$$j_Z = j_S \tag{9}$$

Hkrati pa mora biti izstopno sevanje j_Z enako razliki med sevanjem površine tal j_P, in toplogrednim učinkom G:

$$j_Z = j_P - G \tag{10}$$

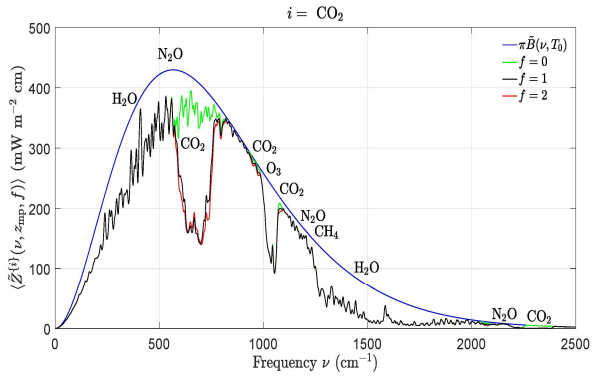
Iz (9) in (10) sledi, da mora biti tudi vstopno sončevo sevanje enako razliki med sevanjem tal in toplogrednim učinkom:

$$j_S = j_P - G \tag{11}$$

To pa si lahko predstavimo tudi grafično s Planckovimi spektri. Planckov spekter sevanja tal je mogoče teoretično izračunati s pomočjo Planckove relacije za odvisnost od valovne dolžine, kjer namesto frekvence uporabimo $\lambda = c/\nu$:

$$j_P(\lambda,T) = (2hc^2\lambda^{-5}) / (e^{hc/\lambda kT} - 1) \tag{12}$$

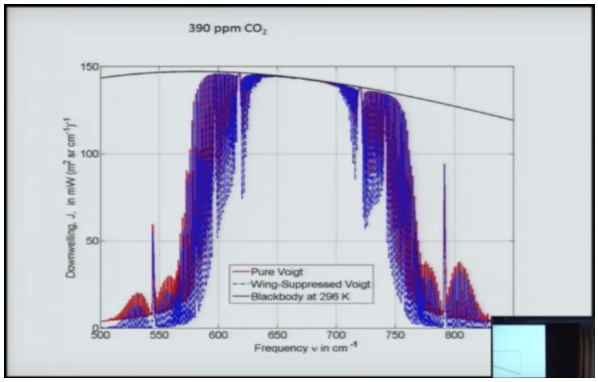
Povprečno globalno temperaturo tal smo že določili: $T = 288$ K. Za valovne dolžine pa vzamemo območje med 1 in 100 µm, kar je območje znotraj katerega je sevalni maksimum za to temperaturo (pri okoli 10 µm). Dovolj dobro ločljivost dobimo, če za korak pri valovnih dolžinah vzamemo $d\lambda = 0{,}1$ µm. Potem spektralna funkcija zgleda kot modra krivulja na **Sliki 6**:



Slika 6: Spekter sevanja tal (modra krivulja) za temperaturo $T = 288$ K po enačbi (12), v primerjavi s spektralno absorpcijo ozračja: črna krivulja je skupni spekter plinov ob sedanji vsebnosti CO_2, zelena krivulja je za primer brez CO_2, rdeča krivulja pa predstavlja učinek podvojitve vsebnosti CO_2. Na horizontalni osi je prostorska frekvenca v številu valov na cm.

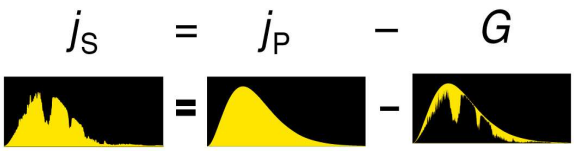
Spekter izstopnega sevanja planeta pa je mogoče bodisi izmeriti s sateliti, bodisi izračunati na podlagi empiričnih podatkov za posamezne pline v ozračju, ki so zbranih v podatkovni zbirki HITRAN, kot sta to naredila van Wijngaarden in Happer [5]. Črna krivulja na **Sliki 6** iz njihove študije velja za sedanjo vsebnost CO_2 v ozračju. Površina pod posamezno krivuljo je enaka izračunanim gostotam sevalne moči za sevalne gostote iz enačbe (11).

Iz **Slike 6** je razvidno, da podvojitev današnje koncentracije CO_2 ne bo privedla do večjih sprememb globalne povprečne temperature, saj je razlika med rdečo in črno krivuljo zelo majhna, znaša manj kot 2% celotnega absorbiranega sevanja v okolici dominantne resonance CO_2, ki je pri 15 µm, oziroma v okolici 666 valov na cm na horizontalni lestvici. To je posledica dejstva, da je spekter CO_2 že pri sedanji koncentraciji nasičen, ker preprosto ni več fotonov, ki bi jih lahko pri povečani koncentraciji zajel. To je razvidno na bolj podrobnem prikazu spektra na **Sliki 7**, kjer je vrh ostro omejen z gostoto sevanja tal, oscilacije pa so prisotne le na robovih spektra. Pri podvojeni koncentraciji bi se povečala le strmina robov, ker je pač absorpcijska energija kvantizirana z jakostjo medatomskih vezi CO_2, in spekter nima možnosti, da bi se še bolj razširil.



Slika 7: Podrobnejši prikaz spektra CO_2 v območju okoli dominantne resonance pri 15 µm, oziroma 666 valov na cm.

Vendar pa imamo še en pomembnejši dokaz, da so pri IPCC napačno ocenili učinek toplogrednih plinov. S pomočjo Slike 6 in enačbe (11) lahko to nazorno pokažemo.



Slika 8: Prikaz enačbe (11) v grafični obliki.

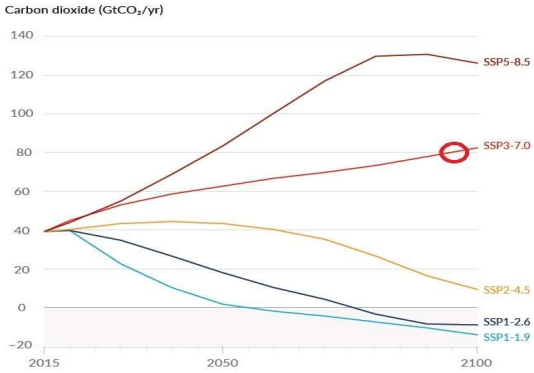
Ker se vstopno sončevo sevanje j_S skoraj konstantno, se tudi izstopno sevanje j_Z dolgoročno ne spreminja s koncentracijo CO_2 (kot potrjuje tudi **Slika 2**). To pomeni, da mora biti sprememba G natančno enaka spremembi sevanja površine, j_P. Za podvojitev koncentracije CO_2 smo že z enačbo (7) izračunali spremembo gostote sevalne moči, ta prispeva 3,7 W/m^2. Za toliko bi se v teh okoliščinah povečal tudi toplogredni učinek G.

Vendar pri IPCC podajajo drugačno oceno, pravzaprav več različnih ocen odvisno od posameznega scenarija znižanja izpustov toplogrednih plinov. Ti scenariji se v AR6 imenujejo *Shared Socio-economic Pathways*, SSP. Vsakemu SSP scenariju so dodelili drugačno stopnjo znižanja izpustov, učinek pa so potem označili z dvema številoma, prvo število pomeni predvideni porast temperature, drugo število pa je pripadajoče povečanje gostote sevalne moči.

Za zgled vzemimo SSP3-7.0, (**Slika 9** in **Slika 10**) ki v AR6 predstavlja primer, ko bi se izpusti še naprej povečevali po sedanji stopnji in za njihovo zmanjševanje ne bi naredili ničesar (temu scenariju pravijo *Business As Usual*). Predvidevajo da bi se v tem primeru količina izpustov CO_2 podvojila leta 2095.

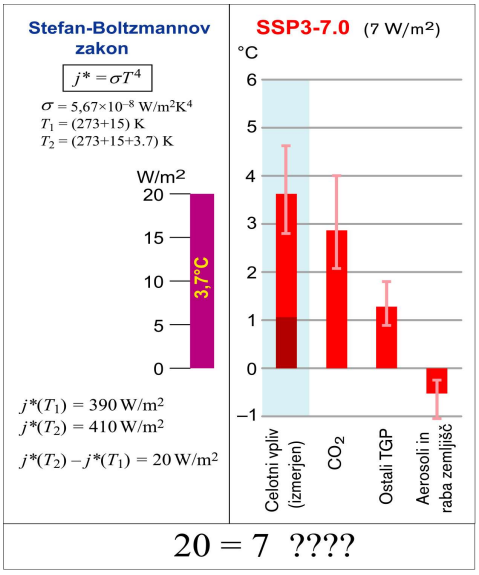
Torej bi se od leta 2015 do leta 2095 izpusti povečali s sedanjih 40 na 80 milijard ton na leto. Ta prirast pomeni vsako leto

dodatnih 0,5 milijarde ton CO_2. Toda meritve vsebnosti CO_2 zadnjih 60 let kažejo, da ta narašča za polovico počasneje kot naraščajo izpusti, saj polovico sproti posrkajo naravni ponori (oceani in fitoplankton, kopenske rastline in bakterije v tleh). Sedanja celotna količina CO_2 v ozračju znaša 3200 milijard ton. Če torej vsako leto v ozračju ostaja dodatnih 0,25 milijarde ton, bi ob sedanji stopnji rasti izpustov skupno količino CO_2 podvojili v 65 letih od leta 2015, oziroma že leta 2080.



Slika 9: Predvideni scenariji zmanjševanja izpustov po IPCC. Scenarij SSP3-7.0 predvideva nadaljnje povečevanje izpustov po sedanji letni stopnji, kar naj bi leta 2095 privedlo do podvojitve letne količine izpustov (rdeči krogec).

Kako verjetni so ostali scenariji najbrž nima smisla razpravljati. Poglejmo bilanco sevalne moči za SSP3-7.0 po oceni IPCC. Predvideva se najverjetnejši porast temperature za 2,6°C (oziroma najverjetneje v območju med 2 in 5°C) nad sedanjo temperaturo, ki je že za 1,1°C višja od temperature leta 1850, skupno torej 3,7°C; to pa naj bi ustrezalo povečani gostoti sevalne moči za 7 W/m^2, **Slika 10**:



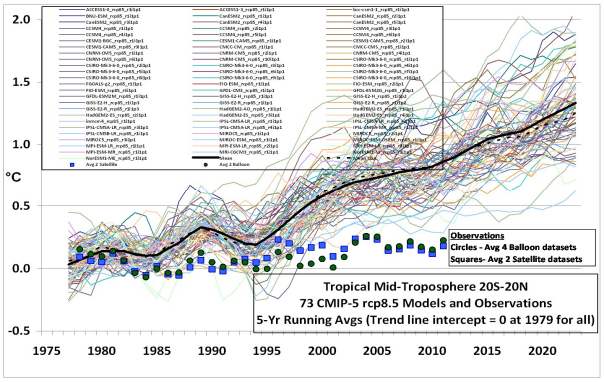
Slika 10: Na desni polovici slike je scenarij SSP3-7.0, povzet po AR6, str. 13 [6]. Na levi pa je izračun gostote sevalne moči za predvideno temperaturno razliko po Stefan-Boltzmannovem zakonu. Številke se ne ujemajo.

Kot vidimo na desni strani **Slike 10**, znaša izmerjeno povečanje povprečne globalne temperature od leta 1850 do danes okoli 1,1°C, nad tem pa je dodano najverjetneje povečanje v primeru podvojitve celotne količine CO_2 v ozračju, kar je ocenjeno na 2,6°C, skupno torej 3,7°C. Od tega odpade samo na CO_2 okoli 2,9°C, ostali toplogredni plini prispevajo še 1,3°C, izpusti aerosolov pa ohladijo ozračje za okoli 0,5°C. Po scenariju SSP3-7.0 se to povišanje temperature zgodi zaradi povečanega toplogrednega učinka za 7 W/m^2.

Toda po Stefan-Boltzmannovem zakonu povišanju temperature za 3,7°C ustreza povečanje gostote sevalne moči za 20 W/m^2.

Kako je lahko 20 = 7? Na to vprašanje ni odgovora. Sklepamo lahko le, da pri IPCC že v osnovi niso pravilno zastavili problema in je model na **Sliki 4** vsaj pomanjkljiv, če že ne povsem napačen, pa tudi to, da se nihče ni potrudil preveriti kako se sedanje sevalno ravnovesje planeta ujema s tistim predvidenim za primer podvojitve vsebnosti CO_2 v ozračju.

Dodatna težava je, da je ta napaka v klimatski občutljivosti za faktor 3× vgrajena v vse računalniške klimatske modele in so posledično vse napovedi rasti temperature do konca tega stoletja močno pretirane. To dejstvo je bilo očitno že leta 2010, ko sta dr. *Roy Spencer* in dr. *John Christy* zbrala in objavila napovedi rasti temperature 73 računalniških klimatskih modelov, ter jih primerjala s temperaturami izmerjenimi do leta 2010 s sateliti in meteorološkimi baloni, **Slika 11**:



Slika 11: Napovedi rasti globalne temperature 73 računalniških klimatskih modelov od leta 1978 do leta 2023 v primerjavi z izmerjenimi temperaturami do leta 2010 (tenke črte so napovedi potekov temperatur posameznih modelov, debelejša črna črta je njihovo 5-letno povprečje, modri kvadratki predstavljajo letna povprečja satelitskih meritev, črni krogci pa so meritve z meteorološkimi baloni).

Žal ta napaka ni brez posledic tudi v realnem svetu, gre namreč za verjetno najdražjo računsko napako v zgodovini človeštva. Zaradi te napake je bilo do sedaj na svetovni ravni po nepotrebnem zapravljeno po grobi oceni več kot 18 bilijonov ameriških dolarjev (samo v Nemčiji je bilo za njihov program *Energiewende* v 15 letih porabljenih okoli 600 milijard evrov, v ZDA pa 3800 milijard dolarjev). Posredna škoda pa je še mnogo večja, saj je zaradi tega bilo po svetu ustavljenih veliko investicij v energetski, industrijski in kmetijski razvoj, kar bi prineslo velik

družbeni napredek, še zlasti v državah v razvoju bi to v veliki meri pripomoglo k zmanjšanju revščine in lakote.

3 Zaključek

Izračuni s katerimi IPCC, za njimi pa pretežni del svetovne politike in množičnih medijev ustrahujejo prebivalstvo s posledicami prihodnjih podnebnih sprememb in posledično upravičujejo uvajanja raznih omejitvenih ukrepov s ciljem zmanjševanja izpustov toplogrednih plinov, vsebujejo številne napake. Nekaj najbolj resnih je opisanih v tem članku, izračuni dokazujejo, da je ocenjen vpliv toplogrednih plinov na podnebje prevelik vsaj za faktor 3×. Zaskrbljujoče je, da se o teh napakah ne govori niti v znanstvenih krogih, pa je ravno znanost tista, ki bi morala vse tovrstne teoretične predpostavke in na njih zasnovane izračune sproti temeljito preverjati in morebitne napake odpravljati. Da se to ne dogaja je najbrž posledica dejstva, da so tudi mnogi znanstveniki podlegli političnim pritiskom in grožnjam z omejevanjem financiranja znanstvenih raziskav tako samim znanstvenikom kot njihovim institucijam, če bi javno dajali izjave, ki ne soglašajo z uradnimi političnimi opredelitvami do problemov vpliva na podnebje. To seveda ne pomeni, da vpliva človeških dejavnosti na podnebje ni. Vendar bi morali biti ti vplivi realno ocenjeni, morebitni nujni omejevalni ukrepi pa temeljito pretehtani in sorazmerni, predvsem pa naj ne bi povzročali več škode kot koristi.

ZAHVALA

Avtor se zahvaljuje Vladimirju Alkalaju in Rafaelu Mihaliču za pomoč pri strokovnem pregledu in preverjanju besedila.

IZJAVA

Avtor za ta članek ni prejel nobene finančne ali kakršne koli druge podpore javnih institucij ali privatnih organizacij. Stališča in strokovne ugotovitve izražene v članku so izključno sad avtorjevih izračunov na podlagi javno dostopnih izmerjenih podatkov in pregledovanja svetovne literature na tem področju in ne izražajo uradnih stališč ali opredelitev ustanove v kateri je avtor zaposlen.

VIRI

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[3] Šesto poročilo IPCC: AR6, Ch.7, Figure 7.2, str. 934 (2021), <https://www.ipcc.ch/assessment-report/ar6/>

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[6] Šesto poročilo IPCC: AR6, SPM, Figure SPM.4, str. 13 (2021), <https://www.ipcc.ch/assessment-report/ar6/>

Vrednost električne energije intermitirajočih virov in kanibalizem na trgu z električno energijo

Value of Electricity From Intermitend Sources and Electricity Market Cannibalism

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POVZETEK

Intermitirajoči viri električne energije (OVE), predvsem vetrne (VE) in sončne elektrarne (SE), prevzemajo vedno večji delež v proizvodnji električne energije. V Sloveniji je rast količine SE eksplozivna. Ta razvoj lahko pripišemo subvencijam in privilegiranemu položaju na trgu. Če naj bi bila "veter in sonce zastonj" in subvencije kljub temu potrebne, se lahko upravičeno vprašamo: "Koliko pa je na trgu sploh vredna električna energija iz OVE?"

V članku smo zato za Nemčijo in Slovenijo analizirali tržno vrednost proizvodnje OVE za leto 2023 in prvo polovico leta 2024. Izračuni so temeljili na javno dostopnih podatkih.

Izkazalo se je, da zaradi lastnosti OVE in obratovalnih značilnosti elektroenergetskega sistema (EES) tako v Nemčiji, kakor Sloveniji, pride do izrazitega tako imenovanega kanibalskega učinka na trgu. V Sloveniji omenjeni učinek zmanjša tržno vrednost energije iz SE v letu 2024 na nekaj nad polovico tiste, ki bi jo pričakovali, če v EES ne bi bilo SE. Ta vrednost je le malo nad tisto v Nemčiji, čeprav je relativni delež energije iz SE približno 2 x manjši, kot v Nemčiji. Sklepamo, lahko, da zaradi povezanosti Entso-e sistema Nemci problem kanibalizma cen deloma "izvažajo", mi pa "uvažamo".

Pri vsem tem nismo upoštevamo stroškov obratovanja in nadgradnje EES zaradi OVE. Že samo "redispatching" potisne vrednost energije iz Nemških SE navzdol proti ¼ pričakovane vrednosti (tiste brez SE v EES).

Brez slabe vesti lahko torej trdimo, da se bo dejanska tržna vrednost energije bodočih OVE ob trenutnem trendu rasti hitro bližala vrednosti 0. In to ne upoštevajoč dodatnih stroškov EES zaradi OVE.

ABSTRACT

Intermittrnt electricity sources (RES), in particular wind power (WT) and solar energy (SE), are accounting for an increasingly large share of electricity generation. In Slovenia, the growth of SE is explosive. This development is due to subsidies and a privileged position on the market. If 'wind and sun are free' and subsidies are nevertheless necessary, one can rightly ask: 'How much is electricity from renewable energies worth on the market?'.

In this article, we have therefore analysed the market value of renewable energy generation for Germany and Slovenia for 2023 and the first half of 2024. The calculations are based on publicly available data.

It turns out that due to the characteristics of RES and the operating characteristics of the electric power system (EPS), there is a pronounced so-called cannibal effect on the market in both Germany and Slovenia. In Slovenia, this effect reduces the market value of energy from SE in 2024 to just over half of what would be expected if there were no renewables in the EPS. This value is only slightly higher than in Germany, although the relative share of energy from SE is only about half as high as in Germany. From this we can conclude that, due to the interconnectedness of the Entso-e system, the Germans are partly 'exporting' the problem of price cannibalism, while we are 'importing' it.

None of this takes into account the costs of operating and upgrading the EPS for renewable energies. Redispatching alone reduces the value of energy from German SE to ¼ of the expected value (that without renewables in the EPS).

It is therefore safe to say that the real market value of energy from future RES will quickly approach 0 given the current growth trend.

KLJUČNE BESEDE

Obnovljivi viri energije, OVE, cene električne energije, elektroenergetski trg, tržna vrednost električne energije, kanibalski učinek

KEYWORDS

Renewables, RES, Electricity prices, Electricity market. Market value of electric power, Cannibalisation effect

1 UVOD

V predhodnem prispevku (na istem mestu pred enim letom) [1] smo analizirali problem ovrednotenja investicij v obnovljive vire energije (OVE). Kakor je bilo izpostavljeno, splošno sprejeta metodologija izrazito favorizira izgradnjo OVE in ne upošteva vrste dejavnikov in potrebnih investicij v prilagoditev celotnega elektroenergetskega sistema (EES).

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Hkrati odpira vrsto ne le ekonomskih, pač pa splošnih družbenih dilem povezanih s pojmovanjem enakopravnosti ljudi v družbi v smislu "*quod licet iovi non licet bovi*" (pomensko: "Kar je dovoljeno nekaterim, ni dovoljeno drugim!"). Dodatno gre pri tem za politično pogojeno prerazporeditev premoženja ljudi, če uporabimo blagi izraz.

Izkazalo se je tudi, da v primeru "nekega zmernega" deleža OVE v določenem EES kakih večjih problemov in v prispevku izpostavljenih dilem ni oz. so zanemarljive in problemi tehnično obvladljivi z obstoječim EES. Kakor pa delež OVE zraste nad omenjeni "zmerni delež" in se začne bližati politično sprejetim in ekonomsko in tehnično nerazumnim mejam, pa problemi (in stroški) eskalirajo. Kje je meja tega "zmernega deleža" je vprašanje za milijon dolarjev in je skoraj ni moč izračunati. Pogojena je s strukturo EES, lastnostmi in vrsto virov električne energije, lastnostmi porabnikov itd. Pa tudi, če bi bila znana, to za politiko, za religiozno prepričane ljudi in oportuniste ne bi pomenilo veliko. Pač v smislu "*après nous, le déluge*" (za nami potop).

Za neko družbo oz. državo, kot celoto, torej velja, da omenjenega "zmernega deleža" ni smiselno preseči. Še zdaleč pa ne velja za akterje na trgu, ki v taki situaciji lahko pridobijo velike ekonomske koristi. V tržnem gospodarstvu s tem sicer ni nič narobe, problem pa je, da so te koristi pogojene s siromašenjem tihe večine in z "zdravo konkurenco" nimajo veliko opraviti. Zlobneži bi to pospremili s pripombo o "ribarjenju v kalnem" in na situacijo lahko v določeni meri gledamo tudi s tega stališča, saj večini ljudi niti približno ni jasno, kako zadeve potekajo in za kaj gre. Edino, kar opazijo je, da se vse draži, plače capljajo bolj ali manj na mestu ali zelo obotavljivo in z velikim časovni zamikom skušajo slediti inflaciji, na sosednjih vilah so "en, dva, tri" zrasle sončne elektrarne preko celih streh in prizidkov, njim pa "elektro" ne dovoli postaviti par panelov na uti, ker so "kapacitete omrežja izčrpane".

V tržnem gospodarstvu pač razvoj družbe diktirajo pravila trga, zato si v nadaljevanju poglejmo, kakšno vlogo na njem igrajo intermitirajoči OVE (sončne, vetrne elektrarne) in kakšna je dejanska tržna vrednost njihove električne energije. Z drugimi besedami; zanima nas, koliko bi bila na trgu vredna električna energija OVE, če bi za vse nove OVE elektrarne ta trenutek ukinili njihov privilegirani položaj na trgu z električno energijo in bi bile te povsem izenačene s "klasičnimi" viri.

Pri analizi smo pod drobnogled vzeli zadnjo leto in pol dogajanja na nemški in slovenski borzi z električno energijo. Omenjeno časovno obdobje smo izbrali, ker podatki zaradi pretresa in spremembe funkcioniranja celotne družbe med "obdobjem covida" niso relevantni, po drugi strani pa je večanje instalirane moči in s tem deleža OVE pri proizvodnji električne energije tako hiter, da analiza stanja pred letom 2020 ne bi imela nobenega smisla.

Nemčija je bila izbrana, ker gre za državo, ki je po eni strani sinonim za "*Energiewende*" (energijski preobrat) in zaradi njene ekonomske in politične teže v veliki meri diktira evropsko politiko na tem področju, po drugi strani pa ima odličen sistem javno dostopnih podatkov povezanih s proizvodnjo virov električne energije (recimo [2, 3]). Pri Sloveniji smo se seveda omejili le na sončne elektrarne (SE), saj je prispevek vetrnih elektrarn (VE) zanemarljiv.

2 OSNOVE TRGA ELEKTRIČNE ENERGIJE "ZA TELEBANE"

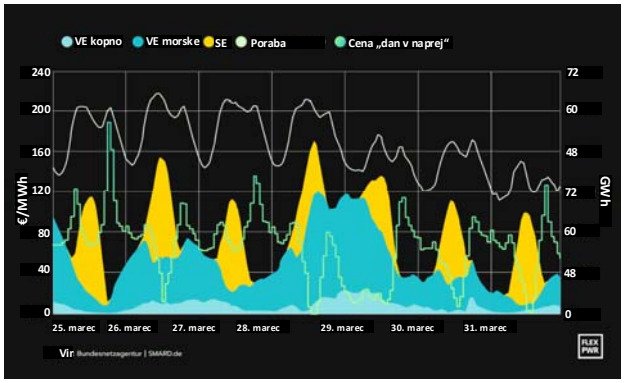
Principi trgovanja z električno energijo v Evropi so relativno zapleteni in so za povprečnega prebivalca Evrope prej, kot ne, španska vas. Tudi elektrotehniki na področju elektroenergetike, ki se z omenjenim trgom (v nadaljevanju označujemo s "trg" dejavnosti povezane s trgovanjem z električno energijo) ne ukvarjamo neposredno, se večinoma ne moremo pohvaliti z ekspertnim znanjem na tem področju. Ker pa razvoj EES v veliki meri diktira prav trg, je potrebno poznati vsaj njegove osnove, saj sicer ni mogoče niti razumeti, niti predvideti, niti načrtovati prihodnjega razvoja EES. Zlasti slednje dejstvo pa je ključnega pomena za zanesljivo dobavo električne energije in ga opisuje znana krilatica: "Ko se v EES pojavijo problemi, je že 10 let prepozno." Torej si v nadaljevanju oglejmo nekaj osnovnih dejstev v smislu serije knjig "Za telebane", ki se jih nekoliko izkušenejši še dobro spomnimo in so predstavljale pravo odrešitev za povprečne uporabnike česarkoli že.

Trg z električno energijo v EU so začeli uvajati ob koncu prejšnjega stoletja in se od tedaj neprestano razvija. Že v 80-tih je Evropska komisija začela zagovarjati tako imenovani prosti evropski trg z električno energijo. Prej so bili namreč EES bolj ali manj omejeni na posamezne države. Povezovanje EES med seboj in vzpostavljanje velikega sinhrono delujočega sistema je tehnično in regulatorno izjemno kompleksna naloga in lahko traja reda desetletja, kakor kaže praksa pri priključitvi dežel vzhodnega bloka po padcu železne zavese. Ima pa velik, povezan EES, velike prednosti pred majhnim in omogoča zanesljivejše in cenejše obratovanje. Ker gre za tehnično zelo zapleten sistem, pri katerem je, zato da sploh lahko stabilno obratuje, potrebno zagotavljati določene tehnične pogoje in upoštevati tehnične omejitve, mora biti tudi trg z električno energijo z jasnimi pravili in omejitvami zasnovan tako, da je skladen s tehničnimi pogoji za varno obratovanje EES. Elektrika je namreč izrazito neprimerno blago za trgovanje in lahko bi rekli, da zanjo prosti trg ni ustrezna rešitev. Problem pa je, da zaenkrat v družbenem sistemu, v katerem živimo, boljše rešitve ne poznamo.

Osnova obratovanja EES je dejstvo, da se ta mora sproti prilagajati (zagotavljati energijo) porabi, ki se tekom vsake minute, ure, dneva, tedna, sezone ves čas spreminja. Skratka proizvodnja in poraba morata biti ves čas v ravnotežju. To ravnotežje pa zagotavljajo elektrarne z neprestanim prilagajanjem proizvodnje. Različne elektrarne pa imajo različne obratovalne karakteristike, različno sposobnost prilagajanja proizvodnje, različne načine in čase zagona, različne investicijske stroške, različne tekoče stroške (cena primarnega energenta, na primer goriva), različne stroške zagona, različne dinamične lastnosti, različne možnosti zaustavitve (pri npr. jedrskih elektrarnah sta zaustavitev in ponoven zagon kompleksen in dolgotrajen, več dni trajajoč proces, povezan z velikimi stroški), pa še kaj bi se našlo. Stohastični OVE (VE, SE) dandanes nimajo sposobnosti prilagajanja potrebam EES, kar sicer ne pomeni, da je tehnično ne bi mogle imeti, vendar za ceno manjših dobičkov, v kolikor to ne bi bilo podprto s še dodatnimi subvencijami. Ker torej OVE nimajo ene od osnovnih lastnosti, ki jih elektrarne *morajo* imeti, jih pravzaprav ne moremo imenovati "elektrarne". To so stohastični viri električne energije in kar "narava da", pač proizvedejo. Tu pa se že nakazuje, kam pes taco moli. Razliko med proizvodnjo in porabo (ki se ves čas

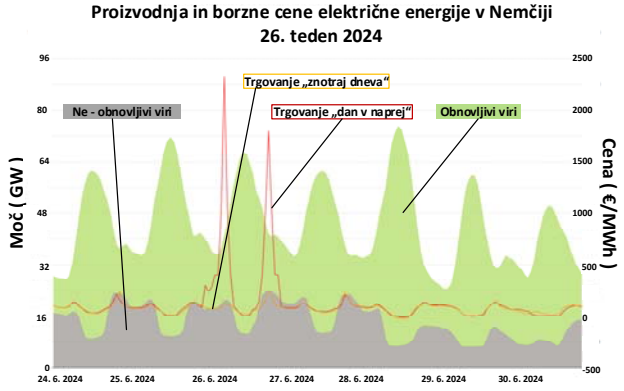
spreminja) morajo izravnavati "klasični" viri (ali v prihodnosti shranjevalniki električne energije, ki pa so zaenkrat za resno sistemsko shranjevanje za red velikosti predragi, razen tega pri današnji tehnologiji na Zemlji še zdaleč niti ni dovolj surovin zanje). Seveda obstaja tudi možnost prilagajanja porabnikov (prostovoljnega ali prisilnega – beri izklopi), ampak s tem je razkošja kadarkoli dostopne elektrike za ljudi konec in znamenite redukcije iz 80-tih let v katerih ne bi uživali verjetno niti največji nostalgiki, lahko doživijo renesanso.

Omenjeni problemi so tem večji, čim večji je delež OVE. Kljub posebnostim trga z električno energijo, pa na njem vendarle še vedno veljajo klasična tržna pravila, torej če je blaga veliko, je poceni, če ga je malo, pa je drago. Ker je električna energija za funkcioniranje družbe nujna, zato lahko ob pomanjkanju doseže neverjetne cenovne skoke (v J. Avstraliji npr. v nekaj urah skoraj 300+ - kratnik, torej 30 000 % dolgoletnega povprečja [4]). Še zanimivejša je situacija, ko je elektrike preveč. Nekaterih elektrarn in tisočev SE namreč ni moč poljubno izklapljati. Takrat doseže električna energija na borzi vrednosti blizu nič ali celo negativne vrednosti (V smislu: "Plačamo, samo vzemi!"). Ilustracijo prikazuje slika 1.



Slika 1: Proizvodnja OVE in cena na borzi EPEX (Nemčija) zadnji teden marca [5]

Jasno je razvidno, da sta cena na borzi in proizvodnja OVE obratno korelirani. Še bolj zanimiva je situacija na isti borzi junija in julija, kjer je cena v 12 urah skočila iz vrednosti malo nad 0 na skoraj 2500 €/MWh in nazaj na 0 ter v naslednjih 12 urah podobno – slika 2, 14. junija pa je bila cena okrog poldneva negativna, približno –150 €/MWh (negativen trikratnik neke povprečne borzne cene).



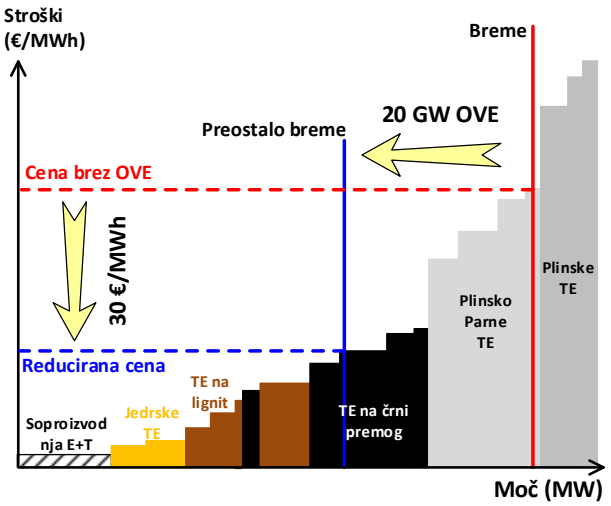
Slika 2: Proizvodnja OVE in cena na borzi EPEX (Nemčija) zadnji teden junija [1]

Mesec dni kasneje, 14. julija, je bila cena negativna med 8. uro zjutraj in 17. uro.

Ob tem se lahko upravičeno vprašamo, kak smisel sploh ima graditi recimo dodatne SE, če je pa takrat, ko proizvajajo največ, cena elektrike skoraj nič, in kako se obstoječim izide račun. Kratek odgovor je: "Ker so subvencionirane in njihov dohodek ni odvisen le od tržne cene." Torej lastnikov kaj dosti ne motijo negativne cene na borzi. Seveda pa to vpliva na vse udeležence na borzi. Problematične so zlasti elektrarne, ki rabijo dolgo časa (beri: je drago) za zagon in tiste, ki imajo sicer nizke stroške obratovanja in velike stalne stroške (beri: velika investicija) in torej za rentabilnost potrebujejo veliko obratovalnih ur. Tipično gre za jedrske elektrarne, dobre premogovne elektrarne z visokim izkoristkom, plinsko-parne elektrarne, lahko tudi za pretočne hidroelektrarne oz. elektrarne z majhno akumulacijo (ravno včeraj, 5. 7. sem iz prve roke izvedel, da hidroelektrarne na Savi že ves mesec po malem prelivajo vodo, ker je elektrike čez dan preveč in je sistem ne more absorbirati).

V takih razmerah se elektrarn z nizko ceno primarnega energenta in visokimi investicijskimi stroški (beri: dobrih, energetsko učinkovitih elektrarn) ne izplača graditi. Ob nespremenjenem trendu bi količina OVE narasla do meje, ko bi ob ugodnih naravnih danostih proizvajali velike presežke električne energije, ki bi jih bodisi na nek način "metali vstran" (recimo s prelivanjem vode v hidroelektrarnah in/ali zaustavitvijo jedrskih elektrarn) ali shranjevali v hranilnikih električne energije. Problem je, da so za shranjevanje na sistemskem nivoju ti pri obstoječi tehnologiji za red velikosti predragi, razen tega zanje na Zemlji ni dovolj surovin. Na OVE in hranilnikih temelječ EES je sicer tehnično teoretično mogoče izgraditi, vendar njegove cene niti najbogatejša družba ne bi mogla plačati.

Ob tem še enkrat poudarimo, da pri dosedanji razpravi o ceni elektrike gre za ceno, ki bi jo dosegla na borzi dodatna elektrarna (marginalna cena), in da ne moremo celotne količine električne energije iz OVE ovrednotiti po tej ceni (marginalni). To bi veljalo le za ta trenutek dodano dodatno elektrarno. Če bi namreč odvzeli vso električno energijo OVE, bi se cene drastično spremenile. Logiko ponazarja slika 3.



Slika 3: Logika določanja cene na borzi Vir: prirejeno po[6]

Na sliki 3 je obrazložena logika določanja borzne cene po obstoječih pravilih. Na abscisni osi je potrebna moč porabe in/ali proizvodnje, predvidena za npr. določeno uro prihodnjega dneva, na abscisi pa je cena za 1 MWh električne energije. Višina bar diagramov predstavlja minimalno ceno, ki jo lahko na trgu ponudijo posamezne elektrarne (na MWh). V bistvu gre za lastno ceno proizvodnje, pod katero bi proizvajale izgubo. Cena zadnje elektrarne, ki je potrebna za zadovoljitev porabe (recimo stičišče polne in črtkane rdeče črte) potem velja (toliko dobijo plačano) za vse elektrarne na levi strani. Problem te logike je, da se OVE privzeto postavijo s ceno 0 na začetek tega diagrama. Na ta način imajo zagotovljen odjem, kar je po "zdravi kmečki logiki" povsem ustrezno. Na ta način se poraba iz "klasičnih" elektrarn zmanjša (na sliki 3 konkretno za 20 GW), saj jo pokrijejo OVE. Posledično se "rdeča črta" pomakne v diagramu proti izhodišču na območje cenejših elektrarn (modra črta).

To ima dve, pravzaprav tri posledice. Prva posledica je, da dobre plinsko – parne elektrarne in elektrarne na črni premog ostanejo "brez posla" – glej sliko. Če se to dogaja pogosto, postanejo nerentabilne in bankrotirajo. Druga posledica je, da vse elektrarne levo od modre črte zaslužijo manj. Za fiksno subvencionirane OVE (tudi t. i. "net-metering" lahko štejemo v to skupino) to ni tak problem, za ostale pa je. Tretja posledica pa je pravzaprav posledica prvih dveh in pomeni, da nihče ne bo več investiral denarja v dobre elektrarne z dobrim izkoristkom, ki pa jih je praviloma problematično pogosto zaganjati/ugašati oz. jim močno variirati obremenitev. Po tej logiki se bo izplačalo graditi le poceni elektrarne s slabim izkoristkom in zelo dragim primarnim energentom. Slednje ni ovira, saj ko OVE "presahnejo", je cena samo nebo ("sky is the limit") – glej npr. sliko 2.

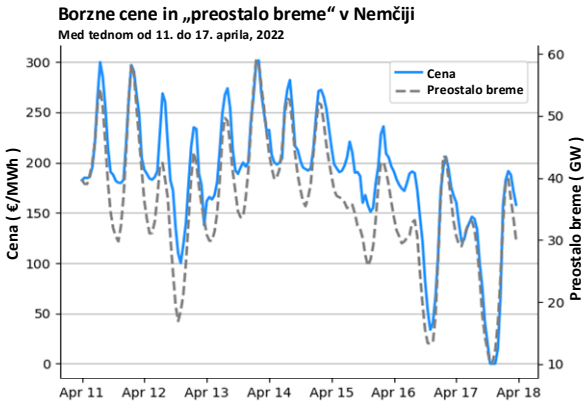
Še opomba; na sliki 3 nas ne sme zavesti nizka cena jedrskih elektrarn. Gre za spremenljive stroške, ki so pri njej zelo nizki. Če bi upoštevali investicijo, pri tej ceni ne bi bila nikoli rentabilna. To dejstvo je seveda odločilno za investicije v nove objekte.

Na ta način pa se tudi dejanska tržna vrednost proizvodnje OVE zmanjša. Več je OVE, bolj je ta pojav izrazit, bolj se niža tržna cena drugim elektrarnam in tudi samim OVE. Govorimo o tako imenovanem učinku kanibalizma ("cannibalisation effect").

Omenjena razlaga opisuje osnovni princip, obstaja še kup dodatnih mehanizmov, ki tehnično omogočajo, da EES stabilno obratuje in lahko ceno potisnejo tudi v negativne vrednosti (kar po opisani logiki ni mogoče).

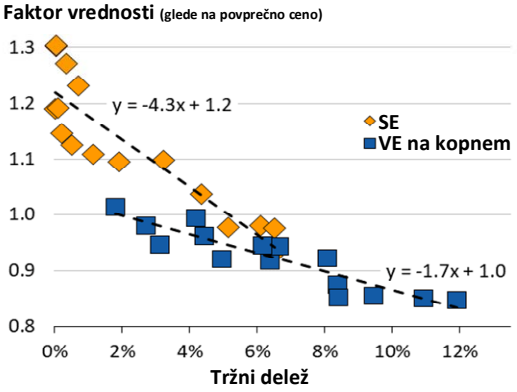
Podrobnejši ekonomski izračuni so razmeroma kompleksni in podrobneje razložijo, zakaj z večanjem subvencioniranih SE in VE privede do padca vrednosti njihove električne energije na borzi proti ali celo pod 0.

Pri zelo majhnem deležu OVE v EES cena oz. vrednost električne energije sledi logiki, ki smo jo poznali pred desetletji. Ponoči in med dela prostimi dnevi, ko večina ljudi in industrije rabi manj elektrike, je cena nizka, podnevi pa je poraba bistveno višja in temu ustrezno tudi cena. Zato je vloga SE v začetku za obratovanje EES pozitivna. Slika pa se diametralno spremeni, če recimo SE v nekem EES proizvedejo reda 10 ali 15 % elektrike. Majhni omenjeni številki sta lahko zavajajoči in delež SE lahko pomeni za EES veliko večji problem, kot bi lahko sklepali iz njiju. Namreč, SE imajo v Sloveniji obratovalne ure, ali bolj po domače, izkoriščenost (koliko dejansko proizvedejo v primerjavi z njihovim teoretičnim maksimumom = maksimalna osončenost 24 ur na dan), nekje okrog 10%. To pomeni, da je pri 10% deležu proizvodnje vgrajena moč SE okrog povprečne proizvodnje sistema. Ko torej sonce zasije opoldne povsod "na polno"(se zgodi tu in tam), SE praktično pokrijejo porabo. Kam pa z viški iz elektrarn, ki jih ni moč zaustaviti? Možnosti je sicer več, a nobena ni ravno poceni. Nemci npr. v takih primerih izvažajo elektriko skoraj zastonj, zvečer (ko SE "ugasnejo") pa jo po zelo visoki ceni uvažajo. In potem se ljudje čudijo, da se elektrika draži, in da ima Nemčija skoraj najdražjo elektriko na svetu?! Ilustracija je na sliki 4, ki prikazuje ceno elektrike (modra krivulja) v odvisnosti od t. i. preostalega bremena (residual load), se pravi bremena, ki ga ni moč pokriti z OVE (modra vertikalna črta na sliki 3), pač pa s klasičnimi elektrarnami (ali uvozom). Če OVE pokrijejo skoraj vso porabo, je seveda preostalo breme majhno (slika 3 – modra črta gre levo, črtkana modra črta pa se pomika navzdol) in cena pade, v skrajnem primeru na 0.



Slika 4: Kanibalska logika; več OVE, manjša cena [7]

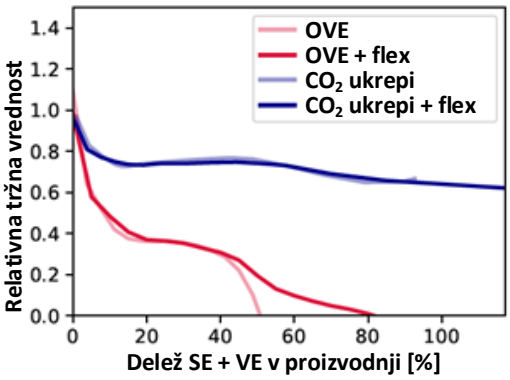
Konkretne izračune so za Nemčijo na podlagi borznih podatkov izvedli v [5] – glej sliko 5 (vsak kvadratek predstavlja eno leto)! Čeprav so podatki stari in delež OVE še relativno majhen, je logika nedvoumna. Hkrati potrjuje tudi omenjeno premiso, da majhen delež SE na obratovanje EES vpliva blagodejno, saj SE proizvajajo podnevi, ko je poraba (in cena) električne energija višja. Zato je tudi "faktor vrednosti" na začetku okrog 1,3 (130 % povprečne cene) in je nekako do 5 % deleža proizvodnje iz SE nad 1.



Slika 5: Kanibalska logika – dolgoročni trend [6]

Opisana logika je v ekonomiji že dolgo znana in nekaj avtorjev se je problema lotila znanstveno, pri čemer so upoštevali zakonitosti trga v EU, karakteristike EES, možnosti prenašanja

energije po EE omrežju itd. Gre za relativno obsežne izračune, za ilustracijo pa podajamo sliko 6. Avtor prispevka [7] je analiziral scenarije razvoja vrednosti električne energije OVE v odvisnosti od večanja njihovega deleža v proizvodnji EES. Pri tem je ugotovil, da samo s subvencijami, brez posebnih dodatnih ukrepov, vrednost njihove proizvodnje pri 50 % deležu pade proti 0. S povečanjem fleksibilnosti EES v smislu možnosti shranjevanja električne energije in prilagajanja porabnikov (oznaka "flex") je sicer mogoče nekaj narediti, vendar se pri višjem deležu OVE cena še vedno giblje blizu ničle. "Rešitev" je našel v spremembi regulative in drastičnem povečanju cene izpustov CO2. Kaj si o vsem skupaj mislim, kot davkoplačevalec, ni za objavo.



Slika 6: Ničvrednost energije iz OVE in "Dekanibalizacija" po ekonomistično [7]

3 IN MEDIAS RES ALI KAJ PRAVIJO ŠTEVILKE

Kot je bilo že omenjeno, je vsak EES specifičen glede strukture, lastnosti in razporeditve virov, možnosti prenašanja energije, lastnosti porabnikov itd. Zato kvantitativna analiza scenarijev nekega EES, povezanih bodisi s tehničnimi lastnostmi ali ekonomskimi kazalci, v splošnem ne velja za nek drug EES ali, zlasti pri velikih EES (kar evropski EES je), ne velja niti za druga območja istega EES. Zato smo si zastavili vprašanje: "Kje na teh grafih iz prejšnjega poglavja pa se nahaja Nemčija in kje Slovenija. V uvodu smo navedli razloge za izbiro Nemčije, kot neke reference.

Na podlagi javno dostopnih podatkov torej poglejmo, koliko bi bila na trgu vredna električna energija OVE, če bi za vse nove OVE elektrarne ta trenutek ukinili njihov privilegirani položaj na trgu z električno energijo in bi bile te po logiki iz Slike 3 povsem izenačene s "klasičnimi" viri. Kot rečeno smo v analizi upoštevali zadnjo leto in pol dogajanja na nemški in slovenski borzi z električno energijo.

Kljub dobri dostopnosti do podatkov [2, 3], je bilo treba nekatere faktorje privzeti. Zlasti to velja za podatke proizvodnje slovenskih SE. Pred leti so na strani ELES, kjer prikazujejo trenutne in historične podatke o proizvodnji in porabi [9] podajali tudi proizvodnjo SE, vendar so to kasneje ukinili. Pridobivanje teh podatkov namreč ni preprosto. Če je veliko SE na nizki napetosti (hišne SE), bi bilo potrebno sprotno zbirati podatke za vsako gospodinjstvo s SE posebej. Zbiranje podatkov na nivoju nizkonapetostnega izvoda ali celo na srednji napetostni strani namreč ne pove mnogo, saj ni mogoče gotovo ločiti med visoko proizvodnjo SE in hkratno visoko porabo ter nizko proizvodnjo SE in hkratno nizko porabo. Podoben problem velja za lastnike SE s tako imenovanim net-meteringom.

Na omenjeni ELES-ovi strani imajo za podatke proizvodnje SE v Sloveniji preusmeritev na ustrezno stran Entso-e [10] in uporabljeni podatki izvirajo od tam. Borzne cene smo povzeli po [11], podatke o količini instaliranih SE v Sloveniji pa po [12] in [13].

Pri analizi podatkov pa sta se pojavila dva problema. Prvi je bil ta, da so bili nam dostopni podatki o instalirani moči sončnih elektrarn samo za trenutek ob koncu leta. Za natančne izračune, koliko je v bistvu celoten sistem SE izkoriščen, bi potrebovali ta podatek za vsako uro. Ker je bil prirast instalirane moči SE leta 2023 v Sloveniji izjemno visok (več od 400 MW - od manj od 700 MW na več, kot 1100 MW), tudi povprečna vrednost ne bi dala sprejemljivih rezultatov. Razen tega (med analizo) ni bilo mogoče najti podatka o instalirani moči elektrarn na polovici leta 2024. Zato smo privzeli linearno rast instalirane moči SE skozi časovni točki 31. 12. 2022 in 31. 12. 2023 za celotno študirano obdobje. Kasneje je ELES v sporočilu za javnost [14] objavil, da bo uvedel na svoji spletni strani tudi sprotno spremljanje proizvodnje in količine obnovljivih virov v Sloveniji. Na žalost za naše obravnavano obdobje to ne pomaga veliko, smo pa imeli priložnost narediti preizkus za eno časovno točko in primerjati ELES-ove nove podatke z našimi predpostavljenimi (ekstrapolacija v letu 2024). Izkazalo se je, da so se skoraj povsem skladajo. To sicer ni dokaz, je pa dober indic, da so naše predpostavke blizu dejanskemu stanju, če zaupamo ELES-ovi oceni trenutnega dejanskega stanja.

Drug problem so predstavljali podatki o urni proizvodnji slovenskih SE na strani Entso-e. Pri analizi se je namreč izkazalo, da je skupna letna proizvodnja (preprost seštevek urnih podatkov) veliko manjša, kot bi jo pričakovali iz podatkov o instalirani moči SE glede na nek tipičen faktor izkoriščenosti (kot rečeno okrog 10 %) in tudi bistveno manjša od podatka na [12]. Špekuliramo lahko, da je slovenski operater pošiljal Entso-e le podatke, do katerih je imel dostop (nekaj več kot polovica ocenjene dejanske energije SE). Zato smo urne podatke o proizvodnji SE v Sloveniji normirali tako, da je na koncu leta bila energija enaka objavljeni letni proizvodnji [12]. Tak pristop je smiseln, ker dejanski poslani podatki, čeprav niso kompletni, podajo časovno razporeditev proizvodnje, z drugimi besedami, kakor je osončena polovica SE, približno tako je po vsej verjetnosti osončena tudi druga polovica. V prejšnjem odstavku omenjeni test je to predpostavko povsem potrdil.

Menimo, da je nekoliko daljši uvod s pojasnilom glede uporabljenih podatkov nujen, ker leži izvirni greh množice študij in prispevkov (zlasti na področju tako imenovane podnebne politike in energetike, ki "dokazujejo" potrebo po neskončnem plačevanju t. i. zelenega prehoda) v prirejenih ali selekcioniranih podatkih (Dokazov in analiz na to temo je veliko, a zaradi nebistvenosti referenc na tem mestu ne navajamo). V nadaljevanju torej poglejmo, kaj so pokazali izračuni.

3.1 Situacija v Nemčiji

Izračuni za leto 2023 in prvo polovico leta 2024 za razmere v Nemčiji so predstavljeni v nadaljevanju.

Tabela 1: izračuni za Nemčijo

Izračunana vrednost ↓ / Leto →	2023	2024
Povprečna cena na borzi [€/MWh]	95	68
Povprečen zaslužek 1 MW VE na uro [€/h]	19,4	14,6
Povprečen zaslužek 1 MW SE na uro [€/h]	6,7	4,3
Vrednost proizvodnje VE glede na povprečno ceno na borzi [%]	85	87
Vrednost proizvodnje SE glede na povprečno ceno na borzi [%]	77	64
Delež VE v proizvodnji D [%]	32	29
Delež SE v proizvodnji D [%]	12	13
Strošek redispatchinga [Mrd €]	2,35	1,175*
Vrednost proizvodnje VE obremenjene za delež redispatchinga na instalirano moč** glede na povprečno ceno na borzi [%]	63	60
Vrednost proizvodnje SE obremenjene za delež redispatchinga na instalirano moč** glede na povprečno ceno na borzi [%]	54	37

* - privzeto

** - v Nemčiji konkretno delitev med VE in SE ca. pol – pol.

Preurejanje predhodno dogovorjene proizvodnje (redispatching) lahko v veliki meri pripišemo volatilnosti proizvodnje OVE. Seveda podatkov, kdo je za posamezen primer "odgovoren" ni in tega velikokrat niti ni moč nedvoumno ugotoviti. Menimo, da razdelitev med VE in SE glede na njihovo instalirano moč predstavlja sprejemljiv kompromis, ki poda vsaj dobro oceno za ta del stroškov implementacije OVE v EES.

3.2 Situacija v Sloveniji

Adekvatno izračunom za Nemčijo smo izvedli te tudi za Slovenijo. Osnovna razlika med naboroma je v tem, da v Sloveniji nismo upoštevali VE, ker je njihov delež zanemarljiv.

Tabela 2: izračuni za Slovenijo

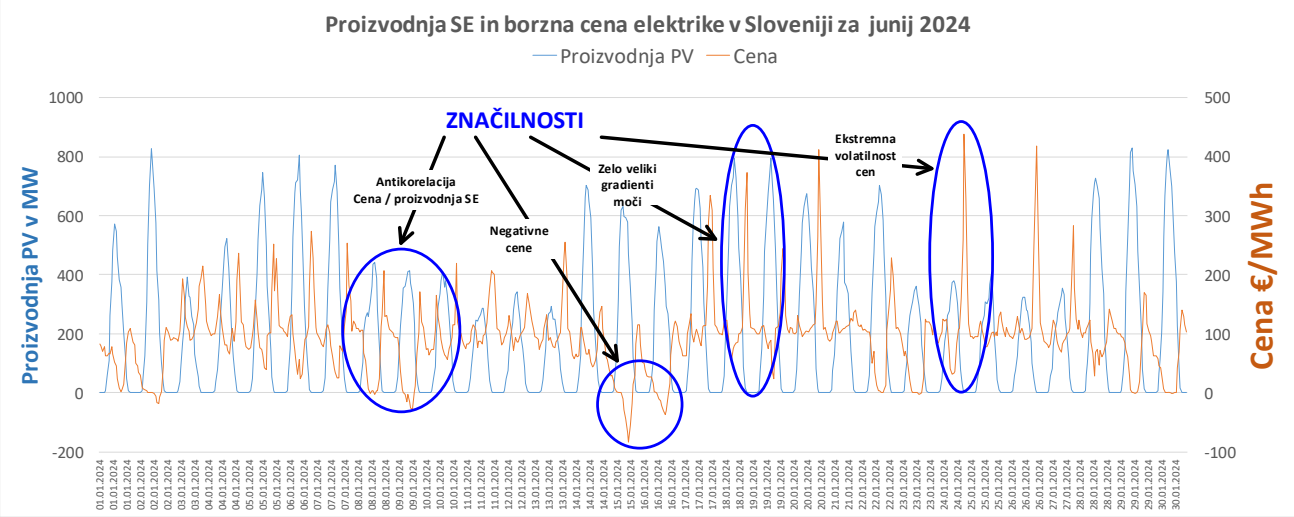
Izračunana vrednost ↓ / Leto →	2023	2024
Povprečna cena na borzi [€/MWh]	104	73
Povprečen zaslužek 1 MW SE na uro [€/h]	6,6	5,1
Vrednost proizvodnje SE glede na povprečno ceno na borzi [%]	83	70
Delež SE v proizvodnji RS [%]	4,6	7,7

Poglejmo, kaj nam povedo navedene številke.

3.3 Diskusija

Preden začnemo z interpretacijo rezultatov velja omeniti, da pri analizi nemških in slovenskih razmer v EES (proizvodnja, poraba) in dogajanja na ustreznih borzah [1, 11] ne gre za dva različna EES, temveč za en povezan EES in dve različni področji. Različne borzne cene nastajajo le zaradi omejenih možnosti prenosa energije. Ker sta obe področji vpeti v skupen sistem (Entso-e), se sistemski učinki OVE na obravnavanih področjih ne odražajo na borzne cene enako, kot bi se, če bi imeli opravka z električnima otokoma. Vpliv je "mehkejši", ker se različna področja do neke mere dopolnjujejo in tudi o tem govorimo, ko izpostavljamo prednosti povezave v velik EES.

Neglede na to pa je možno potegniti vzporednice med predstavljenimi ekonomskimi izračuni iz literature (Slike 4, 5, 6) in med obravnavanima deloma Entso-e. V Nemčiji je vrednost elektrike iz OVE (zmanjšana za ca. 15 % pri VE in med 40 % in 50 % povprečne cene pri SE – ne pozabimo faktor vrednosti za VE se začne pri ca. 100 % in za SE pri ca. 130 % Glej Sliko 5), tudi ob upoštevanju redispatchinga (zmanjšanje za ca. 40 % pri VE in za ca 60 % pri SE), nekoliko višja, kakor bi sklepali recimo iz Slike 6. Razliko lahko pripišemo omenjenemu "omehčanju" kanibalskega učinka zaradi možnosti izmenjave energije z drugimi področji. Električna okolica Nemčije namreč po prispevku OVE za njo zaostaja in blaži omenjeni učinek.



Slika 7: Učinek proizvodnje SE na borzo "Southpool" Vir: lastni izračuni

V Sloveniji je prispevek OVE med 5 in 10 x manjši, kakor v Nemčiji, zato je smiselno primerjati rezultate s tistimi na Sliki 5. Izkaže se, da je kanibalski učinek v Sloveniji (zmanjšanje vrednosti za reda 50 % povprečne cene – zopet ne pozabimo, primerjalna vrednost je 130%) precej večji od tistega, ki bi ga razbrali iz Slike 5, se pa precej dobro sklada s Sliko 6. Sklepamo lahko, da je v električni okolici Slovenije odstotek proizvodnje iz SE večji, kakor v Sloveniji, kar pomeni, da Slovenija v bistvu "uvaža" kanibalski učinek SE, saj je relativno majhen trg. Omenjeno dejstvo do neke mere potrjuje dogajanje na borzi "Southpool". Močna volatilnost cene (nihanje, skoki) namreč ne morejo biti povzročeni z nihanjem proizvodnje le slovenskih SE – glej Sliko 7 – so pa kvalitativno gledano razmere identične dogajanju na drugih (recimo nemški) borzah.

4 SKLEP

"Veter in sonce sta zastonj!" je krilatica, ki jo pogosto slišimo bodisi bodi si od ljudi, ki ne vedo veliko o realnosti, bodisi od tistih, ki namerno zavajajo. Resnica skoraj ne bi mogla biti bolj drugačna. V [1] smo pokazali, kaj vgradnja OVE (recimo SE in/ali VE) dejansko "potegne za sabo" in kake indirektne stroške povzroči v EES.

V tem prispevku pa nas je zanimalo, koliko je resnična tržna cena elektrike iz OVE (SE in VE) v Nemčiji in Sloveniji. Teh podatkov namreč v javnosti ni zaslediti, saj ne skladajo z uradno politiko "zelenega prehoda". Njihovo objavljanje je torej "politično nezaželeno."

Analizirali smo zadnje leto in pol dogajanja v Nemčiji in Sloveniji. Zakaj poleg Slovenije še Nemčijo in zakaj to obdobje pojasnimo v Uvodu. Zaradi narave proizvodnje iz OVE, lastnosti obratovanja EES in značilnosti porabnikov prihaja z naraščanjem deleža proizvodnje iz OVE do tako imenovanega kanibalskega učinka na trgu z električno energijo. To pomeni, da po eni strani OVE sami sebi zbijajo tržno ceno elektrike in po drugi strani ekonomsko onemogočajo najboljše elektrarne (dobre premogovne elektrarne z visokim izkoristkom, neamortizirane jedrske elektrarne in plinsko-parne elektrarne z visokim izkoristkom). Prvo dejstvo za same OVE niti ni tako tragično, saj ekonomsko preživijo s subvencijami in/ali privilegiranim položajem. Bankrot in zapiranje (in seveda ustavitev gradnje česarkoli, kar ni subvencionirano, razen poceni plinskih elektrarn z odprtim ciklom, slabim izkoristkom in zelo drago elektriko) omenjenih klasičnih elektrarn pa lahko obratovanje EES pripelje v nemogočo situacijo, cene elektrike na borzi pa do nepredstavljivih skokov.

Izkazalo se je, da je s kanibalskim učinkom povezano relativno znižanje cene VE v Nemčiji nekje 15 %, SE pa za ca. 50 % povprečne tržne cene. Če omenjenim VE in SE "naprtimo" še stroške "redispatchinga", se ti številki povečata na ca. 40 oz. 90 %. Glede na ekonomske izračune v literaturi jo OVE v Nemčiji zaradi podpore sosednjih sistemov (beri: "parazitiranja" nemškega) še dobro odnesejo.

Za razliko od nemškega je situacija v Sloveniji nekoliko slabša, kot bi pričakovali glede na literaturo. Cena energije SE je za več kot 50 % povprečne borzne cene nižja od tiste, ki bi jo pričakovali, če bi v EES bilo le malo SE (pade iz 130 % na 70 % povprečne borzne cene). Kanibalski učinek Slovenija v bistvu "uvaža" in elektrika iz njenih SE je na trgu še manj vredna, kakor bi pričakovali "iz teorije". V razmerah, kjer bi bili akterji na trgu izenačeni, ne bi imele nove SE nobene možnosti ekonomskega preživetja. In to, brez da bi jim "naprtili" stroške "redispatchinga", kaj šele morebitnih shranjevalnikov.

In nauk zgodbe? Morda bi krilatico "Veter in sonce sta zastonj!" veljalo zamenjati z: "Veter in sonce kmalu ne bosta vredna nič." Pa še retorično vprašanje: "Kdo bo vse to plačal?"

ZAKAJ ŽE, PRAVZAPRAV ???

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Kako razumeti ogljični odtis?

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Povzetek

Ogljični odtis, ki pomeni vsoto neposredno in posredno povzročenih emisij toplogrednih plinov s strani organizacije, izdelka, storitve, dogodka ali posameznika je postal eden od najpomembnejših okoljskih indikatorjev oz. indikatorjev trajnostnosti. Kljub njegovi popularnosti in razširjeni uporabi pa je ogljični odtis povezan z različnimi metodološkimi ter konceptualnimi pomanjkljivostmi. Predvsem je preveliko osredotočanje na ogljični odtis v majhni državi kot je Slovenija, ki v bilanco emisij toplogrednih plinov prispeva minorni delež v primerjavi z velikimi državami, problematično zato, ker se posledično pozablja na nekatere ključne okoljevarstvene probleme, ki so vitalnega pomena za kakovost življenja oz. bivanja.

Ključne besede

ogljični odtis, toplogredni plini, metoda LCA

1 Uvod

Emisije toplogrednih plinov (TGP) veljajo v splošnem v gospodarstvu in politiki za ključni okoljski problem in prioriteto, o katerem se v primerjavi z drugimi okoljskimi problemi neproporcionalno več razpravlja ter se mu namenja medijskega in političnega prostora. Pojmi kot so nizko- in brezogljična družba, nizko- in brezogljično gospodarstvo, razogljičenje, ogljična nevtralnost ter z njimi povezani ukrepi so v vrhu prioritet vladnih ukrepov in trajnostnih politik podjetij [1-3]. Za določene organizacije oz. podjetja je poročanje o emisijah TGP postalo tudi obvezno [4]. Za upravljanje 'ogljičnih politik' so zato potrebni kvantitativni podatki o emisijah TGP, s pomočjo katerih se spremlja tako trenutno stanje glede emisij TGP kot tudi učinkovitost ukrepov v zvezi z njihovim zmanjševanjem. Vlogo takšnega kvantitativnega indikatorja je prevzel ogljični odtis, ki predstavlja glavni kvantitativni indikator za izvajanje in spremljanje podnebnih politik (predvsem zmanjševanja emisij CO_2), tako na nivoju podjetij kot tudi občinskih ter državnih ustanov.

Namen prispevka je prikazati nekatere vidike v povezavi z ogljičnim odtisom (s poudarkom na ogljičnem odtisu izdelkov), ki so praviloma spregledani oz. neupoštevani v gospodarski praksi in družbenih diskusijah ter opozoriti na njegove metodološke in konceptualne pomanjkljivosti.

2 Metodološke in konceptualne pomanjkljivosti ogljičnega odtisa

Ogljični odtis ima pomembne metodološke in konceptualne pomanjkljivosti pri ugotavljanju dejanskih vplivov izdelkov, storitev in podjetij na okolje [5-6]. Gospodarsko, politično in medijsko osredotočanje izključno na ogljični odtis namreč daje zavajajoč občutek glede celovitih vplivov izdelkov, storitev in organizacij na okolje, saj se pozablja na številne druge vplive, ki jih povzročajo podjetja oz. njihovi izdelki ali storitve [7-9]. Posledica tega je, da predstavniki gospodarstva pogosto zgled za svojo "zeleno" naravnanost prikazujejo izključno z osredotočanjem na zmanjšanje ogljičnega odtisa, pri tem pa kot po pravilu pozabljajo na številne druge vplive na okolje (ali pa se jih sploh ne zavedajo), ki so prav tako posledica njihove dejavnosti ali proizvodnje ter uporabe izdelkov [10]. Ob tem velja poudariti, da poleg ogljičnega odtisa obstaja še več pomembnih "odtisov", kot sta na primer vodni in ekološki odtis, za katera velja, da nikakor ne bi smela biti v senci ogljičnega odtisa.

Poleg omenjenih konceptualnih pomanjkljivosti ogljičnega odtisa ne gre spregledati tudi številnih metodoloških pomanjkljivosti njegovega določevanja. Še posebej je ta problem prisoten pri določevanju ogljičnega odtisa izdelkov zaradi njihovih kompleksnih okoljskih življenjskih ciklov. Takšno določevanje ni enostavno, saj mora temeljiti na njihovih velikokrat kompleksnih okoljskih življenjskih ciklih. Le-ti vključujejo številne faze: pridobivanje surovin za materialno in energijsko proizvodnjo, transport, proizvodnjo materialov, kemikalij, sestavnih delov, embalaže, proizvodnjo končnih izdelkov, vplive med uporabo ter pri ravnanju z odpadki.
Metodološke pomanjkljivosti določevanja ogljičnih odtisov izdelkov, li lahko močno vplivajo na končno vrednost ogljičnega odtisa, tako zajemajo upoštevanje različnih meja življenjskih ciklov, vpliv energijskih mešanic različnih držav, dostopnost do verodostojnih podatkov o emisijah TGP v fazah pridobivanja

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surovin in tehnoloških postopkov ravnanja z odpadki, izbor pravilnih emisijskih faktorjev ter potencialov globalnega segrevanja (GWP koeficienti) in upoštevanje oz. izvzetje biogenega CO_2 v izračunih [6]. Vse to lahko vodi do neprimerljivosti vrednosti ogljičnih odtisov. Rezultati so torej odvisni od številnih spremenljivk in predpostavk, a tudi poenostavitev, kar praviloma onemogoča neposredno primerjavo rezultatov izračunov in posledično otežuje pravilno komunikacijo z javnostjo [11-12].

Kljub omenjenim metodološkim in konceptualnim pomanjkljivostim sedanji koncept ogljičnega odtisa že pomeni osnovo za nove zakonodajne ter administrativne ukrepe v gospodarstvu (politične zahteve po ogljični nevtralnosti, obdavčitve, poročanje). Pojavljajo pa se tudi konkretni predlogi, da bi sedanji koncept ogljičnega odtisa morebiti uporabil kot mehanizem dodatnega pritiska oz. kontrole državljanov v okviru ideje o določitvi ogljičnih kreditov posameznika (kreditnih točk) kot del ideje o socialnem točkovanju obnašanja oz. aktivnosti ljudi v povezavi z neposredno in posredno povzročenimi emisijami CO_2 [13-15]. In to ne glede na dejstvo, da odstotek globalne elite s svojimi poslovnimi odločitvami ter načinom življenja povzroča vrtoglave količine emisij TGP [16]. Medsebojni preplet omenjenih vidikov shematsko prikazuje slika 1.

Slika 1: Ogljični odtis – preplet različnih vidikov za njegovo razumevanje

3 Metoda LCA – alternative ogljičnemu odtisu

Zaradi omenjenih metodoloških in konceptualnih pomanjkljivosti se je potrebno v takih primerih poslužiti drugih, celovitejših metod vplivov izdelkov, storitev ali organizacij na okolje kot je npr. metoda LCA ('Life Cycle Assessment'). S to kompleksno analitsko metodo določamo vplive izdelkov v njihovih celotnih okoljskih življenjskih ciklih, ki zajemajo pridobivanje surovin, pridobivanje energijskih virov, proizvodnjo in distribucijo potrebne energije, proizvodnjo polizdelkov, izdelkov ter stranskih izdelkov, transport in distribucijo, učinke med uporabo in alternativne možnosti ravnanja z izdelki po uporabi. Vključuje vse snovne in energijske tokove, tudi take, ki bi bili z uporabo drugih metod lahko prezrti. V obravnavanje življenjskega okoljskega cikla nekega proizvoda je vedno vključeno tudi pridobivanje energije, potrebne za pridobivanje surovin, za njegovo predelavo, proizvodnjo, transport, distribucijo, uporabo itn., ki se prične prav tako s pridobivanjem potrebnih energijskih virov. Vendar z metodo LCA masne in energijske vtoke ter iztoke ne le kvantificiramo, ampak jih povežemo z njihovim dejanskim škodljivim učinkom na okolje ter zdravje. LCA analiza lahko vključuje tudi do 20 različnih okoljskih kategorij, kot so npr. ogljični odtis, razgradnja ozonskega sloja, kisli dež, evtrofikacija, emisije trdnih delcev, ekotoksičnost, raba vode, izčrpavanje mineralnih surovin idr. Kar je posebej pomembno, je dejstvo, da so za ovrednotenje oz. preračun vplivov emisij in drugih snovi na okolje ter zdravje uporabljeni najnovejši in znanstveno podprti modeli, kar daje metodi LCA dodatno veljavo glede verodostojnosti rezultatov. Zato s pomočjo metode LCA podjetja ne pridobijo le podatkov, kakšni so vplivi v posameznih fazah življenjskih ciklov, ampak tudi podatke o vplivih na okolje, ki se jih z drugimi metodami ne da določiti.

Ker metoda LCA temelji na okoljskem življenjskem ciklu, se lahko s celostnim pristopom obravnavanja vplivov proizvoda na okolje v večji meri zagotovi, da se identificirajo najbolj relevantni vplivi na okolje v celotnem proizvodno-distribucijskem sistemu in ne nazadnje, da se prepreči, da bi se okoljski vplivi "prestavljali" iz ene faze življenjskega cikla v drugo in obratno (npr. pri menjavi materalov, sestavnih delov, energentov idr.), saj lahko spremembe z izračunom preverimo vnaprej. Poudariti velja, da je metoda LCA edina mednarodno standardizirana metoda za ovrednotenje vplivov izdelkov na okolje, njen metodološki okvir pa definirajo mednarodni standardi družine ISO 14040 [17].

Ogljični odtis je vselej del LCA analiz, kar pomeni, da ima določevanje vplivov izdelkov in storitev na okolje s pomočjo LCA metode številne prednosti pred določevanjem samo ogljičnega odtisa, kar žal počnejo slovenska podjetja in v kar jih z zakonskimi in podzakonskimi akti sili politika. Ogljični odtis izdelka dobi v okviru LCA analiz povsem drugo perspektivo, saj ga primerjamo z ostalimi okoljskimi indikatorji oz. vplivi na okolje. In prav analize LCA nam dokazujejo, da ogljični odtis ni vedno nujno najbolj vplivni okoljski indikatorji v življenjskih ciklih izdelkov v primerjavi z drugimi okoljskimi indikatorji [9,18]. Če se upošteva celotni okoljski življenjski cikel izdelkov in ne le faza uporabe, se tudi zelo spremenijo okoljski profili e-vozil ter tehnologij za pridobivanje energije iz obnovljivih virov (na primer biogoriv) [19] ali solarnih panelov [20].

A vendarle se je potrebno zavedati, da imajo tudi programska orodja, s katerimi modeliramo življenjske cikle v okviru LCA analiz, vgrajene določene modelne spremenljivke ter poenostavitve, s čimer je možno vplivati na končne rezultate, zato takšne študije zahtevajo izkušene in poštene izvajalce, ki uporabljajo najsodobnejšo programsko opremo ter podatkovne baze.

Zaradi vsega navedenega je lahko uporaba izključno ogljičnega odtisa v promocijske namene tudi sredstvo okoljskega zavajanja

(t.i. "greenwashing") (ANEC/BEUC/ECOS/EEB, 2009; Radonjič, 2016).

4 Zaključek

Za Slovenijo je velika popularnost ogljičnega odtisa in intenzivno osredotočanje politike, medijev ter gospodarstva nanj problematično tudi zato, ker bi tudi v primeru popolne ogljične nevtralnosti države to predstavljalo le minoren prispevek h globalni bilanci toplogrednih plinov (še posebej, če k temu prištejemo enormne emisije ogljikovega dioksida ter mnogih škodljivih plinov in delcev zaradi vojaških aktivnosti v svetu) ob istočasnem ignoriranju ali vsaj manjši pozornosti okoljskih problemov, ki pa jih resnično lahko in moramo sami obvladovati, ker neposredno vplivajo na kakovost okolja in zdravja v Sloveniji. S tem je mišljen predvsem odnos do naših sladkih in morskih voda, do uporabe kemikalij v kmetijstvu, izpostavljenosti kemikalijam v izdelkih, varovanje rodovitnih kmetijskih površin, odnos do gozdov, učinkovito ravnanje z odpadki in zmanjševanje tistih izpustov v zrak, ki imajo lokalne ali regionalne škodljive učinke, bodisi zaradi lokalne industrijske proizvodnje, bodisi zaradi transporta. Razumeti ogljični odtis v okviru okoljskih politik zato pomeni razumeti tako njegove metodološke kot konceptualne pomanjkljivosti.

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Ali je prispevek slovenske živinoreje k podnebnim spremembam precenjen?

Is the contribution of Slovenian livestock farming to climate change overestimated?

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POVZETEK

Za živinorejo so značilni veliki izpusti metana. Metan uvrščamo med kratko obstojne toplogredne pline. Za razliko od CO_2, ki se v ozračju zadrži več stoletij, se metan po navedbah zadnjega (šestega) ocenjevalnega poročila Medvladnega odbora za podnebne spremembe (IPCC) oksidira v približno 12 letih. Za poročanje Okvirni konvenciji Združenih narodov o spremembi podnebja (UNFCCC) uporabljamo metodo potencialnega globalnega segrevanja za stoletni časovni horizont (GWP_{100}). V zadnjem času se vse pogosteje pojavljajo kritike, da metoda GWP_{100} ni najbolj primerna za oceno kumulativnega učinka trajnih izpustov kratko obstojnih plinov na podnebje. Raziskovalci so razvili metodo, ki upošteva lastnosti kratko obstojnih onesnaževal zraka (GWP*). Za to metodo je značilno, da bolje napoveduje odziv temperature zemeljskega površja na izpuste kratko obstojnih plinov kot GWP_{100}. S primerjavo obeh metod je bilo ugotovljeno, da metoda GWP_{100} precenjuje prispevek slovenske živinoreje k segrevanju podnebja za 4,6 krat.

KLJUČNE BESEDE

podnebne spremembe, živinoreja, metan

ABSTRACT

Livestock farming is characterized by high methane emissions. Methane is classified as a short-lived greenhouse gas. Unlike CO_2, which remains in the atmosphere for centuries, methane oxidizes in about 12 years, according to the latest (sixth) assessment report of the Intergovernmental Panel on Climate Change (IPCC). For reporting to the United Nations Framework Convention on Climate Change (UNFCCC), we use the 100-year global warming potential (GWP_{100}) method. Recently, there has been increasing criticism that the GWP_{100} method is not the most appropriate method to assess the cumulative impact of persistent emissions of short-lived gasses on the climate. Researchers have developed a method that takes into account the characteristics of short-lived air pollutants (GWP*). This method is characterized by a better prediction of the response of the Earth's surface temperature to emissions of short-lived gasses than GWP_{100}. When comparing the two methods, it was found that the GWP_{100} method overestimates the contribution of Slovenian livestock farming to climate warming by a factor of 4.6.

KEYWORDS

climate change, livestock farming, methane

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1 UVOD

V javnosti je splošno razširjeno mnenje, da je intenzivna evropska intenzivna živinoreja med najpomembnejšimi vzroki podnebnih sprememb. K temu je veliko prispevalo FAO poročilo Dolga senca živinoreje (Livestock's long shadow) [1]. Najpogosteje izpostavljeno sporočilo, ki so ga mediji posredovali javnosti je, da je živinoreja glavni povzročitelj izpustov toplogrednih plinov (TGP) in da je odgovorna za 18 % izpustov, kar presega izpuste iz prometa. Ob tem sporočilu so bile izražene kritike intenzivne evropske živinoreje, zamolčano pa dejstvo, da se struktura izpustov TGP v Evropi precej razlikuje od izpustov na globalni ravni, saj je raba fosilnih goriv v prometu, industriji in v gospodinjstvih nadpovprečna, število živine pa razmeroma majhno. Zamolčan je bil podatek istega poročila [1], da je prispevek Zahodne Evrope in Severne Amerike k skupnim (globalnim) izpustom metana iz prebavil rejnih živali le nekaj več kot desetina (10,75 %). Le malokdo se zaveda, da je število goved v Afriki (189,6 milijonov) približno dvakrat večje kot v Evropi (celina) (92,1 milijonov, v glavah velike živine) [2].

Za živinorejo so značilni veliki izpusti ne-CO_2 toplogrednih plinov, predvsem metana. Različni toplogredni plini se v njihovem učinku na segrevanje podnebja razlikujejo. Za namene poročanja o emisijah TGP jih preračunamo v ekvivalente (ekv) ogljikovega dioksida z upoštevanjem potenciala globalnega segrevanja za stoletni časovni horizont (Global Warming Potential, GWP_{100}). Po tej metodi je slovenska živinoreja po zadnjih podatkih (za leto 2022) prispevala 8,35 % vseh emisij TGP v Sloveniji. K temu so

največ prispevali izpusti metana iz prebavil (6,31 %), sledili so izpusti metana iz skladišč za živinska gnojila (1,61 %), izpusti didušikovega oksida iz skladišč za živinska gnojila (0,27 %) in posredni izpusti didušikovega oksida, ki nastanejo zaradi uhajanja dušikovih spojin iz hlevov in skladišč za živinska gnojila [3]. K izpustom v živinoreji je največ prispevala govedoreja (92,7 %), sledile so reja prašičev (2,6 %), perutnine (1,6 %), ovc (1,7 %), koz (0,3 %), konj (0,9 %) in kuncev (manj kot 0,1 %) [3].

Ocenjevanje vpliva človekovih dejavnosti na spremembe podnebja na podlagi GWP_{100} sega v obdobje prvega poročila Medvladnega odbora za podnebne spremembe, ki je bilo izdano v letu 1990. Že ob uveljavitvi tega koncepta je bilo prepoznano, da ima ob prednostih (t.j. predvsem enostavna implementacija), tudi resne pomanjkljivosti [4]. Od metode za postavitev različnih TGP na skupni imenovalec pričakujemo predvsem, da bo realno ocenila učinek izpustov teh plinov na spremembe temperature zemeljskega površja. Smith in sod. [5] so opozorili, da koncept GWP_{100} slabo oceni odziv temperature na kumulativne izpuste kratko obstojnih toplogrednih plinov, med katerimi je tudi metan. Za razliko od CO_2, ki ostane v ozračju več stoletij, se metan relativno hitro oksidira (približno 12 let) [6]. Koncept GWP_{100} tega ne upošteva. Za realnejšo oceno vpliva izpustov metana na podnebje so raziskovalci nedavno razvili nov način za preračun izpustov različnih toplogrednih plinov na skupni imenovalec, ki upoštevajo, da je metan v atmosferi kratko obstojen (GWP*) [7, 8, 9].

Za dolgo obstojne TGP je značilno, da se v ozračju akumulirajo. Vsak enkratni izpust (npr. izpust v tekočem letu) poveča koncentracijo plina v ozračju in četudi takoj prenehamo z novimi izpusti, se koncentracije tega plina ne bodo zmanjšale. Vsak enkratni izpust dolgo obstojnega TGP pomeni dodatno segrevanje, ki ga je treba prišteti k učinku vseh izpustov tega plina v zgodovini. Pri metanu je drugače. Koncentracija v ozračju ni odvisna le od izpustov v tekočem letu, ampak tudi od obsega oksidacije metana, ki smo ga v ozračje izpustili v preteklosti. V ozračju se sproti vzpostavlja novo ravnovesje. Če letne izpuste ohranjamo na ravni iz preteklosti, se koncentracije ne spreminjajo. Če letne izpuste povečujemo, se povečujejo tudi koncentracije v ozračju in če jih zmanjšujemo se koncentracije zmanjšajo. GWP* to upošteva in je razmeroma dober približek podnebnemu modelu. Na drugi strani pa GWP_{100} v primeru vzdržnih ali padajočih izpustov metana prikriva napredek proti podnebnemu cilju, ki ga Pariški sporazum določa v °C glede na predindustrijsko dobo [10].

Problematika ocenjevanja izpustov metana na podnebje je bolj obsežno in poglobljeno obravnavana v zadnjem (šestem) ocenjevalnem poročilu Medvladnega odbora za podnebne spremembe. Ugotavljajo, da metoda GWP_{100}, ki jo uporabljamo za poročanje Okvirni konvenciji Združenih narodov o spremembi podnebja (UNFCCC), ni najbolj primerna za oceno kumulativnega učinka trajnih izpustov kratko obstojnih plinov na podnebje [11]. Medvladni odbor v zadnjem poročilu ni priporočil nobene od obravnavanih metodik za preračun izpustov različnih TGP na skupni imenovalec [6]. Zapisali so, da je izbor najprimernejše metrike odvisen od namena primerjave. Na 27. Konferenci pogodbenic Okvirne konvencije Združenih narodov o spremembi podnebja v Sharm El–Sheikhu je bilo izglasovano, da lahko pogodbenice ob GWP_{100} dodatno poročajo tudi na podlagi alternativnih metod, kot je GWP* [12].

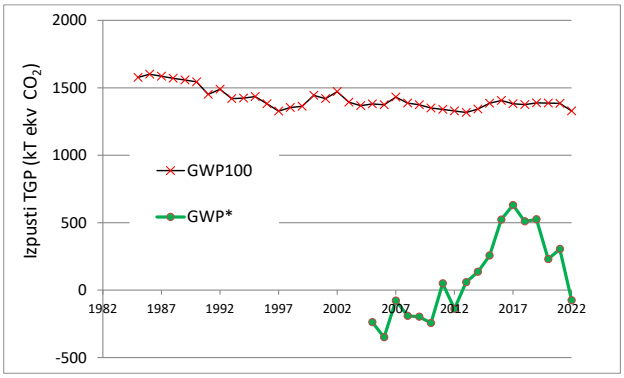
Namen tega prispevka je prikazati, kakšen je prispevek slovenske živinoreje k izpustom toplogrednih plinov, če le tega ocenimo z metodo, ki upošteva obstojnost metana v ozračju (GWP*). Rezultate smo primerjali z rezultati po metodi, ki je splošno uveljavljena za poročanje UNFCCC (GWP_{100}).

2 METODE

Podatke o izpustih metana in didušikovega oksida za obdobje 1985-2022 smo zajeli iz emisijskih evidenc Kmetijskega inštituta Slovenije [3]. Gre za izvorne podatke, ki so uporabljeni za poročanje UNFCCC [13]. Za živinorejo smo upoštevali izpuste metana iz prebavil rejnih živali, izpuste metana iz skladišč za živinska gnojila, izpuste didušikovega oksida iz skladišč za živinska gnojila in posredne izpuste didušikovega oksida, ki nastanejo zaradi uhajanja dušikovih spojin iz hlevov in skladišč za živinska gnojila. Podatki o izpustih metana in didušikovega oksida so bili preračunani v ekvivalente CO_2 ob upoštevanju potencialov globalnega segrevanja za stoletno časovno obdobje (GWP_{100}), kot je trenutno v veljavi za poročanje UNFCCC (faktor 28 za metan in faktor 265 za didušikov oksid). Podatke o izpustih TGP iz živinoreje smo preračunali v ekvivalente CO_2 tudi z alternativno metodo GWP*. Pri tem smo za didušikov oksid uporabili enak postopek kot za GWP_{100}, za metan pa metodo po Cain in sod. [7].

3 REZULTATI IN RAZPRAVA

Podatki o izpustih TGP v slovenski živinoreji so predstavljeni na Grafu 1. Za GWP_{100} razpolagamo s podatki za obdobje 1985-2022. Za GWP* razpolagamo le s podatki po letu 2005. Ker je ocena po GWP* odvisna tudi od preteklih izpustov, podatkov pred tem letom ni mogoče izračunati. Primerjava kaže, da je prispevek slovenske živinoreje k podnebnim spremembam z metodo GWP_{100} zelo precenjen. V obdobju 2005-2022 so se izpusti gibali od 1318 do 1432 kT ekv CO_2. Po metodi GWP* smo imeli v znatnem delu tega obdobja negativne izpuste (obdobje 2005-2010, 2012, 2022). Za leta z negativnimi izpusti je bilo ocenjeno, da je obseg oksidacije metana iz preteklih izpustov presegel izpuste iz tega leta in da je razlika izničila tudi izpuste didušikovega oksida. Povprečje za obdobje 2018-2022 kaže, da metoda GWP_{100} precenjuje prispevek slovenske živinoreje k segrevanju podnebja za 4,6 krat (izpusti po GWP_{100} in GWP* so bili v povprečju 1373 in 299 kT ekv CO_2 na leto). Metoda preračunavanja posameznih TGP zelo vpliva tudi na strukturo izpustov. Po metodi GWP_{100} je prispevek slovenske živinoreje k skupnim izpustom (vsi sektorji) ocenjen na 8,33 %, po GWP* pa na 2,40 % (ocena za obdobje 2018-2022, pri čemer so bili pri skupnih izpustih za GWP* korigirani tudi izpusti metana iz drugih sektorjev). Vedeti moramo, da k ugodnemu rezultatu za živinorejo po GWP* prispeva predvsem razmeroma uspešno zmanjševanje izpustov metana v preteklem obdobju. V primeru hitrega povečevanja izpustov namreč ocene po GWP* presegajo ocene po GWP_{100}. V Sloveniji na to kaže primer reje drobnice, kjer so bili v obdobju 2005-2015 izpusti po GWP* dva do trikrat večji kot po GWP_{100} [14].



Graf 1: Primerjava metod GWP_{100} in GWP* za preračun izpustov toplogrednih plinov v slovenski živinoreji v ekvivalente CO_2. Prikaz zajema tako izpuste metana kot didušikovega oksida.

Nov način obračunavanja toplogrednega učinka metana ne pomeni, da so prizadevanja za zmanjšanje izpustov nepotrebna. Metan je zelo potenten toplogredni plin. V kolikor se zaradi povečevanja izpustov koncentracije v atmosferi povečujejo, se podnebje segreva hitreje, kot kaže GWP_{100}. Na drugi strani pa lahko z zmanjšanjem izpustov metana zmanjšamo koncentracije v ozračju in s tem planet ohladimo. Evropa je ta potencial v precejšnjem obsegu že izkoristila, saj je edini kontinent, na katerem se izpusti metana iz živinoreje zmanjšujejo že nekaj desetletij [15]. Za Nemčijo imamo tudi ocene za čas izpred več kot 100 let. Izpusti metana iz prebavil rejnih živali so že od leta 2003 pod ravnjo iz leta 1892 [16]. To pomeni, da je bil prispevek nemške živinoreje h koncentracijam metana v ozračju pred 130 leti večji kot sedaj. Potencial za nadaljnje zmanjševanje emisij iz evropske živinoreje obstaja, je pa njegov pomen za podnebne spremembe razmeroma majhen. Na globalni ravni prispevajo naravni viri 50,5 % vsega metana, fosilna goriva 17,4 %, živinoreja 15,1 %, deponije in odpadki 8,9 %, gojenje riža 4,1 %, sežiganje biomase 2,3 % in raba biogoriv 1,6 % [15]. Prispevek evropske živinoreje k skupnim globalnim izpustom je 1,5 % [15] in za toliko bi se zmanjšala koncentracija metana v ozračju, če bi ukinili vso evropsko živinorejo.

Uporaba metode GWP* je deležna precej pozornosti tako v znanstveni in strokovni literaturi, kot tudi v javnih medijih. Ob izpostavljanju njenih prednosti je deležna tudi kritik glede pravičnosti in poštenosti [17] in zlorab v smislu prikazovanja podnebne nevtralnosti živinoreje [18]. Do držav, ki so v preteklosti izkazovale velike izpuste in so te izpuste v zadnjih 20 letih zmanjšale, je metodika GWP* kljub velikim izpustom metana na prebivalca zelo prizanesljiva [17]. To sicer velja tudi za GWP_{100} saj so praktično vse mednarodne zaveze na področju blaženja podnebnih sprememb določene v % glede na izhodiščno leto. Res pa je, da pride zaradi kratke obstojnosti in s tem specifičnega izračuna GWP*, vsako zmanjšanje izpustov metana bolj do izraza, kot kažejo absolutne vrednosti izpustov. Pri morebitnem omenjanju podnebne nevtralnosti živinoreje moramo biti precizni in navesti, ali se le ta nanaša le na metan, ali pa tudi na didušikov oksid (kot na grafu 1) ali pa tudi na druge z živinorejo povezane toplogredne pline, ki jih UNFCCC ne poročamo v sklopu sektorja živinoreja.

Sklenemo lahko, da splošno uveljavljena metoda obračunavanja ekvivalentov CO_2 močno precenjuje učinek slovenske živinoreje na segrevanje podnebja. Z nadaljnjim zmanjševanjem izpustov metana v živinoreji lahko sicer prispevamo k ohlajanju podnebja, pri tem pa je potencial evropske živinoreje zaradi zmanjšanja emisij v preteklosti in zaradi obsežnih drugih virov razmeroma majhen.

4 ZAHVALA

Prispevek je bil pripravljen v sklopu projekta V5-2366 »Ovrednotenje dejavnikov za učinkovito zniževanje emisij toplogrednih plinov«, ki ga sofinancirata Agencija za raziskovalno dejavnost Republike Slovenije (ARIS) in Ministrstvo za okolje, podnebje in energijo Republike Slovenije (MOPE) in v sklopu raziskovalnega programa »Trajnostno kmetijstvo« (P4-0133), ki ga sofinancira Agencija za raziskovalno dejavnost Republike Slovenije (ARIS) iz državnega proračuna.

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Oblikovanje specifičnih habitatov kot ukrepanje za zmanjšanje vplivov hidroelektrarn na okolje

Design of specific habitats as a measure to reduce the impacts of hydropower plants on the environment

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Povzetek

Zajezba na vodotoku je tisti del vsake hidroelektrarne, ki predstavlja največjo spremembo v prostoru in ima velik vpliv na okolje v času obratovanja HE. Sodobni pristopi k umeščanju akumulacij zahtevajo celovit in multidisciplinaren pristop ter vključitev različnih deležnikov. Vključevanje širokega kroga strokovnjakov iz različnih področij po eni strani odpre veliko vprašanj, po drugi strani pa omogoči takšno ukrepanje, ki zmanjša vpliv ob umestitvi objekta in tudi v času obratovanja. Primer iz prakse so pretočne akumulacije na spodnji Savi, kjer so se v času gradnje uredili nadomestni habitati, v času obratovanja pa se na podlagi monitoringov in sodelovanja s strokovnjaki s področja ekologije, biologije in drugih naravoslovnih ved zbirajo podatki in oblikujejo nova znanja o prostoru. To omogoča prilagajanje spremembam v naravi, ki so neizbežne: ravno narava je tista, ki daje prostoru dinamiko. Statični objekti, kakršne naj bi bile hidroelektrarne, se morajo prilagajati tej dinamiki z novimi ukrepi, ki ne nasprotujejo naravi temveč sprejemajo nove naravne danosti in gradijo na prednostih, ki jih pretočne akumulacije nudijo. Vzdrževanje hidroelektrarn naj bi bila načeloma rutinska aktivnost. Vendar nova spoznanja v migracijah organizmov (na primer ribe), prihod novih vrst v prostor (na primer bober), širjenje novih tujerodnih vrst (trikotna ladjica), spremembe v hidrološkem režimu reke (prehod Save iz snežno-dežnega režima v dežni režim) in klimatske spremembe zahtevajo razvoj in prilagajanje. Vsi novi ukrepi se dandanes morajo izpeljati po načelih krožnega gospodarstva, upoštevati pa je potrebno tudi spremljanje ogljičnega odtisa, kar je pri aktivnostih vezanih na sedimente vse pomembnejše vprašanje. V družbi HESS imamo postavljen dvojni sistem: spremljanje stanja pretočnih akumulacij v našem upravljanju na eni strani in oblikovanje nabora zaželenih ukrepov za povečanje okoljske in družbene vrednosti. Sistem omogoča primerjavo obeh sklopov in ukrepanje na način, da se ob vsaki sanaciji ali modifikaciji doseže dodana vrednost. Primerov tovrstnega ukrepanja na spodnji Savi je veliko, trenutno v fazi realizacije je projekt ureditve brežine Kompolje an pretočni akumulaciji HE Boštanj.

Ključne besede

Zmanjšanje vplivov energetskih objektov, večanje okoljske vrednosti, vzdrževanje z dodano vrednostjo, ekološka gradnja, sonaraven razvoj

Abstract

Basin of each Hydropower plant represents the biggest spatial change and has the biggest impact on the environment during the operation of the HPP. Modern approaches to the implementation of the basin require a comprehensive and multidisciplinary approach and the involvement of various stakeholders. The involvement of a wide range of experts from different fields opens up many questions. On the other hand it enables such action that minimizes the impact while building the HPP and also during operation. On the lower Sava several examples of good practice can be seen. During construction substitute habitats were arranged and during operation data is collected and new knowledge about ecosystem is developed based on monitoring and cooperation with experts in the field of ecology, biology and other natural sciences. This is the basis of adaptation to the changes in nature, which are imminent. Facilities, such as HPP are designed to be static but that is not how nature works. We must adapt to dynamic dictated by nature with new measures that do not oppose but accept new natural conditions and build on the advantages that HPP basins offer. Maintenance of hydroelectric power plants is supposed to be a routine activity in principle. However, new findings in the migration of organisms (for example different fish species), the arrival of new species in the area (for example beaver), the spread of new non-native species (triangle boat), changes in the hydrological regime of the river (the transition of the Sava from a snow-rain regime to a rain regime) and climate change requires development and adaptation. All new measures nowadays must be carried out according to the principles of the circular economy, also the carbon footprint must be taken into account, which is an increasingly important issue for activities related to sediments. At HESS, we have a dual system when designing modifications of the HPP basins: on the one hand, monitoring of the basins. On the other hand creating a set of desirable measures to increase environmental and social value. This enables the comparison of the two data sets and achieving added value with each renovation or modification.

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There are many examples of good practices on the lower Sava river developed by this principle. Currently the project to improve the bank of Kompolje at the Boštanj HPP is in the phase of development.

Keywords

Reducing the impact of energy facilities, increasing the environmental value, maintenance with added value, eco-development, sustainable development

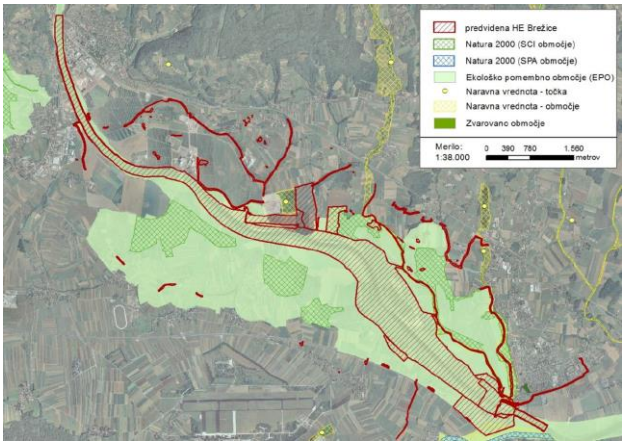
1 Uvod

Razmišljanje o varovanju narave ob umeščanju novega objekta ali nove ureditve v prostor je dejansko primerjava med tistim, kar je, in tistim, kar bo. Zatakne se že pri prvem delu: tistim, kar je, oziroma povedano drugače, stanje, v katerem je narava v tem trenutku. Ali je stanje v tem trenutku res tisto, kar želimo ohranjati? Če govorimo o rekah, varstveniki v Srednji Evropi pogosto štejejo, da je bilo »optimalno naravno« stanje rek v obdobju med 1800 in 1850, ko je bila »dosežena« največja vrstna pestrost v biološkem smislu [1], [2]. Če upoštevamo podatek, da je po ocenah v Srednji Evropi tako ali drugače degradiranih 95% vodotokov, se dandanes torej neizogibno že v štartu vedno pogovarjamo zgolj o tem, kako zelo je stanje degradirano. Ali pri spreminjanju (umeščanju novega objekta oz. ureditve) torej resnično želimo ohraniti to, kar je, se pravi degradirano stanje? Vsaj nekateri bodo rekli, da ne. Želimo si več, nekaj boljšega. Tudi ostali, bolj previdni, se bodo verjetno strinjali, da je nekaj boljšega vsekakor zaželeno.

Drugi del uvodnega stavka »kar bo« se nanaša na načrtovanje in predvidevanje, v kakšnem stanju bo narava po izgradnji oz. po ureditvi. Sodobni pristop je vključevanje širokega nabora strok in znanj, s ciljem nedvoumno zapisati kaj in kako mora biti. Nesporno danes vemo veliko. Znanstveni pristop je temelj današnjega razvoja, zato naj bi mu sledili vsi naravoslovni strokovnjaki (tako inženirji kot biologi). Vendar znanstveni pristop od nas zahteva tudi pogled na celotno sliko (ne spreglejmo gozda pri proučevanju listov). Zanimiv primer je širjenje pristanišča v Singapurju. Habitati in z njimi celoten ekosistem so seveda popolnoma drugačni kot v Sloveniji, posegi in posledice kot proces ter kvaliteta in strokovnost napovedi pa so poučne. Singapur s pristaniščem je eno najhitreje razvijajočih se območij na svetu in je v direktni koliziji s koralnim grebenom, ki je nekoč pokrival več kot 100 km2. Niti nasprotniki uničevanja koralnega grebena niti strokovnjaki na investitorjevi strani pa niso pričakovali, da se bodo korale in z njimi celotni koralni ekosistem pojavil na podvodnih pilotih pomolov [3]. Ko so ugotovili razcvet narave na podvodne stebre, je bilo retrospektivno logično, da se bo to zgodilo: gre za ogromno novih površin, točno na globini z dobro osvetljenostjo in pod vplivom neurij, ter za zaščiteno območje, na katero plovba ne vpliva (pod pomoli). Nekaj, kar je iz retrospektivnega vidika samoumevno, ni znal (pred tem) nihče napovedati.
Znanstveno se je vprašati: Česa vse še ne vemo?

2 Primeri »naravnih« habitatov

Preselimo se bližje nam, v Slovenijo, na spodnjo Savo. V trenutku umeščanja HE Brežice v prostor so strokovnjaki ustvarjali rešitve (prostorske ureditve), ki bi v naravi ustvarile določene pogoje in prostor za življenje določenih organizmov. Pri tem so se strokovnjaki v veliki meri naslanjali na elemente, ki jih je ustvarila narava in so (bili) domovanje številnih organizmov: Poplavni gozd imenovan Vrbina pri Brežicah, gramozne jame, suhi travniki, mlake in jezera. Pa jih je res ustvarila narava?

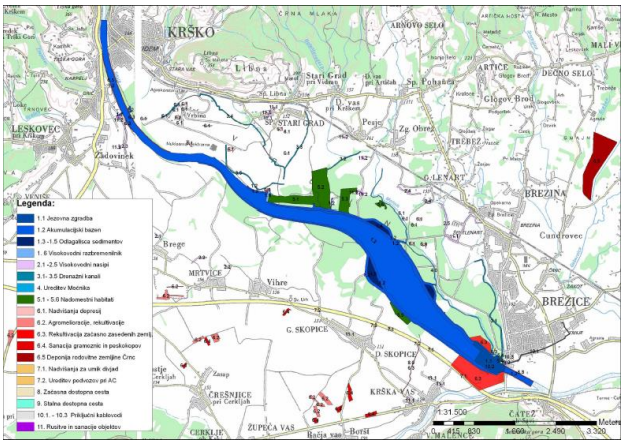


Slika 1: Varovana območja in prikaz infrastrukturnih ureditev HE Brežice [5]

V poplavnem gozdu Vrbina pri Brežicah rastejo v večini topoli, ki so jih zasejali od leta 1952 naprej za potrebe proizvodnje papirja v Tovarni papirja Krško. Gre za v vrste zasajene topole, celoten nasad, na začetku velik 17 ha, v letih največjega obsega pa je pokrival 555 ha. Razdeljen je bil v kvadrante in ločen s pravokotnimi gozdnimi cestami. Posamezne kvadrante so izsekavali z golosekom, ko je bila lesna masa zrela, in zasajevali s sadikami, ki so jih gojili v bližnji drevesnici. Da so ustvarili prostor za nasad topolov, so izkrčili dotedanji poplavni gozd, ki ga je pred tem sestavljal dob (vrsta hrasta). Dob je veličastno drevo, visoko do 40m in s premerom debla tudi več kot 2m. Topol je hitro rastoče drevo, ki hitro nabira lesno maso in je po 8-10 letih pri debelini debla 20 cm že primerno za posek [4]. Sprememba iz naravnega dobovega poplavnega gozda v topolov nasad je nedvomno pomenila izredno osiromašenje ekosistema. Šlo je za industrijski poseg brez okoljevarstvenega razmisleka. Zadnje zasaditve so se izvajale leta 2009, od takrat naprej pa nasad »propada«. Propada seveda le z vidika industrije in proizvodnje lesne mase, z vidika naravovarstva pa se je takrat pričelo uravnoteženje ekosistema z naravnim procesom naseljevanja drugih organizmov in upadanjem monokulture (topola), ki je z vidika narave nevzdržna. V teh razmerah so se na območju naselili nekateri organizmi, med drugimi tudi hrošč škrlatni kuku, ki je v odmirajočem lubju dreves našel zanj bogat življenjski prostor. Rezime: Pri gradnji HE Brežice smo varovali umetno ustvarjen habitat, za katerega se ob nastanku ni smatralo, da bo imel kakšno naravovarstveno vrednost (nasad monokulture), pri čemer se varuje takšno stanje habitata, ki je iz naravnega vidika nevzdržno (naravno nevzdržna prevlada enega

tipa habitata, ki je na kratek rok povzročil ekspanzijo določenega tipa organizma).

Reka Sava je pred izgradnjo HE Brežice predstavljala cca 90m široko strugo v obliki trapeznega korita z utrjenimi brežinami in poplavnim območjem okoli struge. Poplavno območje je bilo ponekod omejeno z varovalnimi nasipi, kjer ni bilo ogroženih objektov, pa se je prosto razlivala. Gramozne jame oz. gramoznice so jame, iz katerih se izkopava gramoz. Ker segajo pod gladino podtalnice, gre v naravi za jezera. Navadno se gramoznica širi v eno stran, tako da se fronta izkopa premika, preostale brežine pa se sčasoma zarastejo in postanejo domovanje za številne organizme. Umetna jama torej s časoma ustvari različne tipe habitatov; od strmih brežin do položnejših, od golih do zaraščenih, od čiste prodnate obale do korenin in mulja v plitvini. S poplavljanjem reke se v ta vodna telesa naselijo ribe, poplavno premeščanje sedimenta pa premesti tudi organizme iz dna vodotoka, ki predstavljajo hrano ribam in dvoživkam. Dvoživke s selitvijo najdejo nove vodne površine, ptiči in mrčes se naselijo še hitreje. Osredotočimo se na ptice, posebej ogrožene vrste lastovke breguljke in čebelarje. Te ptice vsako leto ob selitvi iz Afrike poiščejo sveže erodirano območje ob reki, kjer je voda ob zadnjih spomladanskih poplavah odnesla breg in ustvarila strmo prodnato brežino. V brežini izkopljejo rov v produ, strma brežina nad vodo pa jih varuje, da do gnezd ne pridejo kače in lisice. Reka Sava je prenehala odnašati brežine zaradi stoletja ukalupljanja v trapezoidno strugo z utrjenimi brežinami. Klimaks ukalupljanja se je odvil med leti 1850 in 1950 z gradnjo južne avstroogrske železnice (odsek Zidani Most – Sisak), z gradnjo cest (ob spodnji Savi je potekala že rimska cesta med Celeio (Celje) in Neviodunum (Drnovo pri Krškem, kjer je bilo pomembno pristanišče), s širitvijo mest in razvojem industrije (Radeče, Sevnica, Krško), ne gre pa zanemariti niti vpliva širjenja obdelovalnih površin. Tudi v času Jugoslavije se je ukalupljanje nadaljevalo, kar je lepo razvidno iz katastra vodnogospodarskih ureditev. Rezultat ukalupljanja pa je fiksirana brežina, ki je voda ne erodira in ne ustvarja novih golih strmih brežin, ki jih potrebujejo breguljke in čebelar. Zato so ptice našle nove lokacije vedno novih primernih brežin – v gramoznicah, točno na fronti odkopa, kjer je vsako leto sveža brežina.



Slika 2: Prostorski prikaz posegov ob gradnji HE Brežice [5]; opis nekaterih oznak, za pojasnilo opisov v članku: 5.1, 5.2 in 5.5 so Nadomestni Habitati (NH) 1, 2 in 5, ki predstavljajo nove vodne površine kot nadomestilo za nekdanje gramoznice. 5.3 je NH3, ki v južnem delu predstavlja nove gozdne površine, v severnem delu pa novi suhi travnik. 5.6 je NH6, kjer se nahaja jezero/mlaka za želvo sklednico.

Rezime: Gramoznica je škrbina v okolju (za vsako gramoznico se mora v sklopu pridobitve koncesije izdelati tudi projekt sanacije). Ob podeljevanju koncesij za izkop se gramoznice obravnavajo kot poseg v okolje brez kakršne koli ekološke vrednosti. V primeru gradnje pretočne akumulacije HE Brežice, s katero se je potopilo nekaj gramoznic, pa se je te "škrbine" moralo nadomestiti, tako da so se zgradile nove, nadomestne prodne stene nad vodno površino, s katerimi se je simuliralo habitate v gramoznicah.

3 Primeri »umetnih« habitatov

Je habitat lahko umeten? Habitat je življenjski prostor, torej nekaj naravnega. Če ga zgradi človek, je lahko to naravno? Bistvo narave so procesi, procesi ustvarjajo spremembe, ravno spremembe pa so tista dinamika, ki ustvarja pestrost habitatov, kot na primer različne globine vode, različne brežine gramoznic, različna kvaliteta prsti, različna granulacija sedimenta. Te razlike omogočajo različnim organizmom lokalne pogoje za življenje, zato je ta dinamika tako pomembna. Ko gradi človek, navadno gradi nekaj fiksnega, nekaj, kar bo stalo čvrsto skozi celotno življenjsko dobo. Vsak objekt mora izpolnjevati bistvene lastnosti. Je to združljivo z naravo?

V prejšnjem poglavju opisano ukalupljanje reke je Savi onemogočilo premikanje struge. Kot že omenjeno, je bila reka Sava pred izgradnjo HE Brežice široka cca 90m. Kartografski arhivi avstro-ogrskih katastrov pa na območju Brežic prikazujejo reko, katere glavna struga je široka 500m, zraven nje pa več stranskih strug, rokavov, meandrov in drugih oblik (okljuki, zalivi, mrtvice, jezera…). Vse te oblike nastajajo, ko reka ob poplavah ustvarja novo glavno strugo, stara struga pa se postopoma zamulji, preide v rokav, nato jezero, nato mrtvico, mlako, močvirje in na koncu v suha (občasno poplavljena) tla. Takšne reke od 19. stoletja pri Brežicah ni več, še vedno pa so ostanki nekdanjih strug in drugih vodnih oblik. Tovrstne mlake in močvirja so (bila) pester habitat in zato se je ob gradnji HE Brežice zgradilo nove tovrstne oblike. V prostor se je torej želelo umestiti nekaj, kar je izgubil že več desetletij nazaj. Ni se zgolj ohranjalo stanje reke pred izgradnjo HE Brežice, temveč se je želelo »izboljšati« trenutno stanje narave. Primer takšnega ukrepa je habitat imenovan NH6, ki je bil prioritetno namenjen želvi sklednici. Habitat se je zasnoval kot napol jezero in napol mlaka, z dinamično brežino in globinami ter dovolj golega, prodnatega prostora ob vodi, kjer si lahko želve ustvarjajo gnezda in se sončijo. Vsi podatki po izgradnji so kazali na uspeh. Po nekaj letih »obratovanja« habitata pa so se zgodile določene spremembe: ker ni tekoče vode, ki bi občasno poplavila prodišče, se slednje zarašča in želve izgubljajo prostor za sončenje. Iz bližnjega potoka je bober skopal kanal do mlake in si v mlaki zgradil gnezdo. Po kanalu dostopa do tekoče vode in preko nje do prostora za hranjenje. Narava gre svojo pot. Potekajo naravni procesi, s katerim pa izgubljamo prvoten namen habitata. Ali je ta objekt uspešno zgrajen? Ali uspešno »obratuje«?

Slika 3: Nadomestni habitat 6 (NH6), namenjen želvi sklednici, cca 2 leti po izgradnji. Vidne so prvotno gole površine proda, ki se postopoma zaraščajo. Na desni je vidno porušeno drevje, kjer je aktiven bober [8].

Suhi travniki so nastajali na območjih, kjer je reka nasipala prod. Takšna neugodna rastišča so najprej naselile pionirske rastline, ki so ustvarile tanek sloj humusa, slednji pa je omogočal razrast nezahtevnih rastlin. Večje rastline je ob poplavi odneslo in s tem je nastal specifičen travniški habitat s pestrim ekosistemom rož, med katerimi je 25 ogroženih vrst [5]. Ob umeščanju HE Brežice v prostor se je rezerviral tudi prostor za tovrstne habitate, imenuje se NH3. Pred pripravila so se tla in simulirali pogoji, kakršni majdemo na naravnih suhih travnikih. Tako kot vsaka naravna oblika, tudi suhi travniki preidejo v naslednji stadij, saj večanje debeline humusa tudi večjim rastlinam omogoči, da ustvarijo dovolj bogat koreninski sistem, ki zdrži poplave. S časoma tako travnik preide v gozd. Če se ta naravni proces odvije na zgrajenem habitatu, kateremu je dodeljen namen, ali je projekt uspešen? Ali habitat obratuje uspešno, ali se bo okrivilo tistega, ki je zadolžen za vzdrževanje, da ni ohranjal ustreznih pogojev (ni ohranjal tal dovolj siromašnih)?

4 Ima naravni habitat fazo obratovanja?

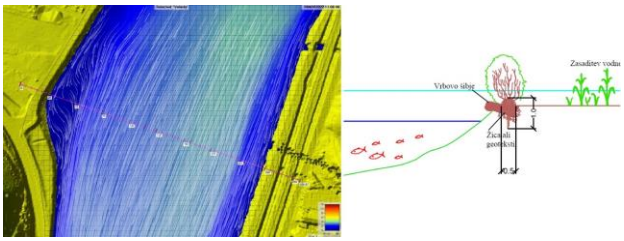
Na spodnji Savi trenutno obratuje 5 HE s pripadajočo vplivno površino. Ukrepi, izvedeni v času gradnje posamezne HE, so predani različnim upravljalcem. To še posebej velja za HE Brežice. Pri gradnji prejšnjih elektrarn se je malo ali delno dajala pozornost naravi, HE Brežice pa je pilotni projekt v Sloveniji, celo v svetu, glede pozornosti, ki se je namenila naravi. V prvi vrsti se je opredelilo vse naravne vrednosti, nato razmišljalo o možnih ukrepih, se ukrepe zasnovalo ali sprojektiralo in na koncu so se objekti in ureditve zgradili, aktivnosti in procesi pa pričeli, pri čemer se je določil tudi izvajalec teh aktivnosti. Na primer, obratovanje prehoda za vodne organizme za premostitev višinske razlike v gladinah vode nad in pod jezovno zgradbo, v katerem se mora ohranjati ustrezna vodnatost/pretočnost ne glede na hidrološko-hidravlične pogoje v reki Savi. Drug primer je že omenjena brežina za breguljke in čebelarje; ker ni vode, ki bi erodirala, niti ni izkopa gramoza, ki bi ustvarjal svež izkop, je potrebno ohranjati strmo brežino na način, da se odkoplje tisti material, ki ga padavine erodirajo. Tam, kjer je predpisano navodilo za vzdrževanje, torej lahko govorimo o obratovanju, tudi če gre za naravovarstveno ureditev. Ribe namreč plavajo skozi prehod za vodne organizme, celo veliko jih je, in ptice tudi kopljejo vsako leto nova gnezda v umetno zgrajenih brežinah. Kjer je naravna oblika ustvarjena, pa je ocenjevanje uspešnosti nesmiselno. Narava je namreč vedno uspešna, vprašanje je samo, ali je ljudem njena rešitev všeč. Obratovanje torej ne obstaja, saj je obratovanje po definiciji ponavljajoč proces. Gonilo narave pa je sprememba.

5 Pristop k izgradnji novega naravnega habitata

Sedaj znamo pristopati znanstveno in multidsciplinarno, zavedamo se, kako »deluje« narava, razumemo spremembe v naravi, poznamo pomen naravnih oblik in opremljeni smo z znanjem (tako tehničnim kot biološkim), kako oblikovati prostor na način, da bo primeren za izbrane organizme.

Slika 4: Otok nanosa (sedimenta) na pretočni akumulaciji HE Boštanj na reki Savi [6].

Na pretočni akumulaciji HE Boštanj se v bližini naselja Kompolje nahaja zožitev struge. Pred zožitvijo ob desnem bregu voda zaradi hidravličnih razmer zastaja in odlaga nanos (imenovan tudi sediment). Ker voda v pretočni akumulaciji dnevno niha zaradi proizvodnje električne energije in ker je odloženega že toliko nanosa, je tam pogosto viden otok. Ker je nanos, ki ga nosi reka Sava, v glavnem zelo drobnozrnat in z veliko organskimi primesmi, otok izgleda kot kup mulja. Fizikalne lastnosti tega materiala so takšne, da zadržuje vodo. Ker je lahek, se ne posede, ne konsolidira in zaradi tega tudi ne more ustvariti dovolj čvrste podlage, na kateri bi se lahko naselile rastline, čeprav je semen v vodi vse polno, kakor pričajo različna testiranja, ki smo jih opravili. Ideja je torej, da ne obnovimo brežine v osnovno obliko trapeznega korita, utrjenega s skalometom, temveč da uporabimo lokalne hidravlične razmere in omogočimo naravi njen razvoj. Po pogovorih z ZRSVN smo prišli do zaključka, da bi bilo na območju HE Boštanj koristno ustvariti boljše pogoje za vidro. Zato je ideja, da to lokacijo, ki trenutno nima bistvene ekološke vrednosti, preuredimo na način, da bo vsaj sprva tu našla svoj življenjski prostor vidra, kasnejši naravni razvoj pa bo pokazal, kakšne načrte ima narava.



Slika 5: Rezultati študije ureditve brežine [7]. Levo: Prikaz rezultatov hidravličnih izračunov. Desno: Prikaz idejne rešitve ureditve brežine.

Hidravlična analiza je pokazala, da ni ovire za ureditev brežine, ki bo ustvarila kombinacijo čvrste površine in vodnih lagun, saj tudi ob najvišjih pretokih reka Sava na tem mestu ne bi odnašala materiala. Izdelali smo idejno zasnovo brežine in sedaj pristopamo k izdelavi projekta za izvedbo nove brežine. Ustvarili bomo lepšo brežino, ki ne bo kazila podobo reke Save, na in ob kateri poteka rekreacija in turizem. Vpliv na proizvodnjo je zanemarljivo majhen, saj že sedaj otok zmanjšuje prostornino vode, ki se uporablja za proizvodnjo električne energije. Stroški vzdrževanja bodo manjši, saj ne bo potrebno čiščenje in ohranjanje osnovne utrjene brežine. Narava pa bo dobila nov prostor.

6 Prihodnost sodelovanja z naravo

Je z naravo možno sodelovati? Je narava pripravljena sodelovati? Vse, kar lahko naredimo, je, da se zavedamo naravnih procesov, jih poskušamo čim bolj razumeti in spoznati njihovo kompleksnost ter povezanost. Elektro energetski objekti se ne umeščajo, ker bi bili sami sebi namen, umeščajo se z razlogom. Ker jih potrebujemo. Hkrati je smiselna določena doza samokritičnosti pri »predpisovanju« naravnih procesov in pri napovedovanju, kaj bo narava naredila ali kaj glede okolja lahko pričakujemo v prihodnosti. Dejstvo je, da ne vemo vsega, kompleksnost narave pa je osupljiva, zato je smiselna določena doza ponižnosti. Človek potrebuje svoj prostor za življenje, ravno tako ga narava. Razmišljanje o naravi je še kako ključno, če želimo ljudje preživeti na tem planetu. Izgradnja HE Brežice je primer dobre prakse glede pozornosti, ki se je je namenilo naravi, glede truda in znanja, ki se ga je vložilo, in tudi glede na novo pridobljenega znanja. Predvsem pa je dobra praksa v tem, da se je ob gradnji HE zagotovil in uredil prostor tudi za naravo. S tem se omogoča naravna dinamika in dogajanje sprememb v okolju, kajti to je naravno. Tudi če kakšen ukrep sedaj ni popolnoma takšen, kot se je sprva zastavil, gre še vedno lahko za primer dobre prakse. V najslabšem primeru kot pokazatelj, kaj lahko naredimo še boljše.

7 Zaključki

Ker je celoten članek napisan v poljudnem stilu, naj zaključim s tehničnim komentarjem. Tehniki smo navajeni ravnati s številkami, vrednotiti po kriterijih in razvrščati v razrede. Naravo je težko razvrščati na tovrsten matematičen način iz več razlogov. V prvi vrsti so naravni sistemi preveč kompleksni, da bi jih enoznačno vrednotili, pogosto pa jih niti ne razumemo v celoti. Pomen naravnih oblik in njihovo vrednost vedno vrednotimo z antropološkega vidika, ki je avtomatsko subjektiven. Objektivna ocena vrednosti ni možna, še manj z vidika narave. Vrednosti posameznega organizma ali lokalnega habitata za celoten ekosistem ni mogoče ovrednotiti.

Slika 6: Primer tipičnega vodnega telesa s habitatno diverziteto, kakršna se je umeščala na potokih v bližini HE Brežice [8]. Proces erodiranja na levi strani slike ustvarja strmo brežino, v kakršni lastovice breguljke in čebelarji gradijo gnezda. Na desni strani poteka odlaganje in ustvarjanje prodišča, kjer pričenjajo z rastjo pionirske rastline, na kamnih pa se sončijo želve. Plitvine in tolmuni ustvarjajo različne pogoje za različne velikosti rib, različno obvodno rastlinje pa hrano za različne organizme. "Izgradnja" tovrstne ureditve neizbežno vodi v spremembo, saj bo narava že ob prvem dežju takšen "objekt" spremenila. Faza obratovanja takšnega "objekta" v smislu ponavljanja procesov zato ne obstaja. Vse, kar lahko ljudje naredimo, je, da zagotovimo prostor in pustimo naravnim procesom naravno pot.

Za konec upoštevajmo še človeški faktor in različne razloge za ravnanje posameznikov, tudi inženirjev in znanstvenikov, ki pogosto upoštevajo zgolj tisto, kar se je dogodilo v njihovi karieri, preteklost in prihodnost pa presegata okvir njihovega zanimanja. Narava ni tako ozkogleda, zato si je treba priznati, da vsega pač ne vemo. Ukrepe, za katere so bili strokovnjaki čvrsto prepričani, da bodo delovali, je narava »odpeljala po svoje«. Degradiranost okolja je narava pogosto preoblikovala v nekaj nepričakovanega, kar čez desetletja cenimo in želimo ohraniti. Zato posegi v prostor, kakršne so tudi gradnje elektro energetskih objektov, niso nujno takšna degradacija okolja, kakršna izgleda na prvi pogled. Zaradi našega lastnega obstoja na planetu je brez dvoma potrebno pri umeščanju v prostor vložiti trud, čas in denar tudi v ohranjanje narave. Pri tem ni smiselno, da ohranjanje narave temelji strogo na načrtovanju in predvidevanju naravnih procesov in naravnega stanja, temveč je preudarno vsaj deloma dovoliti, da naravni procesi oblikujejo prostor tudi po lastni poti. Sodobni pristopi k umeščanju zahtevajo tovrstno širokoglednost, potrebna pa je tudi multidisciplinarnost, da se naslovi vse ekološke vidike. Tudi v 3. fazi projektov, fazi obratovanja, je pri vsaki spremembi prostor, da se razmisli o možnosti sonaravnega ukrepanja, pri čemer je sonaravno ukrepanje že to, da se da naravi prostor.

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Axioms and Myths of Environmental Care and Sustainable Agriculture

Aksiomi in miti o varovanju okolja in trajnostnem kmetijstvu

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ABSTRACT.
This paper challenges common misconceptions about agriculture's impact on the environment, particularly the idea that agriculture is inherently harmful. By providing insights into natural cycles, methane dynamics, and biodiversity benefits, the study highlights how well-managed agricultural practices, such as diverse crop management and rotational grazing, contribute positively to the environment. Contrary to the myth, correctly managed farmland and pastures foster biodiversity, support soil health, and integrate animals as a natural part of ecosystems. The paper compares the environmental impact of agriculture with other sectors and emphasizes the need for a nuanced understanding of sustainability in agriculture.

POVZETEK
Prispevek izpodbija običajne napačne predstave o vplivu kmetijstva na okolje, zlasti idejo, da je kmetijstvo škodljivo okolju. Z analizo naravnih ciklov, dinamike metana in koristi biotske raznovrstnosti, študija poudarja, kako dobro upravljane kmetijske prakse, kot so raznovrstne poljščine in rotacijska paša, pozitivno prispevajo k okolju. Nasprotno mitu, pravilno obdelana kmetijska zemljišča in travniki spodbujajo biotsko raznovrstnost, podpirajo zdravje tal in vključujejo živali kot naravni del ekosistemov. Prispevek primerja okoljski vpliv kmetijstva z drugimi sektorji in poudarja potrebo po bolj natančnem razumevanju trajnostnosti v kmetijstvu.

KLJUČNE BESEDE
Trajnostno kmetijstvo, metan, biotska raznovrstnost, ekosistemi, upravljanje kmetijskih zemljišč

KEYWORDS
Sustainable agriculture, methane, biodiversity, ecosystems, farmland management

1 Uvod

Kmetijstvo, kljub svoji nujni vlogi pri zagotavljanju hrane za svetovno prebivalstvo, pogosto napadajo, češ da onesnažuje okolje. To prepričanje izhaja predvsem iz dveh dejavnikov: izpustov toplogrednih plinov, zlasti metana, ki ga proizvajajo prežvekovalci, in degradacije tal zaradi intenzivnih kmetijskih praks. Vendar pa so te predstave pogosto poenostavljene in ne upoštevajo ključnih dejstev, kot so naravni cikli metana, trajnostno upravljanje kmetijskih zemljišč in pomen biotske raznovrstnosti, ki jo lahko podpirajo dobro upravljane kmetijske površine [1][2].

Dobro upravljano kmetijstvo, zlasti ekstenzivne metode, kot sta rotacijska paša in ohranjevalno obdelovanje tal, ima zelo pozitivne vplive na okolje. Na primer, travniki in pašniki lahko gostijo večjo biotsko raznovrstnost kot mnogi gozdni ekosistemi, saj omogočajo habitat za številne rastlinske in živalske vrste [3]. Poleg tega so tla na trajnostno upravljanih kmetijskih površinah sposobna skladiščiti več ogljika, kar pripomore k zmanjševanju koncentracij toplogrednih plinov v ozračju [4]. Primerjave z zagrajenimi površinami (ceste, parkirišča, stavbe) so seveda nesmiselne, saj je v resnici kmetijske površine najbolj biološko "bogate", človeško degradirane pa najmanj.

Čeprav zlasti živinoreja prispeva k proizvodnji metana, enemu glavnih toplogrednih plinov, pa se metan v ozračju ohranja le približno 12 let, kar pomeni, da so njegovi dolgoročni učinki bistveno manjši kot pri CO2 [5]. Poleg tega nove tehnologije in prakse, kot so dodatki za prehrano živali, lahko bistveno zmanjšajo emisije metana iz živinoreje [6].

Kmetijstvo je tudi ključno za ohranjanje biotske raznovrstnosti. Dobro upravljana kmetijska zemljišča zagotavljajo pomemben prostor za številne vrste, ki jih ne najdemo v intenzivno gozdnih ali urbaniziranih območjih. Raznolikost vrst na takšnih površinah prispeva k stabilnosti ekosistemov in omogoča večjo odpornost na podnebne spremembe in druge stresne dejavnike [7].

Cilj tega prispevka je podrobneje raziskati vpliv kmetijstva na okolje, zlasti v povezavi z izpusti toplogrednih plinov, biotsko raznovrstnostjo in trajnostnim upravljanjem naravnih virov, ter izpodbijati nekatere uveljavljene mite o kmetijstvu kot največjem onesnaževalcu. Poleg tega bomo preučili, kako lahko trajnostno kmetijstvo prispeva k zmanjševanju negativnih

vplivov na okolje in pomaga pri reševanju nekaterih ključnih okoljskih izzivov.

Da bi argumentirali vlogo in pomen kmetijstva v smislu varovanja okolja, najprej naredimo širšo analizo varovanja okolja, ki temelji na [8, 9, 10]. Naredimo tako analizo aksiomov, osnovnih usmeritev varovanja okolja v sekciji 2, kot tudi mitov v sekciji 3. Zaključimo z diskusijo v sekciji 4.

2 Aksiomi o varovanju okolje

Aksiomi (osnovne usmeritve) varovanja okolja so:

2.1. Rast števila ljudi in standarda je osnovni pritisk na okolje

Ljudje za svoje delovanje in udobje uporabljajo energijo, kar pomeni, da več kot je ljudi in višji kot je življenjski standard, več energije je potrebno za zadovoljevanje njihovih potreb. Posledično se povečuje tudi poraba naravnih virov in nastaja večja količina onesnaževanja, ki vpliva na kvarjenje okolja.

Čeprav se rast svetovne populacije postopoma upočasnjuje, zlasti zaradi nizke rodnosti na večini celin (razen v Afriki, kjer rodnost ostaja visoka), to pomeni, da je v prihodnosti čedalje pomembnejši dejavnik vpliv posameznika na okolje [11]. Ob manjšem številu otrok in staranju prebivalstva bo poudarek na tem, koliko okoljske škode povzročajo posamezni ljudje s svojim načinom življenja in porabo energije. Bolj kot število ljudi bo pomembna njihova potrošnja in ravnanje z naravnimi viri – Koliko površin bodo uničili, koliko onesnaževanja bodo povzročali, Koliko bodo podpirali biotsko raznolikost in sožitje z naravo [12].

Ključen dejavnik v tej enačbi je poselitev – kako in kje so ljudje naseljeni ter koliko prostora je namenjenega različnim dejavnostim, kot so kmetijstvo, industrija, neokrnjena narava in urbani parki. Teoretično bi se vseh 8 milijard ljudi na svetu lahko naselilo na območje velikosti Slovenije, saj bi ob 20.000 km² površine vsak posameznik zasedel približno 2,5 m² prostora.

Torej ta hip število prebivalcev na planetu ni preveliko, če bi delovali smotrno in trajnostno, če bi poseljevali predvsem v mestih, zmanjšali nepotrebno porabo virov in namenjali zadostne površine naravi ter ekosistemom, kjer pomembno vlogo igrajo kmetijske površine in gozdovi.

Trajnostni razvoj bi tako moral vključevati učinkovito rabo prostora, zlasti z vidika urbanizacije in varovanja naravnih območij, ob hkratnem zmanjšanju porabe energije na prebivalca in spodbujanju manj potrošniškega življenjskega sloga. Če bi človeštvo delovalo trajnostno – manj trošilo, učinkoviteje uporabljalo naravne vire in vzdrževalo ravnovesje med človekovo dejavnostjo in ohranjanjem narave – bi trenutna populacija lahko bivala v harmoniji z okoljem brez bistvenih negativnih vplivov na planet [12, 13].

Za Slovenijo in druge države je napotek jasen: treba je stremeti k trajnostni rodnosti (1.9 do 2.2), treba je zmanjšati pritok migrantov – saj to povečuje število prebivalcev in pritisk na okolje. Treba je večino ljudi poseliti po mestih in čim večji del površin nameniti kmetijstvu, gozdarstvu in zavarovanim območjem [8, 11].

2.2. Izgorevanje (fosilnih goriv) največ prispeva k onesnaževanju oz. uničevanju okolja

Vse tehnologije, ki temeljijo na izgorevanju fosilnih goriv (premog, nafta, plin), kot so tiste v prometu, ogrevanju in industriji, prispevajo k izpustom toplogrednih in ljudem škodljivih plinov, kar je glavni vzrok za onesnaževanje okolja. Fosilna goriva so omejeni viri, nastali skozi milijone let iz ostankov starodavnih organizmov, in čeprav predstavljajo izredno zgoščeno energijo, je njihova raba dolgoročno nevzdržna. Po ocenah geoloških raziskav je v zemeljski skorji približno 1.7 trilijona sodčkov nafte, vendar pri trenutni stopnji porabe lahko pričakujemo, da bodo te zaloge izčrpane v nekaj desetletjih. Poleg tega se približno 50 % zalog premoga ocenjuje na količino, ki zadošča še za dobrih 100 let, vendar so tudi te številke odvisne od stopnje porabe [14, 15].

Toplogredni plini, ki nastajajo pri izgorevanju fosilnih goriv, kot so ogljikov dioksid (CO2), metan (CH4) in dušikovi oksidi (NOx), pomembno vplivajo na segrevanje ozračja. Med njimi ima metan sicer večji takojšnji učinek na podnebje, vendar razpade v ozračju v približno 12 letih. Ogljikov dioksid pa ostaja v atmosferi več stoletij, zaradi česar se njegov vpliv dolgoročno kopiči. Prav CO2 je tisti, ki najbolj prispeva k dolgoročnemu segrevanju ozračja in podnebnim spremembam, ker je trajno prisoten v visokem ozračju in povzroča t.i. učinek tople grede.

Zato so tehnologije, ki ne uporabljajo fosilnih goriv, kot so vetrnice, jedrska energija, sončne elektrarne in hidroelektrarne, ekološko bistveno bolj trajnostne. Te tehnologije izkoriščajo naravne vire, kot so veter, voda, sonce ali jedrsko fisijo, ki so v veliki meri obnovljivi in povzročajo manj onesnaženja [16]. Na primer, sončne elektrarne nimajo neposrednih izpustov toplogrednih plinov med obratovanjem, medtem ko vetrnice proizvajajo energijo z uporabo vetrne sile, kar zmanjšuje potrebo po fosilnih gorivih.

Vendar imajo tudi te tehnologije svoje izzive. Jedrska energija, čeprav z nizkimi izpusti CO2, prinaša tveganje v obliki radioaktivnih odpadkov. Vetrne elektrarne lahko vplivajo na lokalne ekosisteme in predstavljajo izziv glede stabilnosti oskrbe z energijo, kadar ni dovolj vetra. Sončne elektrarne pa zahtevajo velike površine zemljišč, kar je hudo problematično (okoljski kriminal v imenu varovanja okolja), zlasti če se postavljajo na kmetijskih območjih ali naravnih habitatih.

Znotraj kmetijstva pa so v zadnjem desetletju v ospredje prišle tako imenovane biogorivne kulture, kot je oljna repica, ki naj bi predstavljale obnovljiv vir energije in zmanjšale odvisnost od fosilnih goriv. Vendar se je pokazalo, da ima proizvodnja biogoriv več negativnih kot pozitivnih učinkov na okolje. Proces pridelave oljne repice za gorivo pogosto zahteva več fosilnih goriv (za gnojenje, obdelavo tal, žetev in predelavo), kot jih biogorivo prihrani ob končni uporabi. To pomeni, da celotni življenjski cikel proizvodnje teh goriv v mnogih primerih ne vodi k zmanjšanju emisij, ampak celo k povečanemu ogljičnemu odtisu [15]. Čemu smo sploh uvedli tovrstne ukrepe, ko pa očitno škodijo okolju?

Za Slovenijo je osnovna trajnostna usmeritev, da opušča predvsem termoelektrarne na premog in se usmeri v jedrsko in trajne vire, kjer je to sprejemljivo in okolju primerno. Vsak ukrep pa mora biti premišljen (primer okoljskega kriminala je postavljanje sončnih panelov na kmetijskih površinah).

2.3. Aksiom: Ohranjanje biotske raznovrstnosti je ključnega pomena za stabilnost ekosistemov

Zmanjševanje biotske raznovrstnosti, ki ga pospešujejo izgorevanje, uničevanje kmetijskih in gozdnih površin, velike kmetijske monokulture in invazivne vrste, zmanjšuje odpornost ekosistemov. Eni izmed dejavnikov zmanjševanja biotske raznovrstnosti so monokulturni sistemi, saj ustvarjajo homogene omejene ekosisteme, kjer je manj prostora za prosto živeče rastline in živali. Prav tako so te kulture bolj občutljive na bolezni in škodljivce, kar zahteva večje količine pesticidov in umetnih gnojil, ki dodatno škodujejo okolju [17, 18, 19]. Za Slovenijo to skoraj ne pride v poštev, saj je večina posestev razparceliranih, medtem ko so v nekaterih državah cele doline namenjeni monokulturi. V tropskih krajih izstopa oljna palma (Elaeis guineensis), iz katere pridobivajo palmovo olje, ki se uporablja v številnih prehrambnih, kozmetičnih in industrijskih izdelkih. Ta kultura vodi v obsežno krčenje gozdov, izgubo biotske raznovrstnosti, emisije toplogrednih plinov ter izpodrivanje lokalnih skupnosti.

Prav tako so invazivne vrste, ki jih pogosto nenamerno prenašamo med različnimi ekosistemi, eden največjih razlogov za izumiranje avtohtonih vrst. Invazivne vrste pogosto izpodrinejo avtohtone zaradi svoje agresivnosti, hitrega razmnoževanja ali pomanjkanja naravnih plenilcev. Poleg tega so nekatere invazivne rastlinske vrste, kot je ambrozija, tudi zelo škodljive za zdravje ljudi, saj povzročajo alergije, in čeprav je potrebno minimalno vsaj avgusta kositi dvakrat, se v Sloveniji v marsikateri občini ne izvaja niti to.

Tudi na videz naravna okolja, kot so strnjeni gozdovi, lahko predstavljajo omejeno biotsko področje, če v njih ni zadostne raznolikosti habitatov. Zato je veliko bolj smiselno ohranjati mozaično krajino, kjer so naravne jase, kmetijske površine med gozdom ali občasne poseke (daleč bolje kot strnjeni gozdovi), ki ustvarjajo raznolikost življenjskih prostorov. Takšna krajina omogoča večji razpon ekosistemov, ki so bolj odporni na spremembe in naravne katastrofe. Gozdovi z jasami ponujajo več možnosti za različne vrste rastlin in živali, kar povečuje stabilnost ekosistema.

Podobno so škodljive genetsko spremenjene rastline, ki so pogosto zasnovane tako, da vsebujejo "naravne" strupe za žuželke, kar ne ustvarja le monokultur, ampak tudi "zastrupljene" monokulture. Te rastline ne škodujejo samo škodljivcem, ampak vplivajo tudi na druge, koristne žuželke in lahko dolgoročno škodijo celotnemu ekosistemu, saj strupi prehajajo skozi prehranjevalno verigo.

Še slabše pa so (avto)ceste, ki predstavljajo povsem mrtva območja za večino živih bitij. Ta območja niso zgolj fizično ovira za prostoživeče vrste, temveč so tudi območja, kjer se pogosto dogajajo trki z živalmi (test avtomobilskega stekla). Poleg tega ustvarjajo prekinitev habitatov, kar vodi do izgube genetske raznolikosti med populacijami in posledično večje občutljivosti na bolezni in okoljske spremembe. Avtoceste so v marsičem »polja smrti«, kjer preživetje vrst ni mogoče, razen tistih, ki se v kovinskih škatlah vozijo naokoli.

Eno izmed pomembnih rešitev za ohranjanje biotske raznovrstnosti je tudi sistematično odstranjevanje invazivnih vrst z ustrezno zakonodajno podporo. Na primer, kazni za lastnike zemljišč, ki ne odstranijo alergene rastline, kot je ambrozija, bi lahko spodbudile učinkovitejše ravnanje z invazivnimi rastlinami. Prav tako bi moralo biti dovoljeno humano odstranjevanje invazivnih živali, kot so nutrije v Ljubljanici. Ljudje pogosto ne razumejo škodljivosti invazivnih vrst in se upirajo njihovemu odstranjevanju, čeprav te vrste povzročajo uničujoče učinke na avtohtone ekosisteme. Navedimo dva primera: če bi bili pogoji povsod po svetu enaki, bi prevladovalo recimo 10-krat manj vrst, kot jih je danes. Z globalizacijo se pogoji izenačujejo, saj ljudje postajajo ključni dejavnik v večini ekosistemov, kjer s svojo prisotnostjo in navadami spreminjajo prehranjevalne verige in habitate. Še en primer: sesalci predstavljajo približno 6.400 vrst na svetu. Okoli 36 % teže sesalcev predstavljajo ljudje, medtem ko 60 % teže sesalcev predstavljajo domače živali, kot so govedo, ovce, prašiči in drugi rejni organizmi. Divji sesalci pa predstavljajo le še 4 % vse biomase sesalcev na planet. Ali je projekcija 4, 3, 2, 1, 0 [20, 21]?

Podobno škodljiv vpliv imajo invazivne vrste, kot je nutrija (Myocastor coypus, znana tudi kot močvirska podgana ali bobrovka). Preden nutrije naselijo določeno območje, tam živijo avtohtone vrste podgan, miši, rakov in drugih malih živali. Vendar ko nutrije, ki tehtajo od 5 do 10 kilogramov, pridejo na to območje, uničijo, izpodrinejo ali pobijejo vse, kar jim ne ubeži (recimo ribe). Kljub temu pa lokalno prebivalstvo pogosto protestira proti odstranjevanju nutrij, ne zavedajoč se, kakšno uničenje med avtohtonimi vrstami povzročajo te invazivne živali. Takšne napačne predstave in odpor do odstranjevanja invazivnih vrst lahko povzročijo dolgoročno škodo ekosistemom, ki so že oslabljeni zaradi drugih okoljskih pritiskov.

Kot imamo akcije čiščenja okolja, bi morali izvajati akcije čiščenja invazivnih rastlin in živali in morali bi izobraževati državljane, kaj je to smotrno varovane okolja in kaj to ni.

2,4. Aksiom: Trajnostni razvoj zahteva večji učinek z manjšo porabo energije s pomočjo naprednih tehnologij in pametne rabe virov

Trajnostni razvoj ne pomeni predvsem zategovanja pasu - zmanjševanje porabe, temveč eliminiranje nesmiselnih pristopov ter povečanje učinkovitosti s pametno uporabo virov in tehnologij, kot je umetna inteligenca (AI). Z uporabo AI, avtomatizacije in optimiziranih sistemov lahko povečamo učinkovitost in zmanjšamo porabo energije, ne da bi pri tem ogrozili razvoj [22, 23]. Namesto povečanja porabe moramo iskati rešitve, ki omogočajo večji učinek z manjšo porabo energije.

Preprost primer tega so drevesa. Drevo, zasajeno pred hišo, lahko zagotavlja senco in posledično zmanjša potrebo po hlajenju stavbe za kar 20 %. To je enostaven in naraven način za zmanjšanje porabe energije brez tehnoloških intervencij, hkrati pa z drevesom prispevamo k izboljšanju kakovosti zraka, ki ga dihamo [24].

Na globalni ravni se soočamo s hitrim izginjanjem kmetijskih površin, kar še dodatno ogroža našo sposobnost za trajnostno pridelavo hrane, predvsem pa biotsko raznolikost. Vsako leto po svetu izgubimo približno 10 milijonov hektarjev kmetijskih zemljišč zaradi različnih dejavnikov, kot so urbanizacija, širitev cest, krčenje gozdov in intenzivna kmetijska dejavnost. To je približno enako 14 milijonom nogometnih igrišč [25]. Vsako minuto posekajo za 4 nogometna igrišča gozda v Amazoniji. Kdaj bo konec – ko bomo posekali in uničili vse?

Tudi v Sloveniji je situacija zaskrbljujoča, saj vsak dan izgubimo površino enega nogometnega igrišča kmetijskih zemljišč, kar vodi v zmanjšanje prostora za pridelavo hrane in povečuje obremenitev okolja. Širitev cestne infrastrukture in gradnja novih objektov na teh zemljiščih še dodatno prispevata k izginjanju naravnih površin ter pospešujeta učinke segrevanja podnebja [26]. Takšne prakse ne samo zmanjšujejo biotsko raznovrstnost, temveč ustvarjajo tudi večje potrebe po energiji in povzročajo povečanje toplogrednih plinov [27].

Nadaljnje širjenje cestne infrastrukture in gradnja novih stavb, še posebej veletrgovin in stanovanjskih sosesk na kmetijskih zemljiščih, ne samo zmanjšuje razpoložljivo površino za pridelavo hrane, temveč tudi povečuje izpuste toplogrednih plinov in segreva klimo. Gradnja dodatnih cest in veletrgovin povečuje promet, kar vodi k večji porabi fosilnih goriv in s tem dodatno obremenjuje okolje.

Namesto širjenja teh netrajnostnih praks moramo vlagati v tehnološke inovacije in naravne rešitve, ki bodo omogočile večji učinek z manjšo porabo virov. Pametno zasnovana infrastruktura, AI v energetski učinkovitosti in trajnostne rešitve, kot je zasaditev dreves in ustvarjanje naravnih senčnih površin, lahko pripomorejo k bistvenemu zmanjšanju porabe energije ter ohranjanju naših naravnih virov.

Če pogledamo usmeritve v Sloveniji in zaključke te konference o okolju, jasno opazimo velika razhajanja. Marsikje so strokovni argumenti povsem jasni in na naši strani, pa vendar javnost in mediji tega niti ne vedo.

3 Miti o okolju in kmetijstvu

3.1. Kmetijstvo je okolju neprijazno

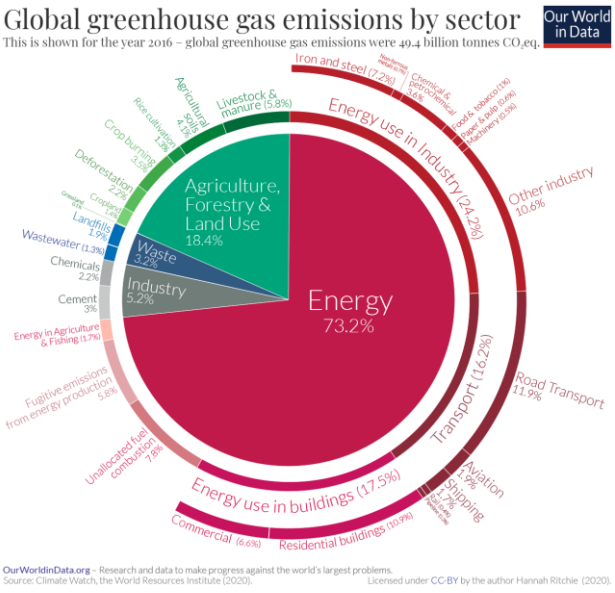
Resnica je veliko bolj kompleksna in v osnovi fundamentalno nasprotna temu mitu. Pravilno upravljano kmetijstvo prispeva k večji biotski raznovrstnosti in trajnostnemu okolju (neekološko ali nekvalitetno kmetijstvo pa seveda škodi). Kmetijske površine, kot so dobro obdelane njive in travniki, ustvarjajo raznoliko krajino, ki podpira različne vrste živali in rastlin. Pravilno upravljana polja in travniki so habitat za številne žuželke, ptice in druge prostoživeče živali, kar prispeva k izjemni biodiverziteti [28]. Na primer, v Evropi so travniki ena izmed najbolj biotsko raznovrstnih ekosistemov.

Metan, ki ga oddajajo prežvekovalci, kot so krave, ima sicer močan učinek na podnebne spremembe, vendar razpade v ozračju v približno 12 letih, medtem ko ogljikov dioksid (CO_2) ostaja v atmosferi več stoletij. To pomeni, da je vpliv metana kratkotrajen in se lahko učinkovito upravlja z uporabo novih tehnologij za zmanjšanje emisij.

Živali so naravni del ekosistema in imajo vlogo pri ohranjanju naravnih ciklov hranil. Paša živali, na primer, spodbuja rast travniških rastlin in s tem izboljšuje strukturo tal ter preprečuje erozijo. Podobno so njihovi odpadki hrana za insekte vseh vrst, katerih število se je v zadnjih 50 letih zmanjšalo za več kot polovico, kot tudi število in teža vseh divjih živali. Kmetijstvo, ki temelji na principih regenerativnega kmetovanja, izboljšuje kakovost tal, saj povečuje njihovo sposobnost zadrževanja vode in hranil. Težko je razumeti nekatere, ki se imajo za zagovornike varstva okolja, ko zagovarjajo invazivne živali in hkrati zahtevajo odstranitev domačih živali.

Strokovne raziskave kažejo, da pravilno upravljane kmetijske površine ključno prispevajo k ohranjanju biotske raznovrstnosti. Na primer, na travnikih, ki so pravilno vzdrževani, lahko uspeva do 40 različnih vrst rastlin na kvadratni meter, kar je veliko več kot v intenzivnih industrijskih monokulturah ali pozidanih površinah, ki so pogosto označene kot "puščave", kjer je prisotnih zelo malo vrst [28, 29].

Zato kmetijstvo ni okolju neprijazno – pravilno izvajano kmetijske prakse prispevajo k trajnostnemu okolju in visoki biotski raznovrstnosti, medtem ko napačne predstave o kmetijstvu pogosto izhajajo iz neustrezno vodenih praks in industrijskih metod pridelave ter napačega razumevanja, kaj je to biotska raznolikost.



Slika 1: Izvori toplogrednih plinov; tri četrtine jih prihaja iz fosilnih goriv. Vir: Hannah Ritchie (2020) - "Sector by sector: where do global greenhouse gas emissions come from?" Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/ghg-emissions-by-sector' [Online Resource]

3.2. Izmed vseh tehnologij je najbolj nevarna in škodljiva ravno jedrska

Tudi tu je resnica ravno nasprotna: Jedrska energija proizvaja minimalne izpuste CO_2 v primerjavi s fosilnimi gorivi in zato predstavlja bolj trajnostno alternativo, čeprav obstajajo tveganja, povezana z odpadki. Poleg tega so nekatere trajnostne energije kot sončna in vetrna podvrženi nihanjem in so zato primerjave, tudi v tem prispevku, narejene na osnovi uravnoteženega energetskega sistema, kjer imate zadosti stalnih virov (hidro, jedrska, termo) in trajnostnih, tj. občasnih. Če ni na voljo zadosti trajnih virov, se cena električne energije zaradi shranjevanja približno podvoji ali potroji [9, 30].

Primerjava po atributih:

Cena na enoto energije (USD/kWh)

Jedrska energija: Povprečna cena proizvodnje jedrske energije znaša približno 0,09 USD/kWh. Visoki začetni stroški

izgradnje jedrskih elektrarn so kompenzirani z nizkimi obratovalnimi stroški in dolgoročno življenjsko dobo [31].

Fosilna goriva (premog, nafta, plin): Cene fosilnih goriv so odvisne od trga, vendar se cena proizvodnje električne energije giblje med 0,05 in 0,10 USD/kWh. Čeprav so začetni stroški nižji, pa fosilna goriva dolgoročno povzročajo stroške zaradi vpliva na okolje in zdravje.

Sončna energija: Stroški sončne energije so v zadnjih letih močno padli in zdaj znašajo med 0,03 in 0,06 USD/kWh, kar jo uvršča med najcenejše vire energije (če imamo osnovno energijsko zahtevo pokrito trajnostno).

Vetrna energija: Cena proizvodnje vetrne energije se giblje med 0,04 in 0,07 USD/kWh, kar jo prav tako uvršča med konkurenčne vire obnovljive energije.

Hidroenergija: Cena hidroenergije je zelo odvisna od lokacije in znaša med 0,03 in 0,05 USD/kWh, kar jo uvršča med cenovno najučinkovitejše vire energije.

Izpusti CO2 na enoto energije (gCO2/kWh)

Jedrska energija: Jedrska energija spada med najmanj emisijsko intenzivne vire, s povprečnimi izpusti CO2 okoli 12 gCO2/kWh (vključno z izgradnjo elektrarn in celotnim življenjskim ciklom).

Fosilna goriva: Premog povzroča največ izpustov, s povprečno 820 gCO2/kWh, plin povzroča približno 490 gCO2/kWh, medtem ko nafta znaša okoli 720 gCO2/kWh [32].

Sončna energija: Sončna energija prispeva približno 48 gCO2/kWh, večinoma zaradi proizvodnje in reciklaže fotonapetostnih panelov.

Vetrna energija: Vetrna energija spada med najbolj čiste vire, z izpusti okoli 11 gCO2/kWh.

Hidroenergija: Povprečni izpusti hidroenergije znašajo 24 gCO2/kWh, vendar se lahko ta vrednost poveča zaradi izpustov metana iz velikih rezervoarjev.

Potrebne površine na enoto energije (m²/kWh)

Jedrska energija: Jedrska energija zahteva najmanj prostora. Povprečna jedrska elektrarna proizvede ogromno količino energije na majhni površini – približno 1,9 m²/kWh [33].

Fosilna goriva: Premogovne in plinske elektrarne potrebujejo približno 40-100 m²/kWh, zaradi potrebe po rudarjenju in skladiščenju goriv.

Sončna energija: Solarne elektrarne zahtevajo veliko večje površine za zbiranje sončne svetlobe, s približno 25-70 m²/kWh, odvisno od učinkovitosti panelov in lokacije.

Vetrna energija: Potrebne površine za vetrne elektrarne znašajo približno 20-60 m²/kWh.

Hidroenergija: Potrebne površine za hidroelektrarne se zelo razlikujejo glede na vrsto projekta, vendar znašajo od 100 m²/kWh ali več pri velikih akumulacijskih jezerih.

Število žrtev v nesrečah na enoto energije (smrti/TWh)

Jedrska energija: Jedrska energija je kljub nekaj odmevnim nesrečam, kot so Černobil in Fukušima, statistično varna z vidika smrtnosti. Povprečje znaša 0,07 smrti/TWh, vključno z nesrečami in dolgoročnimi učinki sevanja [34].

Fosilna goriva: Premog je izredno nevaren tako zaradi nesreč v rudnikih kot zaradi dolgoročnih zdravstvenih učinkov onesnaženja. Povprečno število smrti znaša 24,6 smrti/TWh za premog in 2,8 smrti/TWh za plin.

Sončna energija: Sončna energija je zelo varna, s povprečno 0,02 smrti/TWh, večinoma zaradi nesreč pri namestitvi in vzdrževanju panelov.

Vetrna energija: Vetrna energija prav tako spada med zelo varne vire, s približno 0,04 smrti/TWh.

Hidroenergija: Čeprav hidroenergija večinoma velja za varno, lahko nesreče, kot so zrušitve jezov, povzročijo velike žrtve. Povprečno število smrti znaša 1,3 smrti/TWh, vendar lahko te nesreče lokalno povzročijo večje število smrtnih žrtev [35].

4 Diskusija

Pravilno varovanje okolja temelji na trajnostnem razvoju, kar pomeni pametno rabo virov in naprednih tehnologij, ki omogočajo večjo učinkovitost z manjšo porabo energije. Na primer, uporaba jedrske energije za proizvodnjo električne energije znatno zmanjša izpuste CO2 v primerjavi s fosilnimi gorivi in prispeva k boju proti podnebnim spremembam. Pomembno je tudi ohranjanje biotske raznovrstnosti, saj stabilni ekosistemi zagotavljajo dolgoročno odpornost na podnebne spremembe. Naravne rešitve, kot so sajenje dreves in pametno načrtovanje krajine, lahko prav tako učinkovito zmanjšujejo potrebo po energiji, kot je hlajenje stavb, ter hkrati prispevajo k izboljšanju kakovosti zraka. Pravilno varstvo okolja temelji na pametni kombinaciji naravnih in tehnoloških rešitev, ki zagotavljajo dolgoročno trajnost.

Nasprotno pa nepravilno varovanje okolja pogosto temelji na napačnih argumentih in mitih, kot je prepričanje, da so obnovljivi viri, kot sta sončna in vetrna energija, vedno boljši od jedrske energije. V resnici te rešitve zahtevajo večje površine in so manj zanesljive, ter so nekajkrat dražje, če jih je potrebno shranjevati.

Zmotno je prepričanje, da se gospodarska rast lahko nenehno povečuje, ne da bi to negativno vplivalo na okolje. Prav tako mit, da kmetijstvo škoduje okolju, izhaja iz napačnega razumevanja varovanja okolja.

Kmetijstvo prispeva k ohranjanju okolja in povečevanju biotske raznovrstnosti. Prakse, kot je regenerativno kmetovanje, spodbujajo zdravje tal, zmanjšujejo erozijo in izboljšujejo zmožnost tal za zadrževanje vode. Paša živali na travnikih, če je pravilno vodena, prispeva k naravnemu ciklu hranil, spodbuja rast rastlin in podpira raznolikost vrst. Zmanjšanje metanskih emisij s tehnološkimi inovacijami in trajnostno obdelavo zemljišč omogoča, da kmetijstvo ne le minimizira škodljive učinke, temveč aktivno prispeva k varovanju naravnih virov.

Pogosto napačno predstavljanje kmetijstva kot enega glavnih onesnaževalcev temelji na primerih neustreznih praks, kot so intenzivne monokulture in pretirana uporaba kemikalij, česar v Sloveniji skoraj ni. Vendar pa je resnica, da lahko kmetijstvo, če se izvaja trajnostno, bistveno prispeva k varovanju okolja. Travniki in kmetijske površine lahko podpirajo večjo biotsko raznovrstnost kot mnoge gozdne površine, saj ustvarjajo naravne habitate za številne rastlinske in živalske vrste. Sodobni miti o kmetijstvu, ki ga enačijo z uničevanjem okolja, ne upoštevajo pozitivnih vplivov trajnostnih kmetijskih praks, ki so ključne za ohranjanje ekosistemov.

Zelo pomembno je tudi, kako je kmetijstvo upravljano, recimo ali se zgodaj kosi travo, ali se krave nepravilno hrani itd. Tu so lahko napredni in ekološko zavedni sistemi vodenja kmetij na osnovi umetne inteligence in GPT izredno koristni tako za kmete kot za varstvo okolja. Ko smo predlagali tovrstne ideje predstavnikom oblasti, pa ni bilo prav veliko zanimanja.

V zaključku: kmetijstvo je v svoji osnovi najboljša varovalka okolja in zato bi morali okoljevarstveniki, kmetje in raziskovalci skupaj zagovarjati najboljše rešitve.

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Umetna inteligenca o zeleni agendi (izvedljivost, cena in rezultati zelenega prehoda)

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ABSTRACT / POVZETEK

Dobrobit človeštva se nesmiselno povezuje z zmanjšanjem CO2 izpustov (razogljičenjem, Net Zero), kar povzroča ogromne stroške in še več prikritega onesnaženja, brez otipljivih rezultatov. Le prilagajanje spremembam v okolju je smiselno in ekonomsko učinkovito.

Samo uporaba preizkušenih obstoječih virov zanesljive energije (reke, nafta, plin, jedrska tehnologija) omogoča normalno življenje in razvoj.

S pomočjo umetne inteligence (https://www.perplexity.ai/) sem poiskal odgovore na aktualna vprašanja:

- Stroški razogljičenja (Net Zero)
- Cena hlajenja ($/°C)
- Dosedanje segrevanje in vpliv na populacijo
- Bo segrevanje zmanjšalo število ljudi?
- Zaradi mraza umre 10-krat več ljudi kot zaradi vročine
- Segrevanje 2x hitrejše od svetovnega povprečja
- Hinavščina razogljičenja
- Nasprotovanje jedrski energiji
- Okoljevarstvo kot kult
- Okoljski vidik blejskih kremšnit

KEYWORDS / KLJUČNE BESEDE

CO2, razogljičenje, prebivalstvo, energetika, plin, nafta, jedrska energija, ekonomija

OPTIONAL: ABSTRACT

Humanity's well-being is meaninglessly linked to CO2 reduction (decarbonisation, Net Zero), which entails huge costs and more hidden pollution, with no tangible results. Only adapting to environmental change is sensible and economically efficient.

Only the use of proven existing sources of reliable energy (rivers, oil, gas, nuclear technology) allows normal life and development.

With the help of artificial intelligence (https://www.perplexity.ai/).I have sought answers to the questions at hand:

- - The cost of decarbonisation (Net Zero)
- - Cost of cooling ($/°C)
- - Warming to date and impact on population
- - Will warming reduce the number of people?
- - 10 times more people die from cold than heat
- - Warming 2x faster than global average
- - The hypocrisy of decarbonisation
- - Opposition to nuclear power
- - Environmentalism as a cult
- - The environmental aspect of Bled kremšnites

OPTIONAL: KEYWORDS

CO2, decarbonisation, population, energy, gas, oil, nuclear, economics

1 Stroški razogljičenja

To je kompleksno in večplastno vprašanje, ki vključuje znatne finančne naložbe v različnih sektorjih in regijah. Tukaj je nekaj ključnih vidikov:

1.1 Ocene skupnih stroškov

Globalne naložbene zahteve: Ocenjuje se, da bo za doseganje ničelnih neto emisij od leta 2021 do 2050 potrebnih približno 110 bilijonov dolarjev globalnih kapitalskih naložb, kar je v povprečju 3,5 bilijona dolarjev letno. Ta naložba predstavlja približno 1,3 % predvidenega svetovnega BDP v naslednjih treh desetletjih [4].

Naložbe v posamezne sektorje: Velik del teh naložb, približno 70 % ali 2,4 bilijona USD letno, bi moral biti usmerjen v sektor električne energije. To vključuje naložbe v proizvodnjo električne energije brez emisij ogljika, elektroenergetska omrežja ter shranjevanje električne energije in prilagodljivost omrežja[4].

1.2 Cena na tono CO2

Cene ogljika: Stroške razogljičenja je mogoče razumeti tudi v smislu cen ogljika. Trenutne ocene kažejo, da morajo biti cene ogljika med 50 in 100 USD na tono CO2 do leta 2030, da se uskladijo s cilji Pariškega sporazuma [6]. Svetovna povprečna cena ogljika je leta 2024 znašala 32 USD na tono , kar je pod priporočenim razponom [6].

Stroški razogljičenja glede na kategorijo emisij : Stroški za razogljičenje posebnih kategorij emisij se razlikujejo. Na primer, cena zemeljskega plina je približno 3505 GBP na tono CO2e, medtem ko je za obnovljivo energijo približno 6435 GBP na tono CO2e [1].

1.3 Regionalne razlike

Cene ogljika po regijah: Pobude za določanje cen ogljika se med regijami precej razlikujejo. Evropa in Srednja Azija imata

povprečno ceno ogljika 50 USD na tono , medtem ko je cena v ZDA in Kanadi približno 48 USD na tono . Druge regije, kot sta Latinska Amerika in Karibi, imajo nižje povprečne cene, okoli 24 USD na tono [6].

Naložbene potrebe po regijah: Naložbene zahteve za doseganje ničelnih neto emisij se prav tako razlikujejo glede na regijo, na kar vplivajo obstoječa infrastruktura, politični okviri in gospodarski pogoji[4].

1.4 Izzivi in premisleki

Socialni in gospodarski vplivi: Prehod na ničelne neto emisije bo imel široke gospodarske in družbene učinke, ki bodo vplivali na povpraševanje, kapitalsko porabo, stroške in zaposlovanje v različnih sektorjih[7].

Politika in izvajanje: Učinkovita dekarbonizacija zahteva trdne politične okvire, vključno z mehanizmi za določanje cen ogljika, spodbudami za čisto tehnologijo in mednarodnim sodelovanjem za zagotovitev pravičnega in učinkovitega izvajanja[5][6].

Povzetek

Stroški razogljičenja vključujejo velike finančne obveznosti v različnih sektorjih in regijah, s precejšnjimi razlikami v cenah ogljika in naložbenih potrebah. Za doseganje globalnih ciljev razogljičenja bodo potrebna usklajena prizadevanja in strateške naložbe za uravnoteženje gospodarske rasti z okoljsko trajnostjo.

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2 Stroški odstranjevanja CO2 iz ozračja

Trenutni stroški za neposredno zajemanje CO2 iz zraka so ocenjeni med 600 in 1.000 dolarjev na tono odstranjenega CO2[4][8]. Za široko uporabo tehnologije neposrednega zajemanja iz zraka (direct air capture - DAC) morajo stroški pasti pod 200 dolarjev na tono, idealno bližje 100 dolarjev na tono do leta 2050[4][9]

Raziskovalci ETH Zürich ocenjujejo, da bodo stroški leta 2050 predvidoma med 230 in 540 dolarji na tono, namesto pogosto omenjenega razpona 100-300 dolarjev[6][7].

Projekcije stroškov za posamezne DAC tehnologije do leta 2050:

- Climeworks: 280-580 dolarjev na tono
- Carbon Engineering: 226-544 dolarjev na tono
- Heirloom: 230-835 dolarjev na tono[6][8]

To je približno dvakrat več od nekaterih prejšnjih ocen[6].

Ključno za znižanje stroškov je povečanje obsega uporabe DAC, vendar je v kratkem roku potrebno več zmogljivosti, kot je trenutno načrtovano[4]. Na skupne stroške DAC vplivajo stroški posameznih komponent, stroški energije in stroški integracije[3]. Bolj dovršene komponente, kot so kompresorji, imajo manjši potencial za znižanje stroškov[8].

Kljub višjim napovedim nekatera DAC podjetja že ponujajo cene blizu ali na ravni 340 dolarjev na tono, ki je predvidena za leto 2050[4]. Utežena povprečna cena za DAC s shranjevanjem se je med letoma 2022 in 2023 znižala za 43 %, s 1.261 na 715 dolarjev na tono[4]. Nekatera podjetja trdijo, da so trenutni stroški zajemanja pod 500 ali celo 200 dolarjev na tono[4].

Čeprav se pričakuje, da se bodo stroški z razvojem tehnologije bistveno znižali, nedavne raziskave kažejo, da znižanja morda ne bodo tako dramatična, kot so upali prej. Kljub temu se zdi, da industrija DAC napreduje hitreje pri zniževanju stroškov, kot predvidevajo nekatere študije. Priporoča se nadaljnji razvoj več pristopov DAC za spodbujanje inovacij in znižanje stroškov[6][8].

2.1 Strošek odstranjevanja 1ppm CO2 iz zraka

1 ppm atmosferskega CO2 ima maso 7,76 gigaton (Gt) CO2.

- Pri ceni 100 US$ na tono bi stroški znašali 776 milijard US$.
- Po trenutnih cenah 700-1200 US$/t to pomeni 5 - 9 bilijonov US$
- Do leta 2050 se bi ta vsota prepolovila
- Trenutno je svetovni bruto domači proizvod (BDP) 101 bilijon US$

Za odstranitev 0,2% CO2 (1ppm) bi porabili 10% družbenega proizvoda

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3 Stroški hlajenja ($/°C)

Na podlagi posredovanih rezultatov iskanja je težko podati natančno oceno hladilnega učinka v stopinjah Celzija na milijardo dolarjev, porabljenih za razogljičenje. Vendar pa lahko naredimo nekaj sklepov:

• Odlašanje z ukrepi za zajezitev podnebnih sprememb ima znatne gospodarske stroške. Zamuda, ki povzroči segrevanje za 3 °C nad predindustrijsko ravnjo namesto za 2 °C, bi povzročila dodatno škodo v višini 0,9 % svetovne proizvodnje, kar pomeni približno 150 milijard dolarjev samo za ameriško gospodarstvo[3].

• Obnovljivi viri energije bi lahko do leta 2050 razogljičili 90 % elektroenergetske industrije, kar bi drastično zmanjšalo emisije ogljika in prispevalo k ublažitvi podnebnih sprememb [4]. Stroški tehnologij obnovljive energije, kot sta sončna energija in veter, so se od leta 2010[4] znatno znižali.

• Ocene skupnih stroškov za odpravo podnebnih sprememb segajo od 300 milijard do 50 bilijonov dolarjev v naslednjih dveh desetletjih[5]. Ta ogromen razpon odraža negotovost in zapletenost pri določanju optimalne strategije razogljičenja.

• V scenariju IEA o neto ničelnih emisijah do leta 2050 morajo posredne emisije CO2, povezane s povpraševanjem po hlajenju prostorov, do leta 2030 pasti na približno 40 % današnje ravni [1]. To bi pomenilo, da se povprečna učinkovitost nove klimatske opreme do leta 2035 približa najboljši razpoložljivi ravni [1].

Medtem ko rezultati iskanja ne zagotavljajo natančnega kvantitativnega razmerja med stroški razogljičenja in znižanjem temperature, pa kažejo, da lahko pomembne naložbe v obnovljivo energijo, energetsko učinkovitost in zmanjšanje emisij pomembno vplivajo na omejevanje prihodnjega dviga globalne temperature.

Povzetek

Natančen hladilni učinek na porabljen dolar ostaja negotov in se razlikuje glede na izvedene posebne ukrepe za dekarbonizacijo.

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4 Dosedanje segrevanje in vpliv na populacijo

4.1 Globalno povečanje temperature

• Od leta 1880 se je povprečna površinska temperatura Zemlje dvignila za 0,07°C na desetletje.

• Stopnja povečanja temperature se je od leta 1981 več kot podvojila na 0,18°C na desetletje.

• Povprečne površinske temperature so v zadnjih letih dosledno presegale 1,5°C nad predindustrijskimi vrednostmi.

4.2 Rast prebivalstva

• Svetovno prebivalstvo je zraslo z okoli 1,6 milijarde leta 1900 na 8,1 milijarde leta 2024.

• Stopnja rasti prebivalstva je dosegla vrhunec 2,2% letno leta 1963 in se od takrat znižala na približno 1,1% letno.

4.3 Vplivi podnebnih sprememb na prebivalstvo

• Podnebne spremembe vplivajo na smrtnost in življenjske pogoje preko neposrednih vplivov ekstremnih temperatur in posrednih vplivov, ki jih posredujejo okoljski in družbeni sistemi.

• Ogrožajo prehransko varnost, oskrbo s sladko vodo in zdravje ljudi.

• Dvig morske gladine ogroža stotine milijonov ljudi v obalnih območjih.

• Podnebne spremembe lahko prisilijo ljudi k migraciji, z ocenami do več sto milijonov podnebnih migrantov do leta 2050.

4.4 Rast prebivalstva kot gonilnik podnebnih sprememb

• Rast prebivalstva skupaj s povečano potrošnjo običajno povečuje emisije toplogrednih plinov.

• Vpliva tudi na sposobnost Zemlje, da se upre podnebnim spremembam in absorbira emisije, na primer s krčenjem gozdov, ko se zemljišča spreminjajo v kmetijske površine za prehrano rastočega prebivalstva.

4.5 Demografski dejavniki in podnebna ranljivost

• Ljudje v revnih regijah, kljub temu da malo prispevajo k emisijam, so najbolj ranljivi za vplive podnebnih sprememb.

• Visoke stopnje revščine in socialne neenakosti povečujejo ranljivost za ekstremne vremenske pojave, vodni stres in izzive pri pridelavi hrane.

4.6 Populacijska dinamika in podnebna politika

• Upočasnitev rasti prebivalstva s pravičnimi ukrepi, kot je povečanje dostopa do načrtovanja družine, bi lahko igrala ključno vlogo pri blaženju podnebnih sprememb.

• Vendar lahko tudi v planih z nizko rastjo prebivalstva ogljično intenzivna gospodarska rast še vedno povzroči visoke emisije.

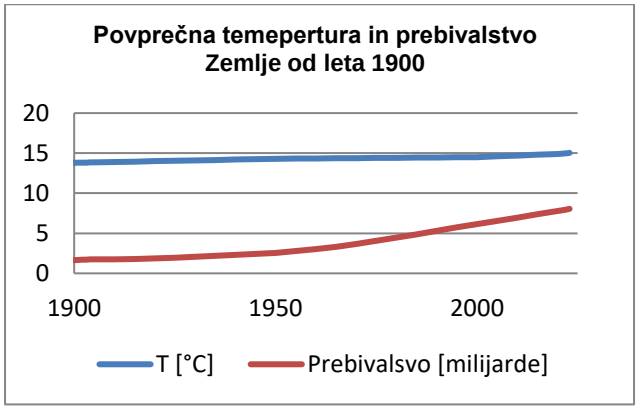
4.7 Zgodovinski kontekst

• Pospeševanje podnebnih sprememb sovpada z obdobji hitre industrializacije in rasti prebivalstva, zlasti od sredine 20. stoletja.

Povzetek

Čeprav naraščajoče temperature niso neposredno povzročile rasti prebivalstva, so začele vplivati na človeške populacije na različne načine. Hkrati je rast prebivalstva prispevala k podnebnim spremembam, kar ustvarja kompleksno povratno

zanko med demografskimi trendi in okoljskimi spremembami. Odnos med podnebnimi spremembami in prebivalstvom je večplasten in vključuje vprašanja emisij, ranljivosti, prilagajanja in strategij blaženja.



Slika1: https://www.perplexity.ai/search/make-graph-of-temaperature-ris-StW7v2gkTGS325Rivulm9A

5 Ali segrevanje zmanjšuje število ljudi?

Dvig globalnih temperatur za 2 stopinji Celzija verjetno ne bo neposredno znižal svetovnega prebivalstva, lahko pa ima pomembne posredne učinke, ki lahko upočasnijo rast prebivalstva ali celo povzročijo upad prebivalstva v določenih regijah. Tukaj so ključne točke:

• Smrti zaradi vročine : višje temperature bodo povečale tveganje za bolezni in umrljivost zaradi vročine, zlasti med ranljivimi skupinami prebivalstva, kot so starejši, otroci in osebe z že obstoječimi zdravstvenimi težavami. To bi lahko povzročilo višje stopnje smrtnosti na prizadetih območjih.

• Vplivi na zdravje : Podnebne spremembe lahko tudi poslabšajo kakovost zraka, širijo nalezljive bolezni ter motijo oskrbo s hrano in vodo, kar dodatno poveča zdravstvena tveganja in umrljivost.

• Zmanjšanje pričakovane življenjske dobe : V regijah, ki so jih močno prizadele podnebne spremembe, se lahko pričakovana življenjska doba skrajša zaradi skupnih učinkov toplotnega stresa, podhranjenosti in bolezni. To bi lahko upočasnilo rast prebivalstva ali celo povzročilo upad prebivalstva.

• Podnebni begunci: Dvig morske gladine, ekstremni vremenski pojavi in degradacija okolja bi lahko povzročilo povečano preseljevanje. S tem bi se povečal pritisk na vire in infrastrukturo sprejemnih območji ter povzročilo socialno in gospodarsko nestabilnost.

• Konflikti in nemiri: S podnebjem povezano razseljevanje in pomanjkanje virov lahko prav tako prispevata k konfliktom, ki lahko dodatno destabilizirajo prizadete regije in povzročijo upad prebivalstva.

• Družbeno-ekonomski vplivi: gospodarske in družbene motnje, ki jih povzročajo podnebne spremembe, kot je zmanjšana kmetijska produktivnost, bi lahko povzročile večjo revščino in nestabilnost. To lahko povzroči zmanjšanje stopnje rodnosti, saj imajo ljudje manj otrok zaradi gospodarske negotovosti ter zmanjšanega dostopa do zdravstvenega varstva in izobraževanja.

5.1 Omejitve

Pomembno je omeniti, da čeprav lahko podnebne spremembe prispevajo k upadu prebivalstva v določenih regijah, je malo verjetno, da bodo v bližnji prihodnosti bistveno zmanjšale svetovno prebivalstvo. Na rast prebivalstva vplivajo številni zapleteni dejavniki, splošni vpliv podnebnih sprememb na število svetovnega prebivalstva pa ostaja negotov.

Povzetek

Čeprav ni pričakovati, da bi dvig globalnih temperatur za 2 stopinji neposredno zmanjšal svetovno prebivalstvo, bi lahko povzročil povečano umrljivost, krajšo pričakovano življenjsko dobo, razseljevanje in nižjo stopnjo rodnosti v močno prizadetih regijah. Blaženje podnebnih sprememb in prilagajanje njihovim vplivom bo ključnega pomena za zmanjšanje teh možnih vplivov na prebivalstvo.

Medicinska revija The Lancet ocenjuje, da je dostop do klimatskih naprav v letu 2019 preprečil skoraj 200.000 smrti med ljudmi, starimi 65 let ali več[9].

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6 Zaradi mraza umre 10-krat več ljudi kot zaradi vročine

Čeprav je res, da je v preteklosti število smrti zaradi mraza znatno preseglo smrti zaradi vročine, se dinamika zaradi podnebnih sprememb spreminja. Tukaj so ključne točke v zvezi

z vplivom naraščajočih temperatur na stopnjo umrljivosti in morebitne posledice za svetovno prebivalstvo:

6.1 Trenutni trendi smrti zaradi temperature

• Smrti zaradi mraza v primerjavi z vročino : Študije kažejo, da na svetu zaradi mraza umre približno devetkrat več kot zaradi vročine. Študija, objavljena v »The Lancet Planetary Health«, je pokazala, da je v zadnjih dveh desetletjih izpostavljenost mrazu predstavljala veliko večino smrtnih primerov, povezanih s temperaturo, pri čemer je bilo približno 8,5 % smrti pripisanih mrazu in samo 0,9 % vročini[1][2][4].

• Spreminjanje vzorcev : Čeprav trenutno prevladujejo smrti zaradi prehlada, se trend spreminja. Smrti zaradi vročine zaradi podnebnih sprememb naraščajo, število smrti zaradi mraza pa se zmanjšuje. Ta premik nakazuje, da se bo ravnovesje v prihodnosti lahko nagnilo k večjemu številu smrtnih žrtev, povezanih z vročino [1][4][5].

Posledice naraščajočih temperatur

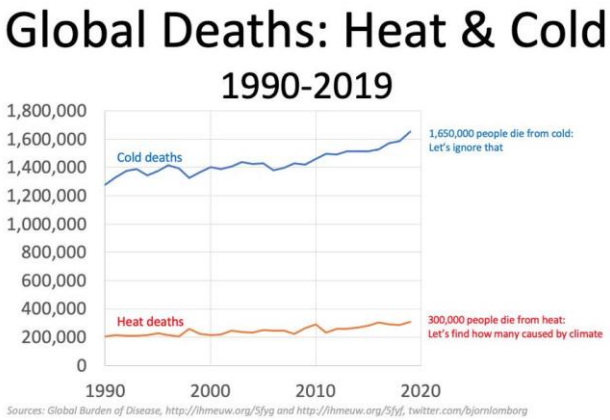
• Povečana smrtnost zaradi vročine : Ko se temperature dvignejo, zlasti v ranljivih regijah, se pričakuje, da se bo število smrti zaradi vročine povečalo. To je še posebej zaskrbljujoče za prebivalstvo na območjih, ki niso vajena ekstremne vročine, in kjer so prilagoditveni ukrepi morda nezadostni[1][4].

• Potencialni vpliv na prebivalstvo : Čeprav celotno število svetovnega prebivalstva morda ne bo takoj upadlo zaradi povečanega števila smrti, povezanih z vročino, bi lahko v nekaterih regijah prišlo do znatnega povečanja umrljivosti in upočasnilo rast prebivalstva ali povzročilo lokalno zmanjšanje. Ranljivo prebivalstvo, zlasti na območjih z nizkimi dohodki, je lahko nesorazmerno prizadeto, kar še poslabša obstoječe zdravstvene razlike in potencialno vodi do večjih migracijskih pritiskov[1][2][5].

• Dolgoročne projekcije : Ker se podnebne spremembe še naprej odvijajo, bi lahko vse večja razširjenost smrti zaradi vročine sčasoma uravnotežila ali presegla smrt zaradi mraza, zlasti če se ne izvajajo prizadevanja za ublažitev. To bi lahko vodilo do višjih splošnih stopenj umrljivosti in vplivalo na populacijsko dinamiko skozi čas[2][4].

Povzetek

Če povzamemo, čeprav število smrti zaradi mraza trenutno znatno presega število smrti zaradi vročine, podnebne spremembe spreminjajo to pokrajino. Pričakuje se, da bo dvig globalnih temperatur povečal smrtnost zaradi vročine, kar bi lahko imelo globoke posledice za zdravje in dinamiko prebivalstva, zlasti v ranljivih regijah. Takojšnje ukrepanje za ublažitev podnebnih sprememb je ključnega pomena za preprečitev teh neugodnih rezultatov.



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7 Segrevanje 2x hitrejše od svetovnega povprečja

Samo nekaj področij je, kjer se to res dogaja

• Arktika, zlasti polotok Tajmir v Rusiji, se segreva 2,5- do 2,8-krat hitreje od svetovnega povprečja. V zadnjih 10 letih so tamkajšnje temperature narasle za 0,8 °C do 1,2 °C (1,4 °F do 2,1 °F) hitreje od svetovnega povprečja [4].

• Rusko ozemlje se na splošno segreva skoraj dvakrat hitreje od svetovnega povprečja kopnega – pri 0,51 °C (0,91 °F) na desetletje v primerjavi z 0,295 °C (0,531 °F) globalno nad kopnim[4].

• Antarktika se segreva dvakrat hitreje od svetovnega povprečja, s približno 20–50 % večjim segrevanjem od ocen iz podnebnih modelov. To temelji na rekonstrukciji temperatur na Antarktiki v preteklem tisočletju z uporabo zapisov ledenih jeder [5].

• Podnebni modeli predvidevajo, da se bo pas južne Azije, ki se razteza od Perzijskega zaliva preko Indije in Kitajske, segreval hitreje kot skoraj kjer koli drugje na Zemlji v različnih scenarijih podnebnih sprememb. V tej regiji živi več kot milijarda ljudi[3].

Povzetek,

Arktika, Rusija, Antarktika in deli južne Azije se soočajo z dvigi temperature, ki so približno dvakrat višji od svetovnega povprečja, pri čemer se Arktika segreva najhitreje in je dvig temperature skoraj trikrat višji. Hitro segrevanje v teh regijah je velika skrb zaradi velike populacije v južni Aziji in možnih vplivov segrevanja Arktike in Antarktike na podnebni sistem.

Ali se res 2x hitreje segreva tudi Slovenija [9]?

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8 Hinavščina razogljičenja

Koncept hinavščine v prizadevanjih za razogljičenje je večplastno vprašanje, ki vključuje neskladja med navedenimi zavezami za zmanjšanje emisij ogljika in ukrepi, ki jih sprejmejo posamezniki, korporacije in države. V diskurzu o podnebnih spremembah in dekarbonizaciji je izpostavljenih več vidikov te hinavščine.

8.1 Razlika med bogatimi in revnimi narodi

Bogate države, ki so v preteklosti največ prispevale k emisijam toplogrednih plinov, pogosto spodbujajo podnebne politike, ki nesorazmerno bremenijo države v razvoju. Mehanizmi, kot je mehanizem Evropske unije za prilagajanje meja ogljika, so na primer kritizirani zaradi zaostrovanja globalnih neenakosti z nalaganjem stroškov revnejšim državam, medtem ko bogate države še naprej porabljajo blago, proizvedeno z visokimi okoljskimi stroški[2][7].

• Hinavščino dodatno poudarja dejstvo, da bogate države pogosto selijo energetsko intenzivne industrije v države v razvoju, pri čemer dejansko izvažajo emisije, medtem ko še naprej porabljajo nastale izdelke [2].

8.2 Individualna in korporativna dejanja

• Posameznikom in korporacijam pogosto očitajo hinavščino, ko se zavzemajo za podnebne ukrepe, medtem ko se ukvarjajo z ogljično intenzivnimi dejavnostmi. To vključuje uporabo fosilnih goriv za potovanja ali proizvodnjo ob javnem spodbujanju trajnosti[3][4].

• Podjetja so včasih obtožena zelenega pranja – podajanja zavajajočih trditev o svojih okoljskih prizadevanjih, da bi bila videti bolj trajnostna, kot so. Vendar pa nekatere študije kažejo, da si številna podjetja, ki se ukvarjajo s trgi ogljičnih kreditov, resnično prizadevajo zmanjšati svoje emisije, čeprav se razpravlja o učinkovitosti in iskrenosti teh prizadevanj [6].

8.3 Sistemska odgovornost proti individualni odgovornosti

• Kritiki trdijo, da osredotočanje na posamezna dejanja, kot je sramotenje bega, preveč poenostavlja vprašanje in ne obravnava sistemskih sprememb, potrebnih za boj proti podnebnim spremembam. Zanašanje na fosilna goriva je za posameznike pogosto neizogibno zaradi trenutne infrastrukture in gospodarskih sistemov, zaradi česar so obtožbe osebne hinavščine manj vplivne[3][5].

• Obstaja poziv k sistemskim spremembam, ki omogočajo bolj trajnostne odločitve, s poudarkom na potrebi po večjih strukturnih reformah namesto zgolj osredotočenju na posameznikovo vedenje[4].

8.4 Podnebne konference in politične zaveze

• Mednarodne podnebne konference pogosto razkrivajo vrzel med zavezami in dejanji. Razvite države so bile kritizirane zaradi zastoja pri finančni podpori za podnebno ranljive države in nezmožnosti ustreznega obravnavanja izgube in škode [8].

• Kljub obljubam, da bodo zmanjšale emisije in podprle globalna podnebna prizadevanja, številne države še naprej izvajajo projekte fosilnih goriv doma, kar poudarja nepovezanost med njihovo mednarodno retoriko in domačo politiko [8].

8.5 Nasprotovanje jedrski energiji

• Nasprotovanje jedrski energiji ob hkratnem zagovarjanju zmanjšanja emisij ogljika je nedosledno, saj bi jedrska energija lahko imela pomembno vlogo pri razogljičenju proizvodnje električne energije. [9][10]

• Na protijedrska stališča nekaterih okoljskih skupin vpliva financiranje s strani donatorjev z izrecno protijedrskimi programi in ne zgolj okoljska vprašanja. [9]

• Kritiki trdijo, da je zaradi zavračanja jedrske energije veliko težje doseči podnebne cilje, saj se s tem odstrani preverjena možnost nizkoogljične tehnologije.[9][10]

Povzetek

Hinavščina prizadevanj za razogljičenje je zapleteno vprašanje, ki vključuje tako dejanja posameznikov kot politike držav. Poudarja potrebo po resničnih zavezah in sistemskih spremembah za učinkovito reševanje podnebnih sprememb in zmanjšanje svetovnih emisij ogljika. Najhujše pa je nasprotovanje jedrski energiji, ki zaenkrat edina zagotavlja zanesljivo in čisto energijo.

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9 Okoljevarstvo kot kult

O pojmu okoljskega gibanja kot o "kultu" se je razpravljalo v različnih kontekstih, pogosto s strani kritikov, ki trdijo, da nekateri vidiki okoljskega gibanja kažejo značilnosti, podobne tistim pri verskem ali kultu podobnem vedenju. Tukaj je nekaj ključnih točk:

9.1 Značilnosti kultnega okoljevarstva

• Apokaliptične pripovedi : Kritiki trdijo, da imajo nekateri okoljevarstveniki apokaliptični pogled na svet in napovedujejo katastrofalne rezultate, če ne bodo sprejeti takojšnji in drastični ukrepi. To odraža napovedi sodnega dne, ki so pogosto povezane s kulti [4][6].

• Moralni puritanizem in ekstremizem : Okoljevarstveno gibanje je včasih opisano kot izkazovanje moralnega puritaizma, z ekstremnimi dejanji aktivistov, da bi opozorili na svoje vzroke. Ta dejanja lahko vključujejo moteče proteste in simbolična dejanja vandalizma, ki veljajo za izraze fanatične predanosti cilju [4].

• Verski jezik in prakse : Za okoljevarstvo včasih pravijo, da prevzema verski jezik in prakse, kot je ideja o "ogljičnih grehih" in potreba po "pokori" z izravnavo ogljika. To je mogoče razumeti kot analogno verski izpovedi in odkupni daritvi [3].

• Protičloveški pogled na svet : Nekateri kritiki trdijo, da se lahko radikalno okoljevarstvo nagiba k protičloveški perspektivi, ki na človeštvo gleda kot na grožnjo planetu. Ta perspektiva lahko zagovarja nadzor nad populacijo ali prikazuje ljudi kot "vrsto plevela", kar lahko razumemo kot razvrednotenje človeškega življenja[2][7].

• Sovražnost do drugače mislečih : Okoljevarstvo je včasih kritizirano zaradi nestrpnosti do nasprotujočih si pogledov, označevanja skeptikov kot "zanikovalcev" in odvračanja od odprte razprave. To odraža, kako kulti pogosto zatirajo nestrinjanje, da bi ohranili enoten sistem prepričanj[3].

9.2 Protiargumenti

Čeprav te kritike obstajajo, je pomembno opozoriti, da vodilno (mainstream) okoljevarstvo ni monolitno in vključuje širok spekter prepričanj in praks. Številni okoljevarstveniki se osredotočajo na dokazih temelječe pristope k obravnavanju podnebnih sprememb in spodbujanju trajnosti. Trdijo, da nujnost okoljskih vprašanj zahteva odločno ukrepanje in da je prikaz okoljevarstva kot kulta napačna opredelitev, ki spodkopava upravičene skrbi glede ekološke degradacije in podnebnih sprememb.

Povzetek

Medtem ko nekateri kritiki dojemajo nekatere elemente okoljevarstva kot kultne, to stališče ni splošno sprejeto in mu pogosto oporekajo tisti, ki vidijo okoljsko zagovorništvo kot racionalen in nujen odgovor na pereče globalne izzive.

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10 Okoljski vidik blejskih kremšnit

Izlet do Blejskega jezera, da bi uživali v lokalni specialiteti , kremšnitah , ima številne okoljske vidike, ki jih je vredno raziskati. Blejsko jezero je naravna znamenitost, ki obiskovalce privablja s svojo lepoto in edinstvenim ekosistemom. Vendar lahko povečan obisk povzroči preobremenitev okolja, kar lahko vpliva na kakovost vode in biotsko raznovrstnost. Pomembno je, da obiskovalci ravnajo odgovorno, spoštujejo naravo in se zavedajo svojega vpliva na okolje.

Priprava kremšnit na Bledu pogosto vključuje lokalne sestavine, ki lahko pozitivno vplivajo na okolje. Uporaba lokalno pridelanih sestavin zmanjšuje ogljični odtis, povezan s prevozom hrane. Poleg tega spodbujanje lokalnih kmetov in proizvajalcev prispeva k trajnostnemu razvoju regije. Paziti pa je treba tudi na embalažo in odpadke, ki nastanejo med potovanjem, saj lahko nepravilno ravnanje dodatno obremenjuje okolje.

Priljubljenost blejskih kremšnit odpira tudi vprašanje trajnosti turizma. Obiskovalce je treba ozaveščati o pomenu ohranjanja naravnih virov in kulturne dediščine. Dejavnosti, kot so organizirani izleti in delavnice o trajnostnem turizmu, lahko pripomorejo k ozaveščanju o okoljskih izzivih in spodbujajo odgovorno vedenje . Tako lahko izlet na kremšnite na Blejsko jezero postane ne le kulinarično doživetje, ampak tudi priložnost za izobraževanje in aktivno sodelovanje pri varovanju okolja.

Slika 4: Blejska kremšnita
https://the-slovenia.com/en/slovenia/blejska-kremsnita-blejska-kremna-torta

10.1 Izračun ogljičnega odtisa

Ogljični odtis potovanja na Blejske kremšnite je odvisen od številnih dejavnikov, kot so prevoz, hrana in namestitev. Če upoštevamo, da se obiskovalec pripelje iz Ljubljane z avtom, poje eno kremšnito in se vrne domov, lahko ocenimo, da je njegov ogljični odtis približno 20,4 kg CO2e.

10.2 Emisije v prometu:

Razdalja LJ-Bled 50 km, skupaj torej 100 km.

Izpust prevoza z avtomobilom: 200g CO2 / km * 100 km = 20 kg CO2.

• Izlet na Bled proizvede 20kg CO2.

10.3 Izpust CO2 kremšnite

Sestavine 1 kg kremšnite: listnato testo: 300 g , vaniljev puding: 400 g , sladka smetana: 300 g

Listnato testo: 2,5 kg CO2 / kg × 0,3 kg = 0,75 kg CO2
Vaniljev puding: 1,5 kg CO2 / kg × 0,4 kg = 0,6 kg CO2
Sladka smetana: 3,0 kg CO2 / kg × 0,3 kg = 0,9 kg CO2

Ogljični odtis znaša 2,25 kg CO2 na kilogram kremšnit.

Velikost kremšnite je 7 cm x 7 cm in tehta 180 gramov.

• Ogljični odtis kremšnite je 0,41 kg CO2 / porcijo, kar ustreza 10 uram človeškega dihanja[9] in 1/50 izleta na Bled.

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11 Pričakovan rezultat razogljičenja

• Vreme bo enako.
• Demontirali bomo kapitalizem in odpravili fosilna goriva.
• Pa kremšnitam smo se bomo odpovedali ;=(((

Radon v stavbah in kakovost bivanja

Radon in buildings and quality of life

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Povzetek

V stavbah, ki niso ustrezno zgrajene ali sanirane, se nabira radon, zdravju nevaren žlahtni plin brez barve, vonja in okusa.

Področje radona v stavbah pokrivajo ministrstva za zdravje, za energijo, za prostor, za graditev … Čeprav so vsa ministrstva aktivna na področju preprečevanja radona v stavbah, niso medresorsko usklajena. Prepogosto se zgodi, da občani prejmejo nasprotujoče si informacije, zato se celo dogaja, da se po energetski sanaciji stavb pojavi radon v bivalnih prostorih.

V Sloveniji merijo radon v javnih stavbah od leta 1990, v stanovanjskih stavbah pa od 2018. Žal so stanovalci premalo informirani o nevarnosti radona, zato je potrebna proaktivna komunikacija za ozaveščanje prebivalstva.

Prebivalstvo in stroko je treba seznaniti o nevarnostih radona v stavbah in predlagati izvedbo ukrepov, ki preprečujejo vdor radona v stavbah.

Ključne besede

radon v stavbah, energetska sanacija, protiradonska sanacija, radonvednost

Abstract

In buildings that are not properly constructed or rehabilitated, radon, a colorless, odorless, and tasteless noble gas that is hazardous to health, accumulates.

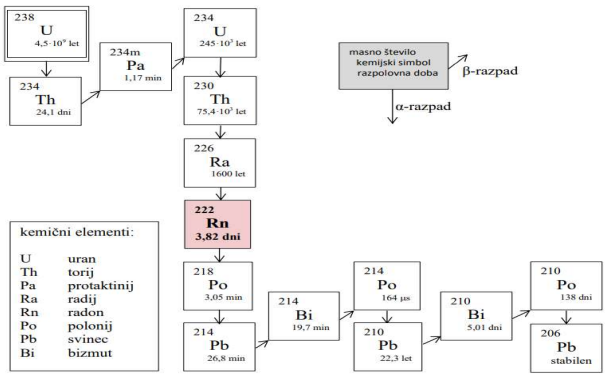
The field of radon in buildings is covered by the ministries responsible for health, energy, space, construction... Although all ministries are active in the field of radon prevention in buildings, they are not interdepartmental coordinated. It happens too often that citizens receive conflicting information, which is why it even happens that radon appears in living spaces after energy renovation of a building.

In Slovenia, radon has been measured in public buildings since 1990, and in residential buildings since 2018. Unfortunately, residents are insufficiently informed about the danger of radon, so proactive communication is needed to raise awareness among the population.

It is necessary to inform the population and the profession about the dangers of radon in buildings and propose the implementation of measures to prevent the ingress of radon in buildings.

Optional: Keywords

radon in buildings, energy rehabilitation, anti-radon rehabilitation, radon knowledge



Slika 1 Razpadna veriga urana (vir1)

1 Radon

Radon je žlahten plin, brez barve, vonja in okusa.

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Beseda »žlahten« naj ne zavede. Čeprav ta beseda pomeni nekaj imenitnega, sodeč po slovarju: žlahtna kapljica, žlahtni kamen, žlahtna plesen, žlahtna gospoda … je radon zdravju nevaren plin.

SSKJ²
žláhten -tna -o prid., žláhtnejši (á)
1. knjiž. *plemenit, izbran:* žlahten človek, mislec / žlahten značaj; biti žlahtnega srca / žlahtni cilji; žlahtne misli / žlahten okus kave / žlahtno vino / žlahtni komedijant od 1992 *igralec, ki na festivalu Dnevi komedije dobi nagrado za najboljšo komično vlogo*

Slika 2 Beseda "žlahten" ima raznolik pomen.

V kemiji pomeni beseda »žlahten« nekaj drugega. Žlahtni plini, včasih imenovani **inertni plini**, imajo svojevrstno mesto v periodnem sistemu. Vsi žlahtni plini, tudi radon (Rn), so znani po tem, da nimajo barve, vonja in okusa. So nevnetljivi, v standardnih pogojih izjemno stabilni.

Radon je kemijski element z vrstnim številom 86 in atomskim masnim številom 222, pri čemer je treba omeniti, da obstaja mnogo različnih izotopov radona. Najbolj dolgoživ izotop radona je ^{222}Rn z razpolovno dobo 3,82 dni. Ostali izotopi imajo razpolovno dobo nekaj minut ali manj; zaradi kratke razpolovne dobe in ker večinoma ti izotopi ne razpadajo z **α** razpadom, ostalih izotopov ne obravnavamo v kontekstu nevarnosti za zdravje.
Radon je element VIII. valentne skupine. Spada med žlahtne pline in tvori enoatomne molekule. Zaznamo ga predvsem zaradi radioaktivnega razpada, z merilnimi napravami.

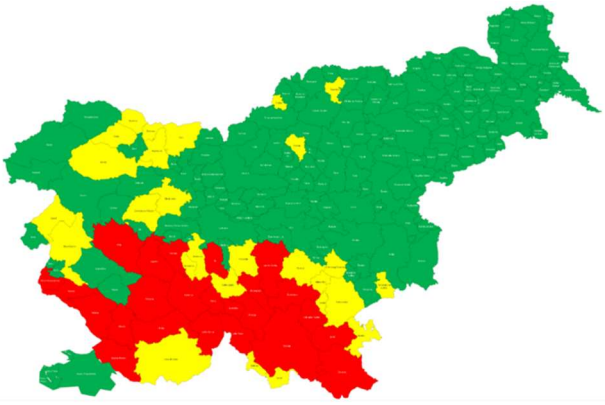
Radon sta odkrila Ernest Rutherford in Friderick Soddy leta 1900. Je najtežji element skupine žlahtnih plinov, je radioaktiven in nastaja pri radioaktivnem razpadu radija.
Še zanimivost. Plin radon nastane iz trdne snovi (radija) v zemljini, kot plin vstopa v stavbe in tam razpade v trdne snovi, ki so radioaktivne.

Za zdravje so nevarni radonovi kratkoživi razpadni produkti. To so kovine, ki v zraku tvorijo radioaktivne aerosole, nanodelce. Med dihanjem se radioaktivni aerosoli nalagajo na stenah dihalnih poti. Od tam sevajo in povzročajo poškodbe tkiva. Mednarodna agencija za raziskovanje raka (IARC) radon in njegove razpadne produkte uvršča med snovi, ki so rakotvorne za človeka (skupina 1).

Radon in njegovi razpadni produkti povzročajo pljučnega raka. Svetovna zdravstvena organizacija (WHO) je ugotovila, da se ob povišani koncentraciji radona za 100 Bq/m^3 tveganje za pljučnega raka poveča za 8 %. Tveganje za bolezen in smrt zaradi pljučnega raka pri povišanih koncentracijah radona je večje pri kadilcih kot nekadilcih. Ocenjujejo, da je vsak deseti rak na pljučih posledica radona oziroma njegovih razpadnih produktov. (7)

2 Vir in vstop radona v stavbo ter dejavniki, ki vplivajo na raven radona v stavbi

Največji izvor radona v bivalnem okolju predstavlja zemljina pod stavbo, manj pa gradbeni material, voda in plin za ogrevanje. Radon je v zaprtih prostorih, v katere prodira skozi slabo izolirana tla in vodovodna ter druga omrežja v stavbi, ki so v stiku z zemljino. Vzrok povišanih koncentracij radona so kamninska podlaga, letni čas, nadstropje v stavbi in tesnjenje oken. Največji vpliv na koncentracijo radona v stavbi ima kamninska podlaga.



Slika 3: Radonski zemljevid Slovenije (8)

Na podlagi do zdaj izvedenih meritev koncentracij radona v Sloveniji in podatkov o geološki sestavi tal so določena območja, kjer je več radona (na zemljevidu obarvano rdeče).
Dodatne meritve se izvajajo tudi na območjih občin, kjer je radon pričakovan (na zemljevidu obarvano rumeno).

Vendar se radon lahko pojavi tudi v stavbah na zelenem področju. V nekaterih ljubljanskih vrtcih in

šolah so izmerili povišane koncentracije radona in jih sanirali (9), pa so te stavbe na zelenem področju.

Za preprečevanje pojava radona v stavbah so preventivni protiradonski ukrepi potrebni tudi na zelenem radonskem področju.

A: obstoječe stavbe: Ukrepi za znižanje radona v obstoječih stavbah

V vsaki stavbi predlagamo zaščitno detekcijo koncentracije radona.

Trenutno veljavna zakonodaja določa, da je dopustna koncentracija radona v zraku bivalnega okolja pod 300 Bq/m^3. Če je mejna vrednost prekoračena, je treba začeti sanacijo radona v stavbi. Raziskave kažejo, da 1/3 slovenskih domov presega zgoraj navedeno mejno vrednost.

Zakonsko določena mejna vrednost koncentracije radona v zraku bivalnega okolja pomeni, da če meritve pokažejo vrednosti pod 300 Bq/m^3, zakonodaja ne predpisuje nujnih ukrepov. Vendar pa je pomembno poudariti:

- 300 Bq/m^3 ni varnostna meja, temveč meja, pri kateri se priporoča začetek sanacije. Že pri nižjih koncentracijah radona obstaja povečano tveganje za nastanek raka na pljučih.
- Svetovna zdravstvena organizacija (WHO) priporoča, da se prizadevanja za zmanjšanje koncentracije radona začnejo že pri vrednostih pod 100 Bq/m^3. To je še posebej pomembno v prostorih, kjer se zadržujejo otroci in občutljive skupine prebivalstva.

Izbira ukrepov naj temelji na velikosti preseženih vrednosti radona in njeni oceni vpliva na zdravje stanovalcev. Najučinkovitejši ukrep je kakovosten gradbeni poseg na talni plošči, saj z njim omejimo vir povišanih koncentracij radona v stavbi. Prezračevanje prostorov in zatesnitev vidnih razpok ter špranj v tleh in stenah, ki mejijo na zemljino, ter instalacijskih vodov sta primerna pri majhnih preseganjih dovoljenih vrednosti, sicer sta le začasna ukrepa.

Pred izvedbo vseh gradbenih ukrepov, ki bi lahko povečali koncentracijo radona v stavbi, svetujemo radonske meritve in izbor tistih ukrepov, ki znižajo prisotnost radona. Zlasti skrb vzbujajoči so nestrokovni ukrepi ob energetskih sanacijah, tesnitvi stavbe, menjavi oken, vgradnji prezračevalnih naprav z izmenjujočim delovanjem, izolaciji fasade, izdelavi prizidkov, tlakovanju dvorišč … Ti ukrepi praviloma povečajo prisotnost radona v prostorih in so, iz tega vidika, škodljivi.

Izvedba protiradonske sanacije obstoječih stavb je določena v Pravilniku (4).

- Kot gradbeni poseg za zmanjšanje izpostavljenosti radonu iz uredbe, ki ureja nacionalni radonski program, se šteje vgradnja aktivnega sistema za prezračevanje zemljine pod talno konstrukcijo.
- Ne glede na prejšnji odstavek je dopustna izvedba pasivnega sistema, če se z njim lahko zagotovi referenčna raven.
- Kot dodaten ukrep k aktivnemu sistemu prezračevanja zemljine se lahko izvede tudi tesnjenje oboda talne konstrukcije in prebojev skozi talno ploščo ter tesnjenje tlorisne površine z radonsko zaporno folijo.

B: nove stavbe: Ukrepi za preprečevanje radona pri projektiranju in izvedbi novogradenj

Zakonodaja določa, da morajo biti stavbe projektirane, grajene in vzdrževane tako, da je koncentracija radona v delovnih in bivalnih prostorih čim nižja in da ni presežena referenčna raven. Območje Republike Slovenije je razdeljeno na dve območji, in sicer na radonsko območje in zeleno območje.

- Na radonskem področju: Projektiranje in gradnja novih stavb na radonskem območju se zagotovi s prezračevanjem zemljine pod talno konstrukcijo stavbe ali s popolnim tesnjenjem med zemljino in notranjim zrakom z radonsko zaporno folijo. Kot prezračevanje zemljine se štejejo tudi arhitekturne rešitve, ki zagotavljajo zadostno prezračevanje prostorov, ki so v stiku z

zemljino tako, da ni presežena referenčna raven. Če pasivno prezračevanje zemljine ne zadošča, se vgradi aktivno prezračevanje.

- Na zelenem področju: Projektiranje in gradnja novih stavb na zelenem območju je določeno enako kot na radonskem področju.

3 Prezračevanje prostorov, popularen, a dvomljiv ukrep

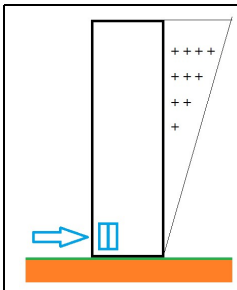
Ukrepi za znižanje koncentracije radona v stavbah so zelo različni (6). Ob pripravi projekta sanacije stavbe je treba upoštevati značilnosti objekta, temeljenje in podkletenost zgradbe, propustnost tal pod osnovno ploščo, in poiskati mesta, kjer radon vstopa v zgradbo. Vstopna mesta določimo s posebnimi instrumenti, ki merijo trenutne koncentracije radona. Čeprav velja splošno prepričanje, da koncentracijo radona v prostorih znižamo s prezračevanjem prostorov, je ta ukrep dvomljiv. Vendar pa tudi ureditev prezračevalnega sistema prostorov le malo zniža koncentracije (običajno 20-30 %). Prezračevalni sistemi, ki v zgradbah ustvarjajo dodaten podtlak, lahko privedejo tudi do nasprotnega učinka in se koncentracija radona v prostorih zviša. Povečano prezračevanje prostorov ali vzdrževanje stalnega nadtlaka v stavbi proti zemljini sta ukrepa, ki sta lahko primerna, če je prezračevanje intenzivno, z nadtlakom. Vendar sta energetsko potratna in ju stroka ne priporoča pri splošnem reševanju težave povišanega radona,

4 Napačno protiradonsko prezračevanje

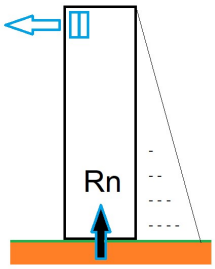
Prezračevanje pomeni izmenjavo zraka. Čist zunanji zrak vstopa v prostor, notranji pa izstopa in odnese vsa onesnažila. Izmenjava je lahko samodejna, zaradi fizikalnih lastnosti zraka ali mehanska, s prezračevalno napravo. Ne glede na način izmenjave lahko nastane v prostoru nadtlak ali podtlak. Iz vidika izmenjave zraka je vseeno, če je prezračevanje nadtlačno ali podtlačno, glede ogroženosti z radonom pač ni.

Premikanje radona skozi zemljino v stavbo je predvsem konvektivno, posledica tlačnih razlik med plinom v zemljini in tlakom v prostorih, ki ležijo nad zemljino. Neprimerno prezračevanje celo poveča koncentracijo radona v stavbah!

V stavbah je večji del leta topleje kot zunaj, zato so tlačne razmere v stavbah odvisne tudi od mesta oziroma višine netesnosti stavbe. Stare stavbe so bile praviloma netesne povsod, zlasti pri vseh okenskih odprtinah, zato je bil zračni tlak v celotni stavbi izenačen s tlakom zunanjega zraka oziroma tlaka v zemljini, možnost vdiranja radona v stavbe je bila majhna.



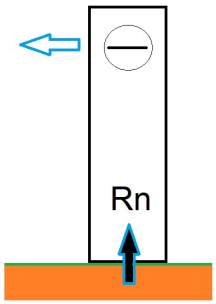
Slika 4 Netesnost spodaj, stavba je v nadtlaku, možnost vdora radona je majhna.



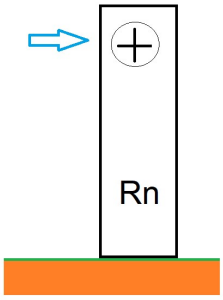
Slika 5. Netesnost zgoraj, stavba je v podtlaku, radon intenzivno vstopa.

V kurilni sezoni je sodobna, tesna stavba takrat, ko je netesna na zgornjem delu ovoja, v podtlaku in vzgonsko črpa radon iz zemljine pod stavbo (slika 5). Izven kurilne sezone, ko je praviloma odprtih več oken, je vzgonski učinek črpanja radona manjši. (slika 4)

Še intenzivnejši je vdor radona v stavbo, v kateri je izmenjujoči zračni tlak zaradi dvosmerne prezračevalne naprave (sliki 6 in 7). Kljub dobrim namenom se stavba z izmenjujočim delovanjem prezračevalnih naprav spremeni v radonsko črpalko, ki ob podtlaku črpa radon v stavbo, ob nadtlaku pa ga ne zmore izriniti iz stavbe.



Slika 6. Ob izmeničnem delovanju prezračevalne naprave odvod zraka ustvarja podtlak in pospešuje vdor radona iz zemljine, odvede pa se le del radona.



Slika 7. Dovod zraka izmenične prezračevalne naprave ne zmanjšuje deleža radona v stavbi. Izmenični dovod in odvod zraka iz stavbe ustvarja učinek radonske črpalke v stavbo.

Prezračevanje ni magična rešitev za zmanjšanje koncentracije radona v stavbi, zlasti ne, če je napačno, s podtlakom ali z izmenjujočimi tlačnimi razmerami. Izmenjujoče prezračevanje lahko celo ustvari učinek radonske črpalke in pospeši uhajanje radona v stavbo.

5 Vpliv Jomkipurske vojne na radon v stavbah

Med Jomkipursko vojno in povečanjem radona v stavbah ni nobene neposredne povezave. Odgovor na prvo svetovno naftno krizo je bilo povečanje energijske učinkovitosti stavb, tudi z zatesnitvijo stavb. Kmalu po tem se je pokazalo, da tesne stavbe niso zdrave (SBS), predpisano je bilo kontrolirano prezračevanje z vračanjem toplote za zadovoljevanje sanitarnih potreb in energijsko učinkovitost. Radon, zdravju škodljiv plin brez barve, vonja in okusa, je bil prezrt. Morda so pozabili nanj zato, ker je že od nekdaj vstopal v netesne stavbe in iz njih neovirano izstopal. V tesnih stavbah pa je ostal ujet. Tako so sodobne, tesne stavbe postale radonske kletke.

Posredno, zaradi neprimerne komunikacije o stanovanjski kulturi, je Jomkipurska vojna vplivala na povečanje koncentracije radona v stavbah.

Zdaj, ko poznamo nevarnosti radona in se znamo zaščititi pred radonom, bi bilo neprimerno, da bi to nevarnost prezrli.

6 Radonvednost

Radonvednost je akcija ozaveščanja prebivalstva in strokovnjakov o radonu v zaprtih prostorih. Vključuje vse udeležence, ki se ukvarjajo z radonom v stavbah, lahko vplivajo na pojav radona v stavbah ali živijo z radonom, od načrtovalcev, projektantov, izvajalcev do stanovalcev.

Radonvednost želi podati celovite informacije o pojavu radona v stavbah in o njegovem preprečevanju, ob rabi stavb ter sočasni celoviti oziroma delni prenovi stavb in ob novogradnjah.
Vsi, ki vas zanima radon v bivalnih prostorih, ste povabljeni, da se pridružite akciji radonvednost.

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Postavljanje sončnih elektrarn na kmetijskih površinah- okoljski kriminal ali trajnostna raba prostora

Setting up solar power plants on agricultural land - environmental crime or sustainable use of space

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Povzetek

Napačne besede, navržene v eter, so nevarne, tudi če so povedane z nasmehom. Smo v času pred jedrskim referendumom, ko javni in tihi jedrski podporniki intenzivno oblikujejo javno mnenje v korist novi jedrski naložbi, brez ustreznih argumentov.

Tiho, prikrito jedrsko lobiranje se začelo že pred več kot tremi desetletji, ko je civilna družba zahtevala referendum o zaprtju NEK. Zato lahko neutemeljeno in neprimerno kritiko obnovljivih virov energije razumemo dvolično.

Ko napačne besede padejo na plodna tla, se razplamti požar negativnih čustev. Pojavijo se civilne iniciative, ki jim praviloma sledijo ovire ali prepovedi postavitev naprav za rabo obnovljivih virov energije. To spremljamo pri vseh možnih obnovljivih virih: vetrnih, vodnih, geotermalnih, sončnih, izrabi organskih ostankov …

Zaradi lahkotnih izjav o obnovljivih virih, ki so lahko napačno razumljene, država nazaduje na področju rabe obnovljivih virov. Taktika jedrskih zagovornikov je videti preprosta: blokiranje obnovljivih virov toliko časa, da bo jedrska energija spoznana za edino možnost. Je to razlog, da vetrne elektrarne preštejemo na prste ene roke, da smo menda edina evropska država brez plavajočih sončnih elektrarn, da je geotermalna energija, ki ima kapaciteto slovenske polovice jedrske elektrarne, spregledana, da je gradnja hidroelektrarn, ki jim pravijo mesoreznice, ustavljena in da je energijska raba organskih ostankov blokirana?

Ob neprimernih besedah ne smemo ostati tiho. Pogrešamo vključujoče in transparente javne razprave o energetski prihodnosti Slovenije.

Spodbujajmo odprt pogovor o trajnostnem energetskem prehodu.

Keywords / Ključne besede

Okoljski kriminal, okoljsko zavajanje, tiho spodbujanje jedrske energije

Abstract

Wrong words projected into the ether are dangerous, even when said with a smile. We are in the time before the nuclear referendum, when public and silent nuclear supporters are intensively shaping public opinion in favour of a new nuclear investment, without adequate arguments.

Silent, covert nuclear lobbying began more than three decades ago, when civil society demanded a referendum on the closure of the NPP NEK. Therefore, the unfounded and inappropriate criticism of renewable energy sources can be understood in two ways.

When the wrong words fall on fertile ground, a fire of negative emotions is ignited. Civil initiatives appear, which are generally followed

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by obstacles or bans on the installation of devices for the use of renewable energy sources. We monitor this for all possible renewable sources: wind, water, geothermal, solar, use of organic residues...
Due to light statements about renewable resources, which can be misunderstood, the country is regressing in the field of renewable resources. The tactic of nuclear advocates seems simple: block renewables for so long that nuclear power is recognized as the only option. Is this the reason that wind power plants can be counted on the fingers of one hand, that we are supposedly the only European country without floating solar power plants, that geothermal energy, which has the capacity of half of Slovenia's nuclear power plant, is overlooked, that the construction of hydroelectric power plants, which are called butchers, has been stopped and that the energy use of organic residues is blocked?
We must not remain silent in the face of inappropriate words. We miss inclusive and transparent public debates on Slovenia's energy future.
Let's encourage an open conversation about a sustainable energy transition.

Optional: Keywords
Environmental crime, environmental deception, tacit promotion of nuclear energy

Slika 1: Fragments of wind turbine blades await burial at the Casper Regional Landfill in Wyoming. Photographer: Benjamin Rasmussen for Bloomberg Green; Zavajajoča fotografija, ki jo širijo nasprotniki vetrnih elektrarn v Sloveniji. Tega v Sloveniji ni.

Poved z nasmehom

Zanimiva je trditev, ki se ponavlja v medijih in v družbenih omrežjih, da je postavljanje sončnih elektrarn na kmetijskih površinah, namesto na strehah stavb, okoljski kriminal (1).

Podobne so tudi trditve, da so vetrne elektrarne okolju škodljive, ker se dotrajanih kril ne da reciklirati, da ne govorimo o neslišnem hrupu, ki ga nekateri okoljevarstveniki slišijo tudi mnogo kilometrov daleč ali o ptičih, ki se zaletavajo v krila vetrnih turbin. Čeprav sodijo te trditve v psevdoznanost (15), se neovirano širijo med prebivalstvom in po družbenih omrežjih.

Nasprotniki hidroelektrarn opozarjajo na kopičenje mulja (8), na izgubo biotske raznovrstnosti, na neprimerne prehode za vodne organizme … Zato predlagajo rušenje vseh jezov hidroelektrarn! Še več, slovenska Mura naj bi ostala reka brez jezov (9). Ob tem, da je na avstrijskem delu Mure vsaj 22 večjih HE skupne moči 350 MW, na slovenski le ena mala, moči 0,5 MW (11). Avstrijska pretočna elektrarna Kalsdorf (12), ki smo si jo ogledali med gradnjo (10), je vzor sonaravne gradnje. Takrat so investitorji predstavili načrtovane ukrepe za varovanje okolja (ohranjanje zamočvirjenih področij, slepih rokavov, otokov …), ki kljub elektrarni omogočajo biotsko raznovrstnost in pestrost. Prepričani smo, da so investirali v varovanje okolja zaradi splošne okoljske zavesti, ki je posledica dolgoletnih usklajenih aktivnosti avstrijskih okoljevarstvenih organizacij. Ne, tega slovenski varuhi voda ne morejo videti, menda imajo plašnice na očeh.

Druga plat medalje

Jedrski zagovorniki nekritično zagovarjajo jedrsko energijo kot edino možnost za trajnostni energetski prehod in za konkurenčno gospodarstvo. Pozivi k dialogu o energetskem prehodu so cenzurirani (14), članki (13), ki apelirajo na pogovor o jedrski energiji, spregledani.

Smo v času referenduma o JEK2. Vprašanje je, ali je javnost obveščena v skladu z določili

Aarhuške konvencije, saj še niso objavljeni podatki, ki jih izrecno zahteva *Resolucija o dolgoročni miroljubni rabi jedrske energije v Sloveniji »jedrska energija za prihodnost Slovenije« (REDMRJE)* (16) za izvedbo projekta JEK2. Hkrati pa vemo, da je ta referendum popolnoma nepotreben, saj GEN že 18 let neovirano pripravlja naložbo novo jedrsko elektrarno. Čemu naj javnost zdaj podpre ta referendum, brez potrebnih podatkov (18), ob pomanjkanju vključujoče in transparente javne razprave o energetski prihodnosti Slovenije in ob popolni odsotnosti ključnih informacij o projektu JEK2?

Dejanski okoljski kriminal

Nasprotovanje dobremu je slovenska energetska posebnost. Skupno vsem popularnim okoljskim trditvam je slepa vera v urbane legende. Res se je dogajal okoljski kriminal, ampak, namesto bi ga družba preprečevala, ga dopušča, hkrati pa ovira marsikaj, kar je dobro. Bolje bi bilo, če bi se družba usmerila v preprečevanje slabega. Vpišimo ekocid v ustavo in prenesimo direktivo o okoljski kriminaliteti (6) v pravni red; zahtevajmo, da se to izvaja.

Ne, ribarjenje v kalnem je donosna dejavnost za marsikatero nevladno organizacijo, ki ima tiho, a močno podporo zagovornikov jedrske energije.

O jedrski energiji slišimo same sladke besede. Kritika jedrske skupnosti je utišana, cenzurirana, preganjana. Da slovenska jedrska skupnost ne spoštuje zavez, da dokazano nezakonito troši denar (17), da kupuje javno mnenje, da v svoje načrte vključuje celotno državno politiko, o tem se ne govori. Jedrski kriminal je doma nekje drugje, na Japonskem, na Češkem (4) ali v Franciji.

Slika 2: Besedna zveza »pecunia non olet« se še danes uporablja za trditev, da vrednost denarja ni omadeževana z njegovim izvorom. Danes bi bilo morda primernejše zapisati, da denar ne seva. Vir: wikipedia, Pripis: Classical Numismatic Group, Inc. http://www.cngcoins.com

Sončne elektrarne na kmetijskih površinah?

Kaj hudega so naredile sončne elektrarne na kmetijskih površinah, da jih imenujemo »*okoljski kriminal*«? Res je, da sončna elektrarna ne sme konkurirati kmetijskim proizvodom. To zgodbo, hrana ali energija, smo že prerasli. Proizvodnja energije ne sme nadomestiti proizvodnje hrane.

Polemiziramo s trditvijo, da na njive ni primerno postavljati sončnih elektrarn, ki bi ovirale kmetovanje, saj Imamo dovolj drugih površin, kjer so sončne elektrarne dobrodošle: strehe večjih stavb, parkirišča, vodne površine, ograje ob avtocestah … Kaj pa, če bi sončne elektrarne sobivale s kmetijskimi površinami in jih ne bi prekrivale?

Agrofotovoltaika (agrovoltaika) in prostostoječa sončna elektrarna

Kmetijsko zemljišče, na katerem stoji sončna elektrarna, lahko po postavitvi elektrarne v polni meri ohrani svoji primarno (kmetijsko) funkcionalnost in jo celo poveča, lahko pa jo ohrani samo v omejenem obsegu. Če postavimo sončno elektrarno nad sadovnjak ali nasad malin, govorimo o **agrovoltaiki**. Če pa postavimo elektrarno na zemljišče, ki je deklarirano kot kmetijsko, na njem pa raste goščavje in je dotlej gospodarsko neizkoriščeno, potem gre za klasično **prostostoječo sončno elektrarno**, zemljišče pa jo lahko lastnik istočasno izkorišča tudi za kmetijske namene, npr. pašo drobnice.

Agrovoltaika ne pomeni zgolj proizvodnje električne energije, ampak upošteva celotno korist, ki jo ima kmet od boljše, bolj kakovostne kmetijske pridelave (zaščita rastlin pred ožigom, zaščita pred točo) in hkrati dodatno proizvodnjo energije.

Kot piše MOPE(2), je agrovoltaika tehnologija, ki združuje kmetijstvo in fotovoltaične sisteme za proizvodnjo električne energije. Gre za integracijo fotonapetostnih panelov v kmetijsko infrastrukturo, na primer na poljih, vinogradih ali drugih kmetijskih površinah. Namen agrovoltaike je izkoristiti kmetijsko zemljišče za dva namena: za pridelavo hrane ali rastlin ter hkrati za proizvodnjo obnovljive električne energije. Prinaša številne prednosti: zmanjšanje izhlapevanja vode zaradi senčenja, zaščito rastlin pred vremenskimi vplivi, izboljšanje učinkovitosti rastlin zaradi regulacije svetlobe, zmanjšanje emisij toplogrednih plinov in diverzifikacijo dohodka. Hkrati pa je treba tudi vedeti, da niso primerna kombinacija z vsemi kmetijskimi proizvodi. Niso univerzalna rešitev, temveč jih je treba premišljeno postavljati.

Naš stik (3) navaja, da lahko namestitev sončnih panelov pri gojenju hrane izboljša zadrževanja vode v sušnih letih in zaščiti pridelke pred ekstremnimi vremenskimi razmerami, v nekaterih primerih pa lahko poveča kmetijski donos. Za jagodičevje ali sadje lahko agrovoltaika omogoči povečanja pridelka do 16 odstotkov, hkrati pa proizvede 63 odstotkov električne energije tradicionalne sončne elektrarne. Pri posevkih, ki potrebujejo več svetlobe, kot je pšenica, znaša izgub pridelka pod 20 odstotkov, dodani prihodki od prodaje električne energije pa močno odtehtajo manjši prihodek od pridelanega žita.

Slika 3 Sicer si ne predstavljamo vinogradov na Krasu v sožitju s sončnimi elektrarnami, v manj vetrovnih krajih pa bi bilo zanimivo. Foto: Naš stik

Koruptivna tveganja?

Predlagamo premišljeno načrtovanje postavitve agrovoltaike, da ne bo doživela enake usode kot bioplinarne. Če se prav spomnimo, afera bioplinarn ni dobila epiloga, očitno je bilo tako veliko denarja odtujenega in razdeljenega, da organi pregona niso bili motivirani. Podatki o gradnji dveh bioplinarn so šokantni, policija je ugotovila veliko oškodovanje državnega proračuna in bank, saj najetih kreditov vlagatelji niso vrnili, pred stečajem pa so vrednejše dele bioplinarn odpeljali neznano kam (4). Podjetja, ki so gradila bioplinarne, so poslovala z izgubo, zemljišča pa so zavarovali z zemljiškim dolgom. Proizvodnja električne energije ni nikoli zaživela, dolgovi so ostali upnikom, kmetom in državi. Ker so v zgodbo vpletena zasebna podjetja in politika, obstaja tveganje za sistemsko korupcijo, saj so verjetno nekatere odločitve politike pripomogle k pridobitvi premoženjske koristi posameznikov, ki so največjo škodo povzročili bankam v državni lasti.

Energija ali hrana? Oboje!

Nekako smo obremenjeni od okoljske nevarnosti fosilnih energentov. Če se ne motim, so nemški proizvajalci avtomobilov dobili dovoljenje proizvodnje ICE avtomobilov tudi po letu 2035, če bodo uporabljali biogorivo (7). Je to za okolje dobro ali slabo?

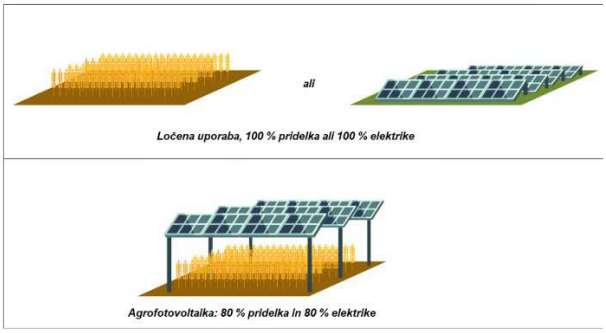
Slika 4: primerjava energetske rabe zemljišč za mobilnost

Indijske izkušnje kažejo, da je iz kmetijskih površin možno dobiti pogonsko gorivo za avto z notranjim zgorevanjem. To je dobro. En hektar kmetijskih površin zadošča za eno leto vožnje povprečnega avtomobila.

Kaj pa, če bi na tem zemljišču postavili sončno elektrarno in s pridelano elektriko poganjali električne avtomobile? Tudi to bi šlo, kar je dobro. Pravzaprav, odlično. En hektar kmetijskih površin zadošča za eno leto vožnje dvesto povprečnih avtomobilov (5.) Razmerje 1:200 pa je veličastno. Je torej, za razogljičenje mobilnosti, bolje primešavati fosilnim energentom majhen delež biogoriv ali proizvajati elektriko za elektromobilnost?

Vprašanje je, ali je v te luči sončna elektrarna na kmetijskih površinah še vedno okoljski kriminal. Dvestokrat večji učinek? Kmet ustvari dvestokrat več, brez škode okolju, in zato postane okoljski kriminalec?

Kaj pa, če bi malo popustili in vgradili sončne panele z manjšimi razmiki med njimi, da bi prepuščali 20 % svetlobe in omogočili padavinam dostop do zemlje? Na hektarju kmetijskih površin bi dobili približno 80 % poljščin in elektrike za 160 avtomobilov, kar tudi ni mačji kašelj.



Slika 5: Agrovoltaika omogoča dvojno rabo zemljišča ob le malo manjšem kmetijskem donosu, pri nekaterih poljščinah pa dodatno ščiti rastline pred premočnim soncem, pozebo ali sušo.

Izračun 1:200

Malo se poigrajmo z oceno donosa. Ocena, tudi če ima majhno napako, je bolj točna kot natančen izračun z napačnimi vhodnimi podatki.

Povprečen donos koruze je 8,5 t/ha. Iz tega lahko pridobimo približno 1.000 l biogoriva, kar je dovolj za vožnjo povprečnega avtomobila z notranjim zgorevanjem za eno leto. En avto na hektar.

Kaj pa, če bi na tem hektarju imeli sončno elektrarno? Ob predpostavki, da je fotovoltaika 20-krat bolj učinkovita od fotosinteze, torej dobimo 20-krat več energije.

Ob predelavi koruze v biogorivo je precej izgub, upoštevamo 50 %, elektrika pa poganja e-avto z zanemarljivimi izgubami. Ne nazadnje, avto na elektriko potrebuje pet krat manj energije kot z motorjem z notranjim zgorevanjem. Ko zmnožimo 20 in 5 ter delimo z 0,5, dobimo dvesto. Dvesto avtov na hektar.

Vztrajati v napačnih odločitvah ali odpraviti napake?

Motiti se je človeško, v zmoti vztrajati pa hudičevo, je ugotovil Seneka, najprej vzgojitelj, pozneje svetovalec rimskega cesarja Nerona.

Bodo nezreli, neodgovorni kritiki sončnih elektrarn priznali, da so se motili in bodo dopustili sončne elektrarne na kmetijskih in vodnih površinah? In drugo vprašanje, ali bodo okoljevarstveniki nasprotovali okoljskemu kriminalu, ki ga sedaj tiho podpirajo?

Predlagamo okoljsko osveščanje namesto novega ludističnega gibanja, oviranja obnovljivih virov brez razumnih razlogov.

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Skrivnost ljubljanske pitne vode in kanal C0
The secret of Ljubljana's drinking water and the C0 canal

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POVZETEK

V prispevku odkrivamo razlog za čisto pitno vodo Ljubljane in projekt, ki jo ogroža. Ljubljana, glavno mesto Slovenije z blizu 300.000 prebivalci in z več kot 100.000 dnevnih obiskovalcev ima vir pitne vode, ki je ni potrebno kemijsko obdelati, na primer klorirati. Podtalnica prihaja od reke Save in se črpa v glavnem na dveh črpališčih, Kleče in Šentvid v obsegu 90 odstotkov pitne vode za mesto. Začetki črpanja segajo v leto 1890. Večje območje je zaščiteno z uredbo o Ljubljanskem polju, ki je po sestavi slabo sprijet prod.

Ali je prod kot filter za podtalno vodo iz Save dovolj za nastanek čiste pitne vode? Izkazalo se je, da ne. Skrivnost ljubljanske pitne vode iz tega vira je v biološkem filtriranju. Biološki filter sestavljajo organizmi, ki živijo v temi ob težkih življenjskih pogojih. Širša javnost je bila šele v letu 2024 seznanjena z odkritji doc. dr. Ceneta Fišerja o bogatem podzemnem življenju raznovrstnih, a občutljivih organizmih in njihovi funkciji pri čiščenju podtalnice iz Save.

Skrivnost je prišla na dan ob protestih strokovne in druge javnosti zaradi gradnje velikega kanala C0, premera 1,2 m skozi to območje, ki bi odvajal fekalije in industrijske odplake tudi iz občin Medvode in Vodice. Onesnaženje biološkega filtra bi pomenilo njegovo uničenje in s tem čiste pitne vode.

Pomemben element zaščite te pitne vode je tudi dejstvo, da vodonosnik Ljubljanskega polja spada v kritično infrastrukturo po EU direktivi in slovenskem zakonu, kar spada tudi v skrb za nacionalno varnost.

Obstajajo alternativne rešitve brez kanala C0, ki ga bo treba odstraniti iz območja. Gradnja kanala C0 je del evropskega projekta: Odvajanje in čiščenje odpadne vode na območju vodonosnika Ljubljanskega polja (2017).

ABSTRACT

In this article, we discover the reason for Ljubljana's pure drinking water and the project that threatens it.

Ljubljana, the capital city of Slovenia with nearly 300,000 inhabitants and more than 100,000 daily visitors, has a source of drinking water that does not need to be chemicaly treated, for example chlorinated. Drinking groundwater comes from the Sava River and is mainly pumped at two pumping stations, Kleče and Šentvid, which account for 90 % of the city's drinking water. Pumping dates back to 1890. The larger area is protected by the Ljubljansko polje Regulation, which is composed of poorly adhered gravel.

Is the gravel sufficient as a filter for groundwater from the Sava River to produce clean drinking water? It turns out that it is not. The secret of Ljubljana's drinking water from this source lies in biological filtration. A biological filter is made up of organisms that live in the dark under harsh living conditions. It was only in 2024 that the general public was made aware of the discoveries made by Dr. Cene Fišer about the rich underground life of diverse but sensitive organisms and their function in purifying groundwater from the Sava River.

The mystery came to light amid protests from the professional and other public over the construction of a large 1.2 m diameter C0 canal through the area, which would also carry faecal and industrial wastewater from the municipalities of Medvode and Vodice. Contamination of the biological filter would mean its destruction and thus pure drinking water.

Another important element in the protection of this drinking water is the fact that the Ljubljansko polje aquifer is a critical infrastructure under the EU directive and Slovenian law, which is also a national security concern.

KLJUČNE BESEDE

Pitna voda, biološki filter, kanal C0, Ljubljansko polje, EU projekt

KEYWORDS

Drinking water, biological filter, C0 canal, Ljubljansko polje, EU project

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1. UVOD

Avgusta 2017 je bil Sloveniji odobren evropski projekt: Odvajanje in čiščenje odpadne vode na območju vodonosnika Ljubljanskega polja. Celotni projekt sestavljajo 3 deli (1):

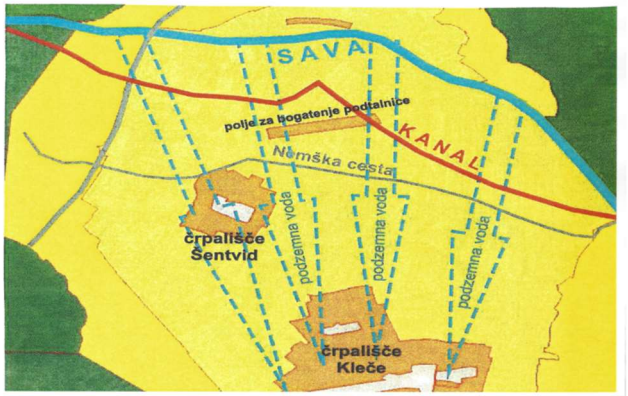
Del 1: Nadgradnja sistema odvajanja komunalne odpadne vode v občinah Medvode (22 km) in Vodice (9,1 km) ter izgradnja povezovalnega kanala C0 v Mestni občini Ljubljana (MOL),

Del 2: Izgradnja III. faze Centralne čistilne naprave Ljubljana,

Del 3: Dograditev kanalizacije v aglomeracijah v Mestne občine Ljubljana.

Celotna vrednost investicije je 135.623.985 evr (z DDV), od tega EU 68.879.165,20 evr (85%), država 12.155.146,80 evr (15%), vse tri občine pa 54.589.673 evr.

V tem prispevku obravnavamo **Del 1, kanal C0**, ki je od Broda do Črnuč v dolžini 4,1 km vgrajen v vodovarstveno območje in bi odvajal tudi odpadne vode iz občin Medvode in Vodice.
Potek trase kanala C0, toka podzemne vode in lokacije črpališč. Kanal C0 križa tok podtalnice. Vsako puščanje gre v tok podtalnice.



Poliestrske cevi kanala , premera 1,2 m.

Po izjavah strokovnjakov je tesnenje pri tako velikem premeru nezadostno za fekalije in industrijske odplake, ob mnogih vplivih na cevi na veliki dolžini 4,1 km (vzgon, potres, napake pri vgradnji, rezanje cevi, vijugasta vgradnja…).

2. Kanal C0 bi zanesljivo ogrozil čisto pitno vodo
Po zaslugi krajanov, zbranih v Civilni iniciativi za čisto pitno vodo (CI), mednarodnega društva Alpe Adria Green (AAG) ter odvetnika, kanal C0 še ni v celoti zgrajen. V območju Črnuč manjka še okrog 120 m. Zaradi nezakonito vodenega postopka projekta in strokovnih napak, se nadaljevanje rešuje na sodišču.
V CI sodeluje več strokovnjakov za komunalno infrastrukturo z mednarodnimi izkušnjami, v njej sodelujem s prispevki v medijih (npr.: Dnevnik).
Zaradi predvidenega ogrožanja pitne vode je Državni zbor ustanovil Preiskovalno komisijo o ugotavljanju zlorab in nezakonitosti pri gradnji povezovalnega kanala C0 na območju ljubljanskega vodonosnika Ljubljanskega polja (Komisija). Komisija je imela 12.9.2024 že 16. sejo s pričanjem vabljenih, tokrat zdravnica in epidemiologinja prof. dr. Dodič Fikfak **(2).**
Povzemamo nekaj ugotovitev strokovnih študij in postopkovne revizije, na osnovi katerih lahko trdimo, da bi do puščanja kanala C0 in onesnaženja čiste pitne vode za Ljubljano **zagotovo prišlo.**

2.1. Revizija Ministrstva za okolje in prostor (MOP) 2019 ugotavlja, da je iz postopkov in dokumentov razvidno, da ni garancije, da kanal C0 ne bi puščal. Povezava na revizijo je v objavi mednarodnega društva Alpe Adria Green **(3).**

2.2. Izdelana je bila Ocena potresne varnosti na trasi kanalizacijskega zbiralnika C0 (HGEM d.o.o., 2017).
Zaradi gradnje na potresnem območju bi kanal moral biti zgrajen po mednarodnem standardu ISO:16134:2006 **pa ni bil.** Standard zahteva ustrezen material in tip cevi ter spojev in poseben način vgradnje.
Traso kanala prečka Žužemberški geološki prelom, Prelomi so nevarne podzemne strukture, kar situacijo kanala še poslabšuje.
Omenjeno poročilo ugotavlja, da na trasi ni bilo izvedenih *''osnovnih geomehansko inženirsko geoloških raziskav''* , ki bi omogočile oceno za pojav likvifakcije (zmehčanja tal) ob potresu ter o možni prisotnosti strižnih sil na tej dolžini 4,1 km med Brodom in Črnučami. Zato so predlagali ustrezne preiskave, **ki pa niso bile izvedene.**
Take preiskave so bile izvedene pri gradnji HE Brežice **(4).** Tla iz slabo sprijetega peska so bila zamenjana zaradi nevarnosti likvifakcije in porušitve jezu. Podobna tla, prodno-peščena zemljina, sestavljajo vodonosnik Ljubljanskega polja.

2.3. Geološko poročilo, 2018: **Program zaščite podzemne vode v času gradnje povezovalnega cevovoda C0 (Geološki zavod Slovenije).** Poročilo ocenjuje tudi razmere med obratovanjem kanala C0. Povzetek **(5).**

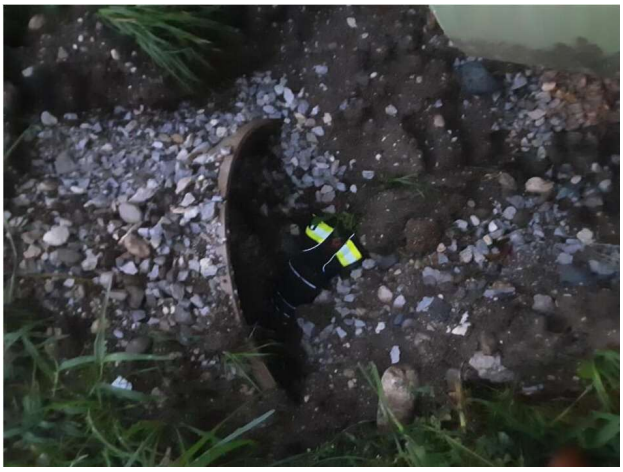
V scenariju normalnega razvoja dogodkov so ocene puščanja kanala. Izgube odpadne vode (puščanje) se do 1 % ne dajo zaznati. Pri polnem pretoku 930 l/s je tako puščanje 9,3 l/s. **Dnevno to pomeni okrog 800 m3 puščanja** fekalij in industrijskih odplak na 4,1 km brez zaznave. **Kanalizacijski standardi dopuščajo tak delež puščanja kot normalen.** Na najbolj občutljivem 2,2 km delu trase, v zaledju vodarn Šentvid in Kleče, se puščanje brez zaznave ocenjuje na 1,8 l/s, kar pomeni 155 m3/dan. Za tako puščanje so dovolj razpoke širine 0,087 mm.
Scenarij najslabše možnosti, torej večje razpoke ali napake pri vgradnji, pa pomeni še bistveno višje količine izpustov v podtalnico s čisto pitno vodo.
Hitrost podtalnice od Save do Kleč je velika, 20 m/dan. Puščanje kanala hitro doseže črpališče.

Poročilo tudi ocenjuje **možnost vzgona** ob poplavah ali gradnji hidroelektrarn blizu Ljubljane. Več kot sto dni na leto je v določenih predelih pričakovati vzgon zaradi dviga podtalnice, ki lahko odpre ali zamakne spoje cevi, da nastanejo reže.

2.4. Geološko poročilo, 2020: Dodatna analiza potresne nevarnosti na območju povezovalnega kanala C0 v Mestni občini Ljubljana (Geološki zavod Slovenije). Posebej je obdelana prisotnost aktivnega Žužemberškega preloma, ki v domnevnem poteku trikrat prečka kanal C0. V zaključku ocenjujejo možnost **potresa s površinskim pretrgom velikosti 10 cm.** Predlagajo dodatne geofizikalne preiskave ter močno priporočajo izvedbo celovite verjetnostne analize PFDH (Probabilistic Fault Displacement Hazard Analysis). Upravičeno domnevamo (nasveti iz leta 2020, ko je velik del kanala že izgrajen), **da noben predlog ni bil izveden.**

2.5. Nestrokovna in malomarna vgradnja kanala C0.
(slike: zasebni arhivi, vendar že predstavljeni javnosti)
DVIG PODTALNICE – VDOR V KANAL
Lanske poplave so razkrile, sicer izven poplavnega območja, torej ne gre za vdor umazane savske vode skozi jaške, ampak za velike razpoke v že vgrajenem kanalu. Narasla podtalnica je namreč vdrla (posnet video toka pitne vode v kanalu) v kanal, kar pomeni, da gre za malomarno vgradnjo in je puščanje zagotovljeno.

VZGON
Kot se spomnimo iz fizike, bo vzgon večji, če so potopljeni volumni večji. Kanal C0 s premerom 1,2 m predstavlja tak velik volumen, ki je lahko delno ali ni napolnjen z odplakami. Primer premika in izmeta vgrajenih cevi večjega premera se je zgodil v Sneberjah ob lanskih poplavah. Gre za priključne cevi na kanal C0.

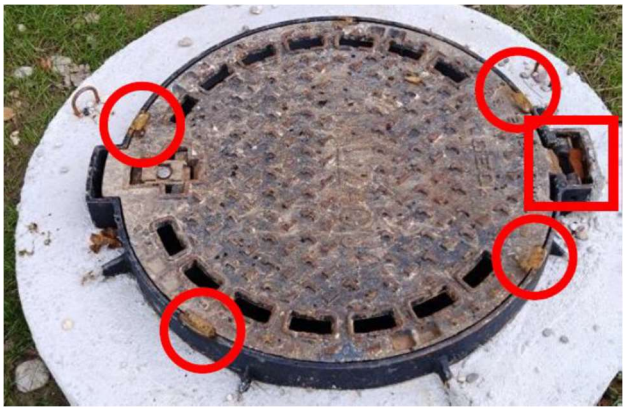


MEHKEJŠE NASUTJE – VEČJI UČINEK VZGONA
Namesto izkopanega peska so na nekaj odsekih nasuli mehko kmetijsko zemljo, pesek pa tržili naprej. Učinek vzgona bi bil večji, kar pomeni večje pomike cevi in nastajanje rež na spojih.

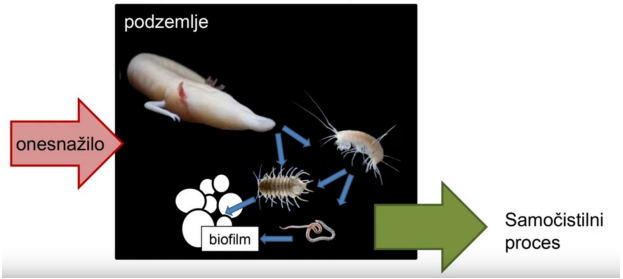
REZANJE CEVI – TESNENJE?
Rezanje cevi in improvizacija s tesnili – proizvajalec cevi ne odgovarja več za tesnost spojev. Ali sploh odgovarja in koliko let ter ob potresih in vzgonu?

VIJUGASTO VGRAJEN KANAL
Na določenih odsekih je kanal vgrajen vijugasto, kar pri velikem premeru vzpostavlja napetosti v tesnenju in v primerih premikov (potres, vzgon) olajša odpiranje spojev. Viden je tudi nedovoljen poseg, zaradi improvizacije investitorja, MOL, na zasebno njivo zaradi potrebne velike delovne širine pri vgradnji kanala. Prišlo je do protestov in nasilja varnostnih služb.

MALOMARNA VGRADNJA – REŽE
Civilna iniciativa je skozi jaške ugotovila obstoječe reže. Vidi se vdor peska skozi režo. Po javno objavljenih napakah pri vgradnji je investitor, Mestna občina Ljubljana, naročil varjenje pokrovov jaškov.



3. Nastanek ljubljanske čiste pitne vode – biološki filter
Skrivnost ljubljanske čiste pitne vode, ki ne potrebuje kemične obdelave, na primer kloriranja, je prišla do širše javnosti šele v letošnjem letu na seji Komisije. Skrivnost nam je na 11. seji (29.5.2024) razkril doc. dr. Cene Fišer iz Biotehnične fakultete **(6).**
Biofilm bakterijske flore na produ in podzemni organizmi (favna, nevretenčarji), ki živijo v prostorih med prodom, čistijo podtalnico, ki pride od Save v Ljubljansko polje, kar prikazuje slika.



Opomba: Človeška ribica na sliki ni del procesa čiščenja, ne živi v produ, je del podzemne favne iz predavanja doc..dr. Fišerja (Cankarjev dom) **(7).**

Šele zdaj lahko razumemo, zakaj imamo v Ljubljani čisto pitno vodo neposredno iz podtalnice, že stoletja.

Puščanje iz kanala C0 bi naš biološki filter, ki je nastajal stoletja, uničilo.
Na to je dr. Fišer **že leta 2016** pisno opozoril Agencijo RS za okolje (ARSO) in MOL ter župana Ljubljane, **a so opozorila ignorirali.** Še več, ARSO je odločil, da presoja vplivov na okolje, kjer bi seveda morali upoštevati biološki filter in kanal C0 odkloniti, **ni potrebna!**

Slika prikazuje podzemno favno iz predavanja, ki zajema širšo tematiko podzemnega sveta, razen školjk in človeških ribic, so drugi prikazani organizmi tudi v vodonosniku Ljubljanskega polja **(7).**

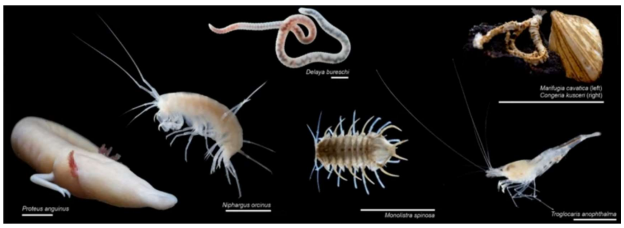
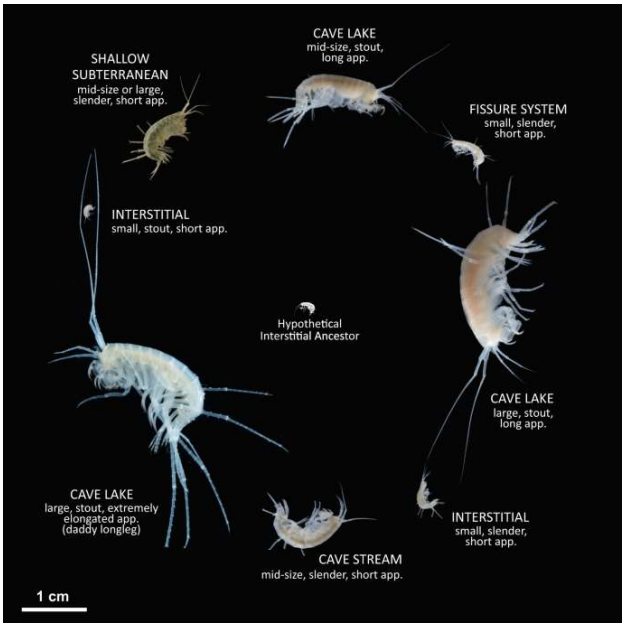


Foto: T. Delić

Ljubljanski vodonosnik je **vroča točka**, **evropskega in svetovnega pomena.** Ta termin se uporablja za podzemlje, kjer je izjemno visoka pestrost podzemnih organizmov. V Ljubljanskem polju so jih **odkrili kar 29**, merilo za vročo točko pa je 25. Razvoj mnogih teh organizmov se odvija že več deset milijonov let **(8).**



Slika prikazuje razvoj podzemnega rakca iz rodu slepih postranic (Niphargus) **(8).**

4. RAZPRAVA IN ZAKLJUČEK

4.1. O imenu projekta

''Odvajanje in čiščenje odpadne vode na območju vodonosnika Ljubljanskega polja.'' Znano je, da kanal C0 premera 1,2 m preko vodonosnika nima nobenega priključka iz območja kakršnekoli odpadne vode iz vodonosnika, ki bi jo bilo treba čistiti. Razumevanje naslova je AAG preveril pri evropski komisiji. V dopisu **(9)** kot rezultat tega dela projekta navajajo: *''As a result it will improve the quality of the aquifer for the abstraction of drinking water in the first place.*''

V prevodu: ''S tem se bo izboljšala kakovost vodonosnika, iz katerega se črpa pitna voda''. Očitno so razumeli, da bo projekt že tako odlično čisto pitno vodo še očistil, čeprav ni jasno kako, če kanal samo prečka vodonosnik.

V pismih bralcev (Dnevnik, 23.2.2023) sem na to opozoril, a brez odmeva **(10)**.

4.2. Zakaj še Medvode in Vodice?

Novodobno okoljsko strokovno ravnanje na področju odpadkov je, da se obdelajo na viru ali čim bližje. Izgovori na pretekla, drugačna načrtovanja izražajo samo nerazumevanje trajnostnega razvoja. Vodenje fekalij in industrijskih odpadnih voda 20 km iz Medvod in 9 km iz Vodic v Ljubljano (Brod) je že v tem smislu zgrešeno.

Ko pa zvemo, da je občina Medvode že bila v projektu kanalizacije skupaj z Mestno občino Kranj in občino Šenčur in enostransko izstopila iz njega, da bi se vključila v ljubljanski projekt pa je jasno, da so prevladali nestrokovni razlogi. Občina Medvode je izstop morala plačati z blizu 350.000 evri **(11).**

Vodice bi se pa lahko priključile na domžalsko čistilno napravo.

4.3. Dodatno varovanje ljubljanske čiste pitne vode

Vodonosnik Ljubljanskega polja spada v kritično infrastrukturo, saj napaja več kot 100.000 prebivalcev. Kritična infrastruktura je opredeljena z evropsko direktivo in slovenskim zakonom **(12)**. Predstavlja pomemben element nacionalne varnosti.

4.4. Biološki filter

Za široko javnost povsem nov in ključen element pri nastajanju čiste pitne vode za glavno mesto Slovenije z okrog 300.000 prebivalci in preko 100.000 dnevnih obiskovalcev, z bolnišnicami, šolami, hoteli in drugo funkcionalno infrastrukturo, je s projektom kanala C0 zanesljivo ogrožen in z njim čista pitna voda. Procesi nastajanja tega filtra so počasni, stoletni in njegovo uničenje bi prineslo za več sto let uničenje vira čiste pitne vode.

4.5. ZAKLJUČEK

Dela na kanalu C0 je treba takoj ustaviti, sporočiti evropski komisiji o spremembi projekta in že vgrajen kanal C0 odstraniti iz vodonosnika. Strokoven predlog prof. dr. Duhovnika je bil jasno postavljen na Komisiji **(13).**

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Kakšna je cena jedrske energije in obnovljivih virov in kakšen je vpliv na okolje

What is the Cost of Nuclear Energy, Renewables, and Their Impact on the Environment

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Povzetek

Strateška odločitev glede izbire osnovnih energentov v državi je ključnega pomena za zanesljivost oskrbe in za ceno energije. Narejena je primerjava cene 1100 MW bloka jedrske energije in 100 % obnovljivih virov (OVE, sončnih panelov) za enako količino oddane energije v omrežje ter vpliv na izrabo prostora.

Ključne besede

Jedrska elektrarna, obnovljivi viri energije, OVE, cena za enako količino energije

Abstract

Strategic decision about the choice of energy sources is crucial for a reliable supply of electricity at a reasonable cost. A comparison is made between the option of a 1100 MW nuclear plant and 100 % renewables (solar panels) for the same amount of delivered energy to the grid, and the impact of the usage of land.

Keywords

Nuclear power plant, renewable energy sources, cost for equal amount of energy produced

1 Ozadje problema

Strateška odločitev glede izbire osnovnih energentov v državi je ključnega pomena za zanesljivost oskrbe in za ceno energije, ki jo industrija in posamezniki potrebujemo, zato je pomembno vedeti, kakšne so možnosti in kakšne so implikacije. V Sloveniji bomo po zaprtju TEŠ6 leta 2033 potrebovali dodatne proizvodne kapacitete za električno energijo z močjo vsaj 1000 MW. Namen predstavitve je primerjava cene za 1100 MW jedrsko elektrarno in cene obnovljivih virov (OVE, predvsem fotovoltaičnih panelov) za enako količino proizvedene energije. Ocene stroškov v medijih se zamegljujejo s parcialnim vpletanjem stroškov financiranja in ocenami na osnovi projekcij gibanja cen, vendar pa so projekcije špekulativne, stroški financiranja pa se pojavljajo pri vseh investicijah. Preprosto nas zanima, kakšni so stroški na dan odločitve za gradnjo, cene na tržišču za to pa so znane.

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2 Cena jedrske energije

V medijih se pogosto pojavljajo šokantno visoke cene postavitve jedrskih elektrarn, kot jih na primer navaja Greenpeace »Finančne ovire za nove jedrske projekte - Greenpeace Slovenija«. Tak izbor cen je nerealen in je posledica dejstva, da evropski in ameriški proizvajalci nekaj deset let niso gradili jedrskih elektrarn. Zaradi tega so bile dobavne verige v veliki meri prekinjene in jih je bilo treba vzpostaviti na novo, vsled česar je prihajalo do zamud in povečevanja stroškov. Situacija je bila drugačna v 60 in 70-ih letih prejšnjega stoletja, ko so ameriški in evropski proizvajalci gradili po več jedrskih elektrarn na leto. Kitajski proizvajalci so v zadnjem desetletju zgradili 39 jedrskih elektrarn, zdaj pa napovedujejo gradnjo po deset (in več) elektrarn na leto in s tem nimajo težav. Pričakujejo, da bodo v obdobju v letih od 2020 do 2035 zgradili 150 jedrskih reaktorjev »How Innovative Is China in Nuclear Power? | ITIF«. Ravno tako je južnokorejski proizvajalec KHPN v Združenih arabskih emiratih zgradil 4 reaktorje v sprejemljivih časovnih rokih in pogodbenih finančnih okvirih. Cena na eno 1400 MW enoto je bila 8 milijard dolarjev »Barakah nuclear power plant - Wikipedia« Trenutna cena jedrskih elektrarn je torej znana in predvidljiva. Za 1000 MW jedrsko elektrarno ELES ocenjuje ceno 10 milijard EUR, ocena GEN energije pa je še nekoliko nižja. Elektrarna daje takšno moč vse dni v letu ves dan, razen v času enomesečnega remonta vsakih 18 mesecev. Življenjska doba jedrskih elektrarn je 60 let ali več. Željeno energijo, upoštevaje čas remonta bi torej dobili s postavitvijo 1100 MW jedrske elektrarne.

3 Cena obnovljivih virov energije

Trenutna različica Nacionalnega energetskega in podnebnega načrta (NEPN) kot eno od opcij predvideva pridobivanje električne energije iz 100 % obnovljivih virov (OVE), pretežno iz sončnih panelov na strehah stavb.

Iz razpoložljivih podatkov dajejo paneli v Sloveniji v povprečju le eno desetino nominalne moči (ker sonce ne sije ponoči in ker se nahajamo na 46. vzporedniku), zato je za približno enako količino energije kot jo proizvede 1100 MW

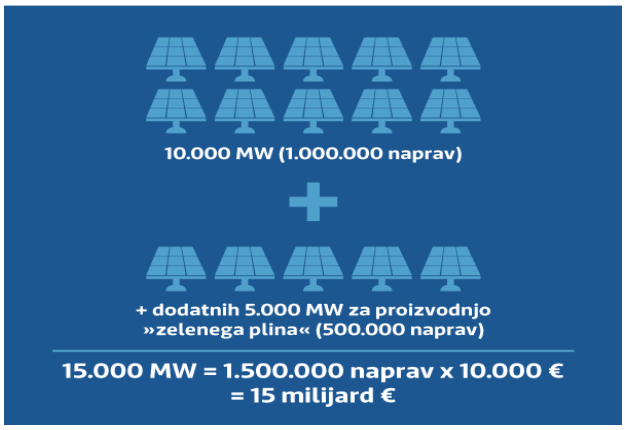
jedrska elektrarna potrebna instalirana moč 10 000 MW sončnih panelov. Če je tipična instalirana moč sončnih elektrarn na strehah stavb 10 kW, potrebujemo torej milijon takšnih enot. Cena ene enote pri ponudnikih v Sloveniji je dobrih 10 000 EUR (če niso potrebna dodatna dela na strehi), to pa pomeni, da celotna investicija znaša vsaj 10 milijard EUR, kar je primerljivo s ceno jedrske elektrarne.

Slika 1: Cena OVE za primerljivo količino energije kot jo proizvede 1100 MW jedrska elektrarna.

3.1 Nestanovitnost električne energije iz sončnih panelov

Resna težava je nestanovitnost proizvodnje električne energije, z viški podnevi in v poletnem času, ko vse elektrike ne bi mogli niti porabiti ali shraniti, in s primanjkljajem v zimskem času, ko je treba potrebe pokrivati z drugimi viri. Največkrat so za to predvidene termoelektrarne na zemeljski plin. To pa pomeni, da v tem primeru uporaba sončnih panelov ne predstavlja več scenarija 100 % OVE, saj je zemeljski plin fosilno gorivo.

Razmere se spremenijo le, če lahko viške energije ob presežku proizvodnje shranimo za nočni čas in za zimske mesece. Danes tehnologija za dolgoročno shranjevanje energije sicer še ni komercialno dostopna, raziskuje pa se v smeri, da bi lahko z elektriko proizvajali »zeleni plin«, pri čemer pretežno mislimo na zeleni vodik, ker je tehnologija pridobivanja zelenega metana tehnološko in ekonomsko bolj nejasna. Tudi NEPN za prihodnost v 100 % OVE scenariju predvideva proizvodnjo zelenega plina. Energijska bilanca je z 10 000 MW sončnih panelov v principu pokrita, žal pa pri izkoriščanju poletnih viškov za proizvodnjo plina in uporabo tega plina za proizvodnjo električne energije prihaja do izgub, ki so fizikalno pogojene in jih ni mogoče bistveno zmanjšati. Povečati bi morali kapaciteto sončnih elektrarn za toliko, da bi z viški energije poleti proizvedli dovolj zelenega plina za izravnavo potreb v zimskih mesecih. Po grobi oceni je v najboljšem primeru možno nazaj v električno energijo pretvoriti kvečjemu eno tretjino poletnih viškov. Praktično to pomeni, da potrebujemo v celoti najmanj 15 000 MW instalirane moči sončnih panelov. V tem primeru znaša cena 15 milijard EUR za milijon in pol 10 kW enot, kar presega ceno jedrske elektrarne že za polovico.



Slika 2: Cena 100 % OVE za primerljivo količino energije kot jo proizvede 1100 MW jedrska elektrarna.

3.2 Neznanke v izračunu

V izračunu je upoštevana predpostavka, da se primanjkljaj energije v nočnem času in ob slabem vremenu nadoknadi s hranilniki, na primer z baterijami, kar praktično podvoji ceno izgradnje sončne elektrarne.

Slika 3: Cena 100% OVE s hranilniki za primerljivo količino energije kot jo proizvede 1100 MW jedrska elektrarna.

Poleg tega je treba k stroškom prišteti še stroške izgradnje plinskih elektrarn in obratov za proizvodnjo zelenega plina, za kar tehnologija na tako veliki skali še niti ne obstaja, in je komercialna cena nedoločljiva. Treba je tudi skladiščiti velike količine plina (kar tudi predstavlja svojevrsten izziv in potencialno nevarnost), zamenjati transformatorske postaje in močno ojačati elektro-distribucijski sistem (precej bolj kot v primeru jedrske opcije, kjer vsaj visoko-napetostni sistem približno zadošča).

Slika 4: Dodatni nedoločljivi stroški OVE: obrati za proizvodnjo zelenega plina, skladiščenje, termoelektrarna na zeleni plin in ojačanje prenosnega elektroenergetskega sistema.

3.3 Življenjska doba OVE

Ocena življenjske dobe sončnih panelov je precej optimistično napovedana na 30 let, kar je težko dokazljivo, saj večina panelov še ne dosega starosti, da bi to lahko statistično potrdili, pa tudi tehnologija izdelave se spreminja. Poleg tega je verjetno večji problem v močnostni elektroniki, da ne omenjamo vremenskih pojavov, kot je bil letos v Slovenski Bistrici, kjer je bila uničena več kot polovica panelov. Življenjska doba jedrskih elektrarn je 60 in več let, zato je treba v enakem obdobju zamenjati sončno elektrarno (ali vsaj večino komponent) najmanj dvakrat, kar izhodiščno ceno lahko še podvoji.

3.4 Umeščanje v prostor in vpliv na okolje

Jedrska elektrarna potrebuje manj kot en kvadratni kilometer prostora (okrog 100 hektarov), kar s stališča izrabe zemljišča ni zelo problematično. Za milijon in pol sončnih elektrarn je po grobi oceni potrebnih deset do petnajst tisoč hektarov površine na sončni lokaciji, saj je treba upoštevati nekaj zemljišča za servisiranje in čiščenje panelov. Resda se predvideva, da bo veliko panelov nameščenih na strehah stavb, vendar si je težko predstavljati, da bi samo z enotami na strehah s primerno osončenostjo dosegli željeno instalirano kapaciteto za proizvodnjo električne energije. Del kapacitet bo treba nameščati tudi na primerno osončena zemljišča.

3.5 Dobavni roki, montaža in servisiranje

Očitek jedrskim elektrarnam je dolga doba umeščanja v prostor in izgradnjo, vendar tudi naročilo milijon in pol 10 kW enot OVE ne bo potekalo čez noč, še manj pa umeščanje v prostor za deset do petnajst tisoč hektarov površine. Od samega naročila panelov domača industrija ne bo imela velike koristi, saj so paneli praviloma uvoženi iz daljnega vzhoda, doma je zaposlena zgolj množica trgovcev, monterjev in serviserjev za domači trg, ki pa ne ustvarjajo dodane vrednosti, ki bi jo lahko tržili v tujini.

4 Zaključek

Cena postavitve jedrske elektrarne z močjo 1100 MW je predvidljiva in znaša približno 10 milijard EUR. Za enako količino proizvedene energije iz malih sončnih elektrarn tipične moči 10 kW potrebujemo milijon takšnih enot, upoštevaje trenutne cene na tržišču pa je strošek primerljiv s ceno izgradnje jedrske elektrarne. Če želimo poletne viške električne energije shraniti v obliki zelenega plina za pogon termoelektrarn v zimskih mesecih potrebujemo najmanj pol milijona dodatnih enot, to pa pomeni že za polovico višji strošek v primerjavi s ceno jedrske elektrarne. V to niso vključene cene baterij za kratkoročno hrambo električne energije, postavitve naprav za proizvodnjo zelenega plina, skladišč plina in distribucijskega sistema ter plinske termoelektrarne, ki je nujno potrebna vsaj za vzdrževanje stabilnosti elektro-distribucijskega sistema. V ceni 100 % OVE je veliko neznank, ki vsaka posebej povečujejo stroške, zato trditev, da je scenarij OVE-plin ali 100 % OVE poceni (milo rečeno) brez trdne osnove.

Podrobnejši izračun je na voljo na portalu »jedrska.si« Kako poceni je elektrika iz obnovljivih virov in kako draga je jedrska energija?

Zahvala

Zahvaljujem se gospe Tamari Langus za uredniške izboljšave besedila in uporabo slik za ilustracijo.

O statusu in prihodnosti jedrske energije

On the Status and Future of the Nuclear Power

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Povzetek

V prispevku pokažemo status jedrskih elektrarn v obratovanju, v gradnji in v razvoju. Na kratko osvetlimo tudi najpomembnejše razlike med reaktorji 2. (npr. NEK) in 3. generacije (kandidati za JEK2). Sledi kratek pregled mednarodnih raziskovalnih in razvojnih prizadevanj, ki so usmerjena predvsem v manjše in modularne enote, ki bodo jedrsko fisijo uporabile kot brezogljični vir toplote za neposredno rabo ali pretvorbo v elektriko. Takšne enote utegnejo biti primerne tudi za decentralizirana pametna omrežja. Komercializacija nekaterih od večinoma že pred desetletji preverjenih zasnov bo omogočila tudi uporabo današnjega rabljenega jedrskega goriva in bo lahko pomembno prispevala k zaključevanju krožnega gospodarjenja z jedrskimi gorivi. Zaključimo s povzetkom največjih izzivov današnje jedrske energetike v Sloveniji in v svetu: sprejemljivost v javnosti, dobavne verige za talente in opremo ter nujnost dolgoročnih investicij v raziskave in razvoj.

Ključne besede

jedrske elektrarne, veliki reaktorji, gigavatni reaktorji, mali in modularni reaktorji, novi talenti

Abstract

Status of the nuclear power in operation, construction and operation is outlined. The main differences of the 2nd (e.g., Krško) and 3rd generation reactors are sketched. This is followed by an outline of the international research and development efforts, focussing mostly on the small and modular reactors to be used as a source of heat for direct use or for electricity production. Such units may be optimal also for decentralized grids. Commercialisation of some concepts proven decades ago may facilitate also the use of today's spent fuel and with this also the closure of the nuclear circular economy. Finally, the major challenges of the nuclear power are briefly discussed: the public acceptance, the supply chains for equipment and talent, and the need for long term investments in research and development.

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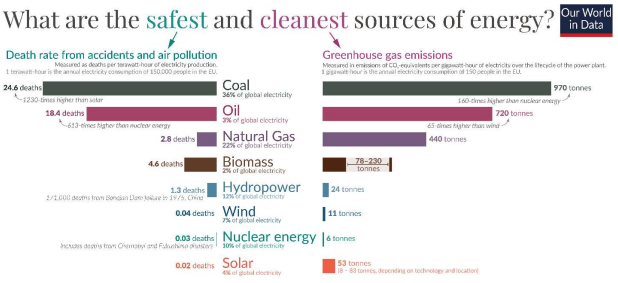
Keywords

Nuclear power plants, large reactors, gigawatt reactors, small and modular reactors, new talents

1 Uvod

Jedrska energija je v letu 2023 prispevala 9,1% vse električne energije [1] oziroma 3,96% vse primarne energije [2] na planetu. Proizvodnja jedrske elektrike na planetu je leta 1996 prvič presegla 2.400 TWh in se je v zadnjih nekaj letih ustalila med 2.600 in 2.700 TWh [3]. Vse jedrske elektrarne, ki smo jih v Evropi, v ZDA in na Japonskem v tem času zaprli, so sproti nadomestile nove elektrarne in sicer predvsem na Kitajskem, v Indiji in še kje: od leta 2000 do danes smo na planetu zaprli 123 reaktorjev s skupno močjo 80 GW, na omrežje pa na novo priključili 121 reaktorjev s skupno močjo 110 GW. Trenutno gradimo 59 reaktorjev, od tega Kitajci 24, sledijo Indijci z 8 [5].

Konec leta 2023 je delovalo 413 reaktorjev s skupno močjo 371,5 GWe. 60 let izkušenj s komercialnimi jedrskimi elektrarnami jedrsko energijo uvrščajo med najbolj varne in najbolj čiste (Slika 1) vire energije na planetu [4].



Slika 1: Najčistejši in najvarnejši viri energije [4]

Razvojna, poslovna in politična podpora jedrski energiji se v zadnjih letih povečujeta tudi v Evropi in Severni Ameriki. V ZDA se povečana politična podpora jedrski energiji vidi v večjih raziskovalno razvojnih vložkih, pa tudi spremembah zakonodaje in davčnih spodbudah. Rezultati se vidijo predvsem v intenzivnem razvoju in trženju malih in modularnih reaktorjev z močjo pod 300 MW. Prve priključitve na mrežo so najavljene okoli leta 2030.

V Evropski Uniji se, s podporo Slovenije, krepi jedrska aliansa, ki si je zastavila cilj 150 GW jedrske elektrike do leta 2050 [6]. Današnja flota zmore okoli 100 GWe in je v povprečju

stara 38 let. Ciljamo torej na 50 novih reaktorjev in 250.000 novih zaposlitev. Alianso sestavlja 15 ministrov za energijo iz Slovenije, Francije, vseh preostalih evropskih jedrskih držav (razen Španije), ter hrvaške, Italije, Poljske in Estonije.

Kitajska načrtuje do leta 2050 za pribl. 300GW novih jedrskih elektrarn, torej skoraj toliko, ko je danes na voljo na celotnem planetu: 371,5 GW.

V nadaljevanju se bomo posvetili dvema skupinama reaktorjev, ki bosta v prihodnosti zagotovo odigrali pomembno vlogo pri čisti energiji na planetu in morda tudi v Sloveniji. Prva skupina so veliki, gigavatni reaktorji z močjo 1 GWe ali več in s klasično zasnovo, druga pa so mali in modularni reaktorji.

2 Veliki reaktorji (1 GWe in več)

Med 59 reaktorji s skupno močjo 61 MWe, ki so danes v gradnji, je kar 50 tlačnovodnih (skupna moč 54,6GWe). Gre za podobno tehnologijo, kot jo uporablja Nuklearna elektrarna v Krškem (2. generacija reaktorjev), z nekaterimi posodobitvami, ki jih bomo na kratko opisali v nadaljevanju.

Japonci gradijo 2 vrelna reaktorja s skupno močjo 2,6GWe, ki tudi sodita med velike reaktorje z GW električne moči. Indija gradi 3 reaktorje, moderirane s težko vodo (skupna moč 1,9GWe). Ti reaktorji sodijo v t.i. tretjo generacijo reaktorjev.

Preostali štirje reaktorji v gradnji sodijo med tako imenovane hitre oplodne reaktorje (moč 2GWe), ki sodijo v 4. generacijo in odpirajo možnosti za uporabo urana 238 in torija 232. Uran 238 ob zajetju nevtrona v jedro namreč transmutira v cepljivi plutonij 239, torij 232 pa v cepljivi uran 233. Plutonij 239 in uran 233 sta torej umetno pridobljeni gorivi v oplodnih reaktorjih in bosta v prihodnosti lahko dopolnili in kasneje tudi nadomestili v naravi prisotni uran 235 (Urana 235 je le 0,72% vsega urana na planetu, preostanek je skoraj v celoti uran 238). S 4. generacijo reaktorjev se na tem mestu ne bomo več ukvarjali. Omenimo le, da bodo takšni reaktorji v prihodnosti pomembno prispevali h krožnemu gospodarstvu z jedrskimi gorivi in s tem tudi k pomembnemu zmanjševanju že tako razmeroma zelo majhne količine radioaktivnih odpadkov.

Reaktorji druge in tretje generacije uporabljajo praktično povsem enako jedrsko gorivo. Razlike v zasnovi reaktorja, goriva in v obvladovanju verižne reakcije, pa tudi pri uporabljenih strukturnih materialih, so torej praktično zanemarljive. Ključne razlike najdemo predvsem pri zasnovi oziroma izvedbi nekaterih varnostnih sistemov. Tako v tretji generaciji najdemo ali več pasivnih hladilnih sistemov, ki za delovanje potrebujejo le gravitacijo, in/ali okrepljeno večkratnost ter geografsko neodvisnost aktivnih hladilnih sistemov. Za drugo generacijo je npr. značilna logika 1 od 2 ali 2 od 3, torej zadošča 1 od 2 ali 2 od 3 aktivnih sistemov, medtem ko v tretji generaciji praviloma zahtevamo delovanje vsaj 1 od 3, včasih tudi 1 od 4 vgrajenih varnostnih sistemov.

Morda najpomembnejši razvojni dodatek v reaktorjih tretje generacije so sistemi za obvladovanje staljene sredice reaktorja. V grobem sta prisotni dve strategiji: hlajenje staljene sredice v reaktorski posodi ali pa ujetje in hlajenje v posebnih zadrževalnikih, ki so nameščeni pod reaktorsko posodo [7].

Praktično zanemarljive spremembe v gorivu in uporabljenih strukturnih materialih ter nekoliko okrepljeni varnostni sistemi, še posebej tisti za obvladovanje staljene sredice reaktorja, zagotavljajo tudi razmeroma dobro obvladovanje tveganj pri izdelavi komponent in pri pridobivanju vseh potrebnih dovoljenj reaktorjev tretje generacije. Uporabljajo torej predvsem tehnologije, ki so bile preverjene že v 2. generaciji reaktorjev.

3 Mali modularni reaktorji

Mali in modularni jedrski reaktorji (SMR, Small Modular Reactors) kot pogonski agregati plovil delujejo že vse od leta 1954, ko so v ZDA splovili prvo jedrsko podmornico Nautilus. Mimogrede, leta 1954 je pričela delovati tudi prva komercialna jedrska elektrarna, in sicer Calders Hall v Združenem Kraljestvu. Mali zato, ker so njihove moči značilno nekaj deset pa vse do morda 300 MWe, modularni pa zato, ker sta na nekaterih plovilih nameščena tudi po dva ali morda celo več reaktorjev.

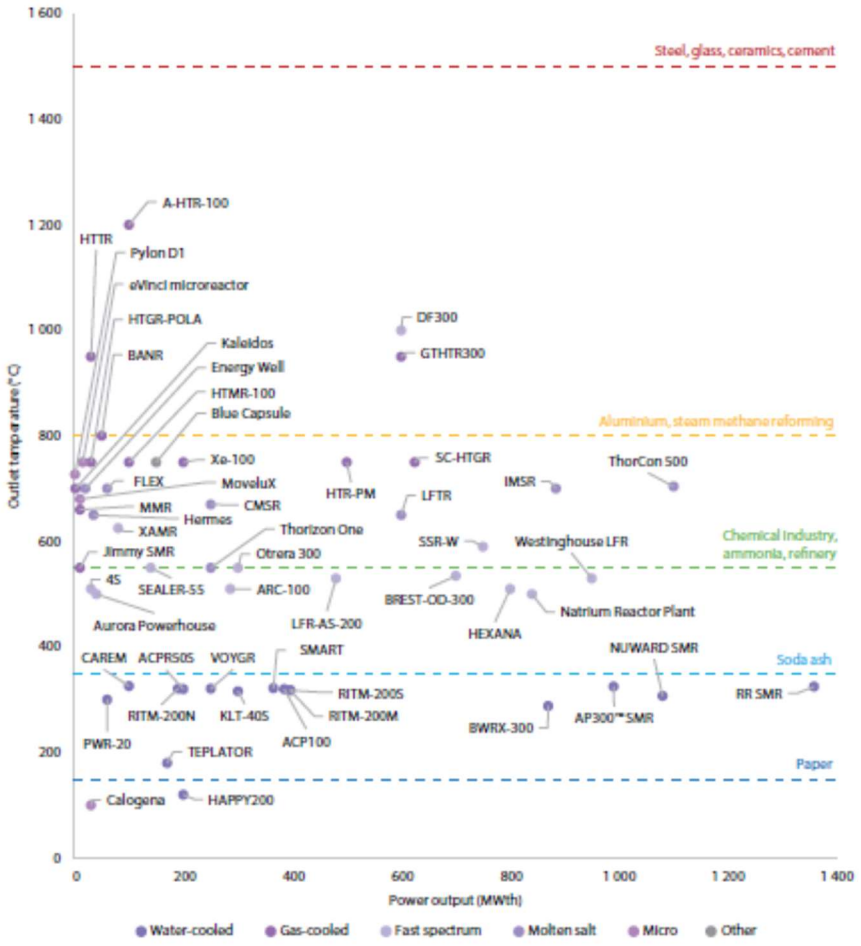
V vojaški mornariški rabi se je uveljavilo gorivo z več kot 90% urana 235. Države, ki takšna plovila gradijo, imajo namreč dostop do visoko obogatenega urana, ki ga lahko uporabijo tudi za jedrsko orožje. V civilni rabi danes velja omejitev na največ 20% urana 235, gorivo za gigawatne reaktorje pa praviloma ne presega 5% urana 235. Pomembna in praktično edina prednost visoko obogatenega urana v mornariških reaktorjih je izjemno dolgo delovanje, tudi 20 ali več let, brez menjave goriva.

Danes na planetu komercialno delujejo 4 SMR. Dva sta nameščena na plavajoči elektrarni Akademik Lomonosov, ki je zasidrana v ruskem zalivu Pevek na vzhodu Sibirije. Dva reaktorja s po 35MWe (150 MW toplote, KLT-40S, Slika 2), ki sta naslednika reaktorjev z ruskih civilnih ledolomilcev, že od leta 2020 oskrbujeta prebivalce z elektriko in toplo vodo. Druga dva delujeta v jedrski elektrarni Shidao Bay na Kitajskem. Dva visokotemperaturna, s plinom hlajena reaktorja HTR-PM (Slika 2) s toplotno močjo 250MW poganjata skupni turbogenerator z električno močjo 250 MW.

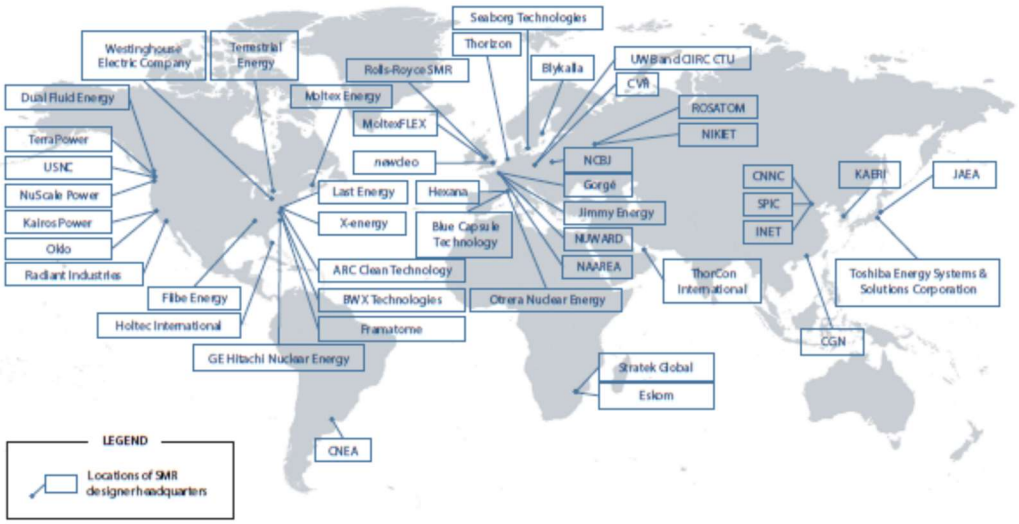
Poročilo agencije za jedrsko energijo pri OECD [8] je v začetku leta 2024 identificiralo 98 zasnov SMR. Izmed teh so jih 56 s podrobnejšim opisom vključili v poročilo. Slika 2 prikazuje porazdelitev zasnov reaktorjev po temperaturi, ki jo dosegajo, po toplotni moči in po zasnovi oz. tipu reaktorja [8].

Večina reaktorjev ima toplotno moč pod 1GW, kar v grobem ustreza tudi elektičnim močem do nekako 300MW. Vodno hlajeni reaktorji dosegajo do nekako 330°C, kar več kot zadošča za daljinsko ogrevanje, nizkotemperaturne industrijske procese in seveda proizvodnjo elektrike s pomočjo vodne pare. Najbolj vroči plinsko hlajeni reaktorji dosegajo 1.000°C, izjemoma tudi več. Vmes pa najdemo reaktorje, hlajene s tekočimi kovinami (svinec, natrij, staljene soli).

Praktično vse zasnove so že bile preverjene pred več desetletji v nekaj več kot 800 raziskovalnih reaktorjih, ki so na planetu obratovali od začetka jedrske dobe s Fermijevim reaktorjem Chicago pile 2 leta 1942. Žal pa pot do hitrejše komercializacije otežuje »izgubljeno znanje«, ena od najpomembnejših posledic razmeroma hitrega opuščanja jedrskih raziskav proti koncu 1960-ih in v začetku 1970-ih. Raziskovalne reaktorje so razgradili, ljudje, ki so jih zasnovali in jih tudi spravili v pogon, pa so že dalj časa v drugih poklicih, mnogi od njih pa tudi niso več med nami.



Slika 2: Porazdelitev SMR po moči in temperaturi [8]



Slika 3: Geografska porazdelitev sedežev podjetij, ki razvijajo SMR [8]

Najhitrejšo komercializacijo in seveda tudi pridobivanje vseh potrebnih dovoljenj zato pričakujemo pri lahkovodnih reaktorjih, ki danes predstavljajo daleč največji delež delujočih komercialnih reaktorjev. Morda še najbližje delujočemu

demonstratorju do leta 2030 ali vsaj v prvih letih 2030-tega desetletja so tako VOYGR, AP300 in BWRX300 (ZDA), CAREM (Argentina), seriji RITM in KLT (Rusija) in morda tudi NUWARD (Francija).

Slika 3 prikazuje geografsko porazdelitev sedežev podjetij, ki razvijajo male oz. modularne reaktorje. Z velikim naskokom vodijo ZDA, sledita Evropska skupnost in Rusija. Ključni razlog za veliko število zagonskih podjetij v ZDA je v tem, da je vlada po zastoju v 1980-ih že konec 1990-ih let pričela razmeroma veliko investirati v raziskave in izobraževanje v jedrskem inženirstvu. Rusi in Kitajci razvojnega cikla nikoli niso prekinili. Kitajci zaradi pomanjkanja energije sicer več virov usmerjajo v gigavatne reaktorje. Evropa, z njo žal tudi Slovenija, močno zaostaja. To je v veliki meri posledica preusmeritve razvojnih sredstev iz jedrske energije v druge t.i. čiste oz. zelene energetske tehnologije.

4 Ključni izzivi jedrske energetike

Ključni izzivi jedrske energetike danes večinoma niso tehnični. Na trgu je namreč dobavljivih več vrst gigavatnih reaktorjev, ki temeljijo na preverjenih tehnologijah izdelave in obratovanja, so že pridobili vsa potrebna dovoljenja v več državah po svetu, in tudi dosegajo predvidene 90% in višje faktorje izrabe.

Med ključne izzive pa lahko štejemo razmeroma visoke investicije, še posebej stroške financiranja, razmeroma dolgo gradnjo in premajhno kapaciteto dobavnih verig za opremo, in morda še bolj pomembno, za nove jedrske talente. Skupni imenovalec vseh izzivov je dezinvestiranje v proizvodne ter seveda tudi raziskovalne in razvojne kapacitete v preteklosti. Tudi zato je jedrska energija, ne glede na svojo nesporno čistost ter energetsko, prostorsko in snovno izjemno učinkovitost, v javnosti marsikje izgubila kredibilnost oz. zaupanje. Če namreč niti tisti, ki z neko tehnologijo že zaslužijo, niso pripravljeni investirati v njeno prihodnost, se bo dvom v to tehnologijo razmeroma hitro razrasel tudi v njihovi okolici in seveda tudi v splošni javnosti.

Z jedrsko elektrarno namreč sobivamo stoletje ali morda celo več (desetletje za odločitev, desetletje za gradnjo, šest ali več desetletij z obratovanje in še desetletje ali dve za razgradnjo). Stoletje prinese s sabo ogromne spremembe tako v znanosti in tehnologiji, kot tudi v družbi. Te spremembe v veliki meri sooblikuje in napoveduje znanost. Tudi zato bi bilo naivno pričakovati, da lahko jedrska energetika na dolgi rok uspeva brez strateškega sodelovanja in aktivnega sobivanja z znanostjo [8].

Najpomembnejši izziv gradnje novega jedrskega bloka v Sloveniji utegne biti pravočasno zagotavljanje dovolj odlično izobraženih, usposobljenih in motiviranih jedrskih talentov. Pričakovano število je blizu 1.000 v vsem času gradnje, torek okvirno vsaj 100 vsako leto. Ne glede na to, da Slovenija osnovno izobraževalno in raziskovalno infrastrukturo za jedrsko inženirstvo in reaktorsko fiziko ima, bo za uspešno iskanje in razvoj talentov potrebno strateško sodelovanje vseh vpletenih deležnikov, še posebej vlade, investitorja in raziskovalnih ter izobraževalnih institucij [8], [9].

5 Zaključki

Ključni izzivi jedrske energetike danes večinoma niso tehnični, mednje pa lahko štejemo razmeroma visoke investicije, še posebej stroške financiranja, razmeroma dolgo gradnjo in premajhno kapaciteto dobavnih verig za opremo, in morda še bolj pomembno, za nove jedrske talente. Skupni imenovalec ključnih izzivov je dezinvestiranje v proizvodne ter seveda tudi raziskovalne in razvojne kapacitete v preteklosti.

Z jedrsko elektrarno sobivamo stoletje ali morda celo več. Stoletje prinese s sabo ogromne spremembe tako v znanosti in tehnologiji, kot tudi v družbi. Te spremembe v veliki meri sooblikuje in napoveduje znanost. Zato bi bilo naivno pričakovati, da lahko jedrska energetika na dolgi rok uspeva brez strateškega sodelovanja in aktivnega sobivanja z znanostjo.

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Natura 2000 in ohranjanje narave, spodbude ali ovire pri razvoju elektroenergetskega omrežja

Natura 2000 and nature conservation, incentives or obstacles in the development of the electricity network

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Povzetek

Natura 2000 in drugi pravni režimi ohranjanja narave v Republiki Sloveniji predstavljajo pomembno omejitev pri umeščanju elektroenergetskih vodov. Za te posege v varstvena območja se napoveduje, da imajo velike negativne ali celo uničujoče učinke. Pri tem se upošteva, da se narava ne spreminja, da so vse spremembe posledice posameznih projektov in da je potrebno zavarovati zavarovane živalske vrste znotraj posamezne države članice EU. Pregled nekaterih primerov kaže, da izhodišča na katerih temelji ohranjanje narave v območjih Natura 2000 in merila za ocenjevanje vplivov elektroenergetskih vodov na ta območja potrebujejo preveritev, spremembo razmišljanja in verjetno posodobitev zakonodaje. Podani so predlogi s katerimi bi pospešili umeščanje novih elektroenergetskih vodov in obnovo obstoječih, ki bodo potrebni zaradi elektrifikacije mnogih dejavnosti in vključevanja obnovljivih virov.

Ključne besede

Natura 2000, elektroenergetsko omrežje, ohranjanje narave, varstvo narave

Abstract

Natura 2000 and other legal nature conservation regimes in the Republic of Slovenia represent an important limitation in the placement of power lines. These encroachments on conservation areas are predicted to have major negative or even devastating effects. Here, it is considered that nature does not change, that all changes are the result of individual projects and that it is necessary to protect protected animal species within each EU member state. A review of some cases shows that the starting points on which nature conservation in Natura 2000 areas is based and the criteria for assessing the impacts of power lines on these areas need verification, a change of thinking and possibly an update of the legislation. Proposals are given to speed up the installation of new power lines and the renovation of existing ones, which will be necessary due to the electrification of many activities and the inclusion of renewable sources.

Keywords

Natura 2000, power grid, nature conservation, nature protection

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1 Uvod

Narava predstavlja najbolj zapleten sistem medsebojno odvisnih dejavnikov, ki človeštvu z zagotavljanjem zraka, vode, hrane in energije, omogoča preživetje Ker njenega delovanja ne razumemo, jo mnogi želijo ohraniti nespremenjeno.

V Sloveniji prevladuje prepričanje, da živimo v raznoliki in ohranjeni naravi »na sončni strani Alp«. V medijih posledično zasledimo množico prispevkov, ki poudarjajo kakovost okolja v katerem živimo. Pozablja pa se, da je za preživetje prebivalcev Slovenije, nujno zagotoviti tudi vire za preživetje.

Visok življenjski standard in ustvarjanje dodane vrednosti zahteva kakovostno infrastrukturo. Oskrba z električno energijo je ena pomembnejših, saj omogoča delovanje tudi drugih infrastruktur. Za prenos električne energije od virov do porabnikov, je potrebno elektroenergetsko omrežje. V Sloveniji so mnogi deli tega omrežja starejši od pol stoletja [1] in jih bo nujno obnoviti oz. nadomestiti in zgraditi tudi nove. Evropski trg električne energije spodbuja tranzit med državami, kar tudi zahteva ojačitve in širitve omrežja [2]. Po drugi strani pa postopki umeščanja za nekatere elektroenergetske objekte trajajo več kot deset let [3, 4]. Elektroenergetskim vodom se pripisuje pomembne negativne vplive na naravo. Obseg ukrepov za izogibanje vplivom in omilitvenih ukrepov je vse večji, kar vse bolj obremenjuje investicije v elektroenergetsko omrežje in posredno ustvarjalce nove vrednosti.

2 Konzervatorski pristop

Danes se vse več virov namenja zbiranju informacij o naravi. Dopolnjujejo se seznami rastlinskih in živalskih vrst, ki bivajo na določenem območju. Kljub vse obsežnejšim bazam podatkov o naravi, pa ne moremo pojasniti delovanja celotne narave.

Zbrani podatki kažejo na spremembe v naravi, ki jih tudi ne moremo z zanesljivostjo pojasniti. Elektroenergetski vodi povzročajo določene spremembe v naravi. Ker pa so številne vzročne povezave v naravi še vedno neznanka, je uveljavljen konzervatorski pristop, ki ima za cilj, da se ohranja naravo nespremenjeno. To dokazuje že mednarodno uveljavljen izraz »nature conservation« (ohranjanje narave), ki je cilj vseh predpisov in priporočil v zvezi z naravo [5]. Vsi sistemi varstva narave tako danes temeljijo na ohranjanju narave, podobno kot je to razumljivo v arheologiji, in to četudi se narava spreminja

tudi brez posredovanja človeka. Naravi je treba priznati ter upoštevati sposobnost spreminjanja in sorazmerno hitrega prilagajanja človekovim posegom.

Prevlada konzervatorskega pristopa se odraža v naslednjem primeru: če v Sloveniji elektroenergetski vod seka enega od mnogih gozdnih območij, bo kljub napovedanemu razvoju novega redkega habitata poseg ocenjen negativno, saj se delitvi gozdnega habitata na dva dela pripisuje večja škoda, kot bi bila korist novega nadomestnega habitata.

3 Kriteriji vrednosti

Konzervatorski pristop se odraža tudi pri ocenjevanju vplivov elektroenergetskih vodov na naravo. Pri tem je izhodišče, da so različni habitati v trajnem ravnovesju in da se razmerja površin med njimi ne spreminjajo. Vsak poseg, ki vpliva na razmerje površin habitatov je tako ocenjen negativno, čeprav iz preteklosti vemo, da so se razmerja stalno spreminjala. Pri tem se predvideva, da so redkejši habitati znotraj posamezne države vrednejši.

Lestvice ocenjevanja vplivov na naravo imajo več stopenj za negativne vplive in le eno stopnjo za pozitivne vplive [6]. Ocena negativnih vplivov pa praviloma ni kvantificirana in temelji na opisu, ki ga izdela strokovnjak s »konzervatorsko izobrazbo«. Pretežna večina vplivov je ocenjenih bolj ali manj negativno. Posledično ni mogoče najti presoje vplivov elektroenergetskega voda na okolje, ki bi napovedal pozitivne učinke na naravo.

4 Ločitev vplivov elektroenergetskega voda in podnebnih sprememb

Pri presoji vplivov elektroenergetskega voda na naravo se uporabljajo najnovejši zbrani podatki s terena, ki upoštevajo tudi vplive podnebnih sprememb in vremena v posameznem letu na stanje habitata in na obseg populacije zavarovane živalske vrste. Na podlagi zbranih podatkov so določeni omilitveni ukrepi, ki ne odpravljajo le neposrednega negativnega učinka elektroenergetskega voda, ampak tudi posledice drugih dejavnikov. Takšen primer je zahteva po ohranitvi ptic kulturne krajine, ki so v resnici območja ekstenzivnega kmetijstva nastala pred nekaj stoletji, ki so se jim te ptice prilagodile. Ta habitat pa nadomeščajo območja intenzivnega kmetijstva, ki pa tem vrstam ne ustrezajo [7]. Tega ni mogoče omiliti z omilitvenimi ukrepi drugih projektov. Presoja ne ločuje neposrednih vplivov elektroenergetskega voda od posledic podnebnih sprememb. Z lokalnimi ukrepi je mogoče se izogniti ali omiliti lokalne vplive, ni pa mogoče lokalno odpraviti vlive podnebnih sprememb, ki jih je treba obravnavati globalno.

5 Neponovljivost elektroenergetskega voda in neponovljivost habitatov

Pri presoji vplivov elektroenergetskega voda na naravo je izhodišče, da ima vsak vod drugačne vplive na habitate [8] in da ni podobnih habitatov. Kljub obstoju mednarodne klasifikacije habitatnih tipov [9], po katerih so razdeljene vse površine v Sloveniji, se presoja vsakega voda izvaja posebej brez uporabe dokazanih vplivov podobnega voda na podobne habitate. Do sedaj tudi niso bile uporabljene primerjave s podobnimi vodi v podobnih habitatih v tujini. Pri določanju vpliva novega elektroenergetskega voda in omilitvenih ukrepov se tudi nikoli ne uporablja rezultatov monitoringov izvedenih podobnih vodov, temveč se za vsak vod izvaja nova celovita presoja in nova presoja vplivov v celoti.

6 Hitra prilagodljivost narave

V naravi je mogoče opaziti množico sprememb, kjer se živalstvo pa tudi vegetacija spremenijo v nekaj desetletjih, kar bi lahko trdili, da so to hitre spremembe, ki se zaključijo v obliki novega naravnega ravnovesja.

Takšni značilni primeri so opuščene gramoznice (Slika 1), ki se v nekaj desetletjih razvijejo v vredne habitate, ki se nato tudi naravovarstveno zaščitijo. Kljub očitnemu hitremu razvoju habitata pa ni mogoče zasuti staro gramoznico in odpreti novo z napovedjo, da bo v nekaj desetletjih po opustitvi le-te nastal podoben vreden habitat.

Slika 2: Gramoznica Dobrovnik pri Lendavi, ekološko pomembno območje in naravna vrednota (ID. 7422)

O nečem podobnem smo bili priča tudi v prvi fazi širitve COVID-19, ko je omejitev gibanja prebivalstva zunaj stanovanj privabila mnoge divje živali v naselja. Tudi sicer se živali učijo in iščejo hrano po deponijah odpadkov in smetnjakih, kar vse dokazuje njihovo prilagodljivost človekovemu okolju.

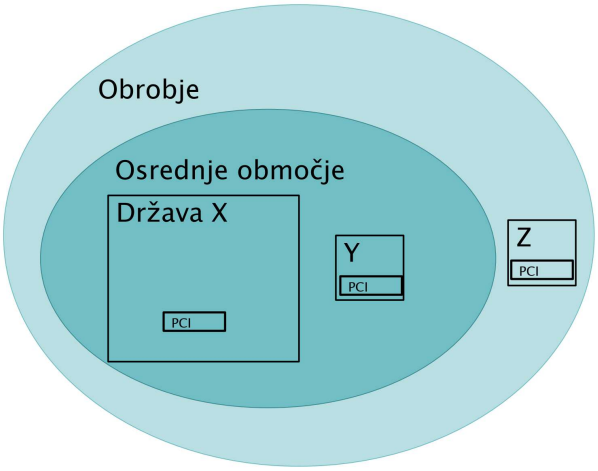
7 Natura 2000

Natura 2000, kot najobsežnejši sistem varstva narave v državah članicah EU [9, 10] temelji na več zanimivih izhodiščih.

Kljub temu, da EU določa množico ureditev, ki veljajo enotno za celotno območje EU, pa so območja Natura 2000 določena za vsako državo članico posebej. Tako se naravovarstvena vrednost določa glede na redkost tega habitata ali zavarovane živalske vrste znotraj države članice. Tako je v eni državi ob mejni reki zaradi ptic zavarovano območje, v sosednji državi na drugi strani iste reke pa te ptice niso zavarovane.

Druga posebnost je določitev vpliva elektroenergetskega voda na posamezno zavarovano živalsko vrsto v obliki odstotka od populacije v posamezni državi članici EU. Slika 2 prikazuje lokacije treh podobnih elektroenergetskih vodov (vsak

elektroenergetskega vod z oznako PCI ima površino 1 km^2) glede na območje zavarovane živalske vrste. Hipotetični primer: površina države X = 100 km^2, Y = 10 km^2, Z = 10 km^2; pri tem sta državi X in Y na osrednjem območju visoke gostote zavarovane populacije (1000/km^2) in država Z na obrobju populacije z nizko gostoto (100/km^2).



Slika 2: Lokacije treh podobnih vodov glede na območje zavarovane živalske vrste

Tabela 1 prikazuje delež prizadetih osebkov v odstotkih glede na populacijo v posamezni državi. Enak elektroenergetski vod v osrednjem območju populacije prizadene enako število osebkov, a je v državi X prizadet le 1 % populacije, ker je država 10x večja od države Y. Posledično bo vpliv v državi X ocenjen kot zanemarljiv, medtem ko bo vpliv v državi Y kljub enakemu številu prizadetih osebkov ocenjen kot velik. V državi Z bo prizadetih 10x manjše število osebkov kot v državah X ali Y in bo vpliv ocenjen kot velik, ker bo prizadeto 10 % populacije v tej državi. Država Z bo tudi težje zagotavljala ugodne življenjske pogoje, ker so ti pogoji že sedaj očitno manj ugodni, ker je gostota populacije mnogo manjša. Ni izključeno, da bodo drugi negativni vplivi na populacijo v državi Z pripisani elektroenergetskega vodu, pri katerem bo zato treba izvesti obsežne omilitvene ukrepe, čeprav je v tej državi prizadeto najmanjše število osebkov zavarovane vrste.

Tabela 1: delež prizadetih osebkov v odstotkih

Država	Površina (km^2)	Gostota populacije (št./km^2)	Prizadeta populacija (št.)	**Prizadet % v državi**
X	100	1000	1000	**1**
Y	10	1000	1000	**10**
Z	10	100	100	**10**

Poseben primer ocenjevanja vpliva predstavlja ocenjevanje vpliva elektroenergetskega voda na ptice selivke v obliki izgube procentov populacije, ker se uporabljajo podatki o populaciji na območju načrtovanega elektroenergetskega voda, pri čemer se zanemari vpliv pogojev preživetja na drugih kontinentih ali na njihovi vsakoletni selitveni poti.

8 Koristi in škode pri elektroenergetskem vodu

Metoda za določanje vplivov elektroenergetskih vodov na naravo je poponoma enaka kot metoda za določanje vplivov za katerikoli proizvodni ali drugačen projekt. Vendar pa bi morali elektroenergetske vode obravnavati celostno in drugače od projektov, ki niso infrastrukturni. Pri odločanju o stroških omilitvenih ukrepov za vod bi morali preveriti ali so ti stroški upravičeni. Upoštevati moramo, da bodo stroški omilitvenih ukrepov bremenili gospodarstvo, ki bo moralo ustvariti dodatno dodano vrednost. Dodatna vrednost pa je na koncu uporabljena za pokritje stroškov omilitvenih ukrepov elektroenergetskega voda. Pri tem se vedno zanemari, da vsaka gospodarska dejavnost povzroča negativne vplive na okolje. Zato je pomembno, koliko gospodarstvo povprečno obremenjuje okolje. Drugače povedano, »umazana industrija« bo ustvarila bistveno večjo škodo v naravi za ustvarjanje dodatne dodane vrednosti, kot pa bo korist za naravo zaradi izvedbe omilitvenih ukrepov za elektroenergetski vod.

9 Strateška presoja

V Sloveniji že desetletja izvajamo celovite presoje vplivov planov na okolje. Pri tem se ne izvaja strateška okoljska presoja plana ampak celovita presoja vplivov projektov, ki so vključeni v plan, na okolje. Zato se običajno zahteva množica podrobnosti, ki bi jih morali preverjati pri presoji vplivov posameznega projekta na okolje (»Environmental Impact Assessment«, skrajšano EIA [11]). Šele zadnji predlog spremembe Zakona o varstvu okolja uvaja neposredni prevod mednarodno uveljavljenega pojma »Strategic Environmental Assessment« (skrajšano SEA [12]). Sprememba poimenovanja postopka v »strateško okoljsko presojo« pa ne bo pospešila umeščanja elektroenergetskih vodov, če se bo izvajala kot do sedaj celovite presoje.

Naša posebnost je tudi, da izvajamo celovito presojo vplivov elektroenergetskega voda na okolje, tudi če je pri projektu obravnavanih več variant poteka. V številnih evropskih državah variante obravnavajo pri presoji vplivov voda na okolje (po EIA postopku).

Značilen primer neustrezne strateške presoje pri nas je presoja celotnega razvoja vodotokov. Ker ni izvedena strateška okoljska presoja vseh vodotokov v Sloveniji, ki bi razvrstila vse vodotoke od naravovarstveno najvrednejših do najmanj naravovarstveno vrednih, tudi ni mogoče izvesti kakršnegakoli razvojnega projekta. Z razvrstitvijo po naravovarstveni vrednosti bi lahko zaščitili najvrednejše vodotoke in ostale namenili oskrbi s pitno vodo, namakanju, proizvodnji električne energije, turizmu, itd. Sedaj so zavarovana porečja Soče in Mure. Drava je izkoriščena le energetsko, brez vizije za namakanje ali druge razvojne potrebe. Sava bo naravovarstveno preučevana le na odsekih, kjer so predlagane nove hidroelektrarne in tako dolgo, da bo tam najdenih dovolj zavarovanih živalskih vrst in vrednih habitatov, da je ne bo mogoče uporabiti za katerokoli razvojno funkcijo, razen, če bo uspešno izveden postopek prevlade druge javne koristi nad koristjo narave. Primer neuspešno izvedenega

postopka prevlade lahko opazujemo pri hidroelektrarni Mokrice in pripadajočih protipoplavnih in drugih razvojnih ureditvah.

Enako neustrezen pristop je bil v preteklosti izveden pri presojah vplivov polj vetrnih elektrarn na ptice. Vedno se je namreč preučevalo zgolj izbrano lokacijo in jo tudi po podrobnem preučevanju označilo kot naravovarstveno neprimerno, namesto, da bi se izvedla strateška okoljska presoja za polja vetrnih elektrarn na območju celotne Slovenije. Da v Sloveniji ob enakih predpisih EU do sedaj nimamo niti enega delujočega polja vetrnih elektrarn, je dokaz, da ne izvajamo pravilno strateških okoljskih presoj oziroma celovitih okoljskih presoj in presoj vplivov projektov na okolje.

10 Predlogi

Najtežja bo sprememba gledanja na ohranjanje narave od konzervatorskega pristopa nespremenljive narave k naravi kot dinamičnem sistemu v katerem naj človek povzroča čim manjše vplive. Spremembe gledanja na naravo pa ne bo mogoče doseči, če do teh spoznanj ne bo prišel izobraževalni kader, nato pa še z vzgojo nove generacije strokovnjakov za to področje. Največji izziv bo razvoj metod za napovedovanje vplivov človeka na naravo, kot najbolj zapletenega sistema soodvisnih spremenljivk.

Spremembo ocenjevanja vplivov elektroenergetskih vodov na naravo bodo lahko izvedli le kadri, ki bodo sposobni videti tako pozitivne kot negativne učinke človekovih posegov v naravo. To pa bo mogoče šele takrat, ko bodo vplivi kvantificirani na podlagi metod za napovedovanje vplivov, potrjenih z monitoringi pri delujočih podobnih elektroenergetskih vodih v podobnih habitatih. Čim prej je treba v presojo vplivov vključiti monitoringe ravnotežnega stanja narave vodov izvedenih pred več desetletji in na njih utemeljiti predvidene učinke omilitvenih ukrepov. Pri tem pa je še posebej treba upoštevati hitro prilagodljivost živali pri napovedovanju vplivov elektroenergetskih vodov na naravo.

Nujen bo tudi razvoj metod napovedovanja vplivov človeka na naravo do te mere, da bo mogoče napovedati ločeno vplive posameznega elektroenergetskega voda in vplive zaradi podnebnih in drugih sprememb.

Metode za kvantificirane napovedi vplivov elektroenergetskih vodov na naravo bo mnogo lažje razviti, če se bo odstopilo od pristopa obravnave vplivov vsakega elektroenergetskega voda posebej in se bo vzpostavila »banka« podatkov napovedanih vplivov in monitoringov dejanskih vplivov podobnih vodov v podobnih habitatih na nivoju EU ali celo globalno.

Spremeniti bo treba tudi sistem vzpostavitve Natura 2000 območij v EU tako, da se pomembnost območij posameznih habitatnih tipov in populacij zavarovanih vrst določi glede na njihovo redkost na nivoju celotne EU neglede na državne meje. Temu ustrezno bo treba vplive elektroenergetskih vodov na naravo ocenjevati glede na celotno EU.

Pri ugotavljanju koristi vloženih sredstev za omilitvene ukrepe infrastrukturnih projektov bi bilo treba preveriti povprečno škodo na naravi zaradi delovanja gospodarstva na območju, ki je obremenjeno s stroški te infrastrukture.

V Sloveniji pri enakih direktivah EU ne uspemo umestiti elektroenergetskih vodov in mnogih drugih razvojnih projektov. Zato je treba nujno spremeniti način izvajanja strateških okoljskih presoj planov in opustiti sestavljanje planov iz projektov in nato vsakega posebej obravnavati s predhodnimi zahtevami po podrobnih podatkih kot se izvede presoja vplivov projektov na okolje (po EIA postopku).

Pri umeščanju in izvajanju okoljskih presoj elektroenergetskih prenosnih vodov in druge infrastrukture državnega pomena je nujno spremeniti tudi način usklajevanja interesov v prostoru. Nov predpis Združenih držav Amerike [13] dokazuje, da je nujno pospešiti postopke umeščanja tovrstne infrastrukture v prostor in določa, kako to izvesti. Zakon o urejanju prostora omogoča učinkovitejše umeščanje z vzpostavitvijo projektnih skupin, ki bi dejavno usklajevale interese v prostoru in sprejemale odločitve. Ker projektne skupine niso prevzele odločevalske vloge oz. so to vlogo ohranili formalni nosilci urejanja prostora, zakonska ureditev ni zaživela v praksi. Namesto ukinjanja projektnih skupin bi jih bilo ustrezneje nadomestiti s po eno projektno skupino za vsako vrsto infrastrukture, torej za elektroenergetske vode ena projektna skupina. Ta bi morala vključevati kompetentne člane, ki so sposobni sprejemati odločitve, ki bi nadomestile izdajo mnenj nosilcev urejanja prostora.

11 Zaključek

Postavitev množice obnovljivih virov v zadnjih letih, še posebej v drugih državah članicah EU, ob enaki evropski zakonodaji, dokazuje, da je v Sloveniji nujno spremeniti način izvajanja strateških okoljskih presoj planov in presoje vplivov projektov na okolje. Spremembe so nujne pri uresničevanju elektroenergetskih projektov, kot tudi pri vseh ostalih vrstah infrastrukture.

Upravljavci infrastruktur podpiramo izogibanje ali vsaj omilitev vplivov načrtovanih projektov na naravo, če presoje temeljijo na preverljivih, količinsko določenih podatkih in so izvedene v razumnem času. Takšen pristop pomeni hiter razvoj projekta in njegovo uresničitev vključno z izvedbo omilitvenih ukrepov, kar pomeni tudi prispevek k vzpostavljanju kakovostnih habitatov.

V Sloveniji moramo kljub visokemu zavedanju o kakovosti narave doseči nacionalni konsenz, da je nujno hitro sprejeti odločitve in izvesti mnoge razvojni projekte, če želimo zagotoviti vire za preživetje in ohraniti kakovost življenja prebivalstva.

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Sprejemljive in „nesprejemljive“ metode žlahtnjenja rastlin kot del boja za racionalno odločanje v okoljevarstvu

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Izvleček

Žlahtnjenje rastlin se je na znanstvenih osnovah razvijalo od pričetka 20. stoletja in močno vplivalo na prehrano vse večjega števila ljudi. Kratko opisujemo obstoječe metode in njihovo prepoznavnost med prebivalstvom. Žal se najsodobnejši del teh metod – genski inženiring torej metode genskih transformacij in v zadnjem času tudi genskih preurejanj vse prevečkrat na naši celini ocenjujejo z negativnega vidika. Težko je razumeti tako odklonilen odnos, če vemo kaj vse drugim delom sveta prinaša njihov sprejem.

Abstract

Plant breeding has been developed on a scientific basis since the early 20th century and has a major impact on the diets of a growing number of people. We briefly describe the existing methods and their visibility among the population. Unfortunately, the most modern part of the methods - genetic engineering, i.e. methods of genetic transformation and, more recently, genetic editing - are all too often viewed negatively on our continent. It is difficult to understand such a dismissive attitude, knowing all that their adoption brings to other parts of the world.

Ključne besede:

Križanja, Genske transformacije, In vitro embriji oz. protoplasti, Izzvane mutacije, Gensko preurejanje

Metode žlahtnjenja

Med starejše metode žlahtnjenja sodi uporaba znotraj vrstnega in medvrstnega križanja. Križanje omogoči premeščanje genov med sortami ali vrstami rastlin in s tem kopičenje za pridelavo ugodnih lastnosti med potomci. Medvrstna križanja so zahtevnejša in lahko rezultirajo z novo vrsto (tritikala) ali z novimi lastnostmi izhodiščne vrste (paradižnik, itd.). Pogost vir genov so “divji sorodniki”, če so dostopni. Denimo že več let je znana huda odvisnost ozkega nabora genov pri bananah, ki jih zato težko branimo pred boleznimi. V Sloveniji je tak primer hmelj, katerega genska baza je ozka, uspešno pa je bil rešen krompir, odpornost na virus je prišla iz sorodne vrste. Dve biotehnološki metodi pripomoreta k uspehu križanj in sicer in vitro reševanje nezrelih embrijev in fuzije protoplastov. Številne sorte so poliploidne. Nekatere so take že po naravni poti, druge pa smo ustvarili ljudje. Poliploidi (pšenica, krompir, hmelj, jagode itd.) so običajno robustnejši lahko pa tudi brezsemenski (banane, lubenice).

Novejša uveljavljena metoda je formiranje F1 hibridnega semena. Gre za izkoriščanje heteroze (hibridne bujnosti), ki se pojavi pri nekaterih križancih čistih linij v njihovi prvi filialni generaciji. V naše kraje se je zlasti pri koruzi razširila po drugi svetovni vojni. Del prebivalstva se je novosti bal, danes pa je hibridnost številnih vrst pogoj za donosno pridelavo. V pomoč pri žlahtnjenju hibridnih sort je več biotehnoloških postopkov. S haploidi skrajšamo tvorbo čistih linij za mnogo let, z genskimi markerji pa si pomagamo pri odbiri. Eno od takih metod smo pri zelju razvili tudi pri nas (Rudolf Pilih in sod. 2019).

Mutageneza je tehnika 60ih let in je rešila mnoge težave z nedostopnostjo drugih virov genske raznolikosti. Njen ekvivalent je najsodobnejša oblika biotehnološkega žlahtnjenja – gensko preurejanje, ločita pa se po nekaj pomembnih značilnostih. Izzvana mutageneza se izvede z naključnim “obstreljevanjem” delov rastlin ali semen z ionizirajočim žarčenjem ali mutagenimi kemikalijami. Geni, ki mutirajo, so naključno mutirani in zvečine recesivni. Le velikemu obsegu dela lahko pripišemo vsaj delen uspeh, denimo odstranitev določene nezaželene lastnosti recimo erucične kisline v oljni ogrščici. Sodobna metoda genskega preurejanja pa cilja točno določen gen, lahko tudi istočasno v večih različicah (alelnih oblikah), ne pa tudi preostalih genov. Mutageneza se smatra kot neproblematična metoda, o primernosti genomskega preurejanja in njegovi regulativi, pa se v EU sučejo pogajanja že 15 let. V tem času so bili drugod nekateri rezultati že sproščeni (denimo GABA paradižnik na Japonskem), nekateri pa so najavljeni v kratkem (denimo brezglutenska pšenica). Evropski parlament prejšnje sestave je gensko preurejanje sprejel, naloga sedanjega pa je izvedba zakonodaje.

Spornost genskih transformacij

Gibanja aktivistov že tretje desetletje ovirajo aplikacijo sodobnih genskih tehnologij. V predavanju bodo zajeti uspešni primeri uporabe genskih transformacij ter avtorjeve osebne izkušnje pri sproščanju. Poudarjeno bo

tudi, da kljub pomanjkanju argumentov številne aktivistične organizacije sprožajo kampanje tudi proti najbolj nujno potrebnim sortam, denimo pravkar ponovno na Filipinih proti zlatemu rižu (viru vitamina A) in to ne glede na strahotne posledice, ki se merijo v sto tisočih oslepelih otrocih v azijskih državah.

Vir

Rudolf Pilih K. et al (2019) Proposal of a new hybrid breeding method based on genotyping, inter-pollination, phenotyping and paternity testing of selected elite F1 hybrids. *Frontiers in Plant Science*. 2019, art. 1111, vol. 10

Ni fosilnih goriv – ni hrane

No fossil fuels - no food

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POVZETEK

V prispevku je obravnavana poraba energije v sektorju kmetijstva in gozdarstva. Trenutna sektorska poraba končne energije je na nivoju 70.000 ton dieselskega goriva letno. Glede na evropski "Green Deal", ki predvideva razogličenje in opustitev fosilnih goriv do leta 2050, so raziskane možnosti nadomestitve z obnovljivimi viri. Modelska predpostavka je, da se samooskrba s hrano poveča iz sedanjih 40 % na 80 %, hektarski donos pa se zmanjša zaradi zmanjšanja uporabe fitofarmacevtskih sredstev. Obravnavanih je več alternativ nadomestitve, s fizičnim delom ljudi in konj, biodieslom, električno energijo in sintetičnimi gorivi. Možnosti za dejansko izvedbo katerekoli alternative so realno zelo majhne. Ker je hrana nujno potrebna za naš obstoj bomo do odkritja kakih novih tehnologij ostali na uporabi fosilnih goriv.

KEYWORDS / KLJUČNE BESEDE

razogličenje, fosilna goriva, pridelovanje hrane,

ABSTRACT

The paper deals with energy consumption in the agricultural and forestry sector. The current sectoral consumption of final energy is 70,000 tons of diesel fuel per year. In line with the European "Green Deal", which envisages the abandonment of fossil fuels by 2050, the possibilities of replacing them with renewable energy sources are examined. The model assumes that the degree of self-sufficiency in food production will increase from the current 40% to 80% and that the yield per hectare will decrease due to the reduced use of pesticides. Several alternatives are being discussed, including manual labor by humans and horses, biodiesel, electricity and synthetic fuels. Realistically, the chances of actually implementing all alternatives are very slim. Since food is absolutely necessary for our existence, we will have to rely on the use of fossil fuels until new technologies are discovered.

KEYWORDS

decarbonization, fossil fuels, food production

1 UVOD

Zadnje čase se globalno ukvarjamo kako zmanjšati kakršnekoli ogljične odtise v obliki antropogenih izpustov toplogrednih plinov (GHG ang. Greenhouse Gases). V preteklosti je bilo že veliko konferenc in strateških posvetovanj na to temo, večina držav ima tudi že strateške načrte kako to izvesti, npr. Slovenija v Nacionalnem energetsko podnebnem načrtu (NEPN) [1]. Realni rezultati 20 letnega razogličenja so ravno nasprotni. Emisije toplogrednih plinov se globalno povečujejo. V nekaterih državah, ki brezglavo politično forsirajo spremenljive obnovljive vire (VRE ang. Variable Renewable Energy), kot so npr. fotonapetostne in vetrne elektrarne za proizvodnjo električne energije, se je cena le te v zadnjih dveh letih izjemno zvišala, posledično se je pa konkurenčnost teh gospodarstev zmanjšala. Eklatanten primer je Nemčija in njene gospodarske težave zaradi nekonkurenčnosti. Realno gledano, je pa vključevanje VRE virov v neko stabilno elektroenergetsko oskrbo popolno tehnološko parazitiranje, saj VRE viri sami ne morejo obratovati in potrebujejo stabilnega gostitelja (klasične termoelektrarne na premog, plinske, jedrske, hidro). VRE viri torej lahko obratujejo izključno na račun drugega.

Zmanjševanje GHG ob sočasni gospodarski rasti, ki istočasno pomeni tudi povečevanje porabe energije je v nasprotju z drugim glavnim zakonom termodinamike (II. GZT). Trenutno žal ne znamo (in tudi nikoli ne bomo), kako zaobiti II. GZT. Politične direktive in zeleni aktivizem pa na fizikalne zakone ne deluje – še sreča! Navidezno si politika pomaga z zelo ozko izbranimi mejami sistema. Danska npr. vse energijsko intenzivne polizdelke uvaža iz Azije, lesne pelete za ogrevanje Köbenhavna pa iz Brazilije in Kanade, itd., itd,… Npr. na Danskem je poraba jekla na prebivalca večja kot v Sloveniji, toda ker nimajo nobene jeklarne in druge energijsko intenzivne industrije… je njihova energijska učinkovitost merjena kot razmerje med porabo energije in dodano vrednostjo bistveno manjša kot v Sloveniji in celo najnižja v Evropi?? Tako navidezno zmanjševanje GHG na račun nekoga drugega je zelo prikladen politični pamflet, ko prepričuješ ljudske množice o uspešnosti izvedenih "zelenih" ukrepov in kako s tem rešuješ svet. Zelo podobno je tudi z električnimi avtomobili. Njihova emisija GHG je 0 gramov CO_2 na prevoženi kilometer? Emisija električne energija za polnjenje baterije pa najbrž ne?

Ambiciozni evropski podnebni načrt "Green Deal" [2] je opustitev fosilnih goriv in prehod na obnovljive vire energije (OVE) do 2050. Glavna ideja razogljičenja je, da se bo vsa fosilna in jedrska energija nadomestila z VRE električno energijo, tam kjer pa prehod na električno energijo ni možen ali smiseln, bo izvedena zamenjava z vodikom in sintetičnimi gorivi, ki se bodo pridobivali iz VRE električne energije. Ideja je navidezno dobra in izvedljiva, dokler govorimo o lekarniškem in laboratorijskem nivoju izvedbe prehoda in zelo ozko postavljeno bilančno mejo sistema. Ko pa se bilančne meje razširijo in

preidemo na nivo držav ali globalni nivo, pa ugotovimo, da II. GZT še vedno velja. Realno se pojavi zelo veliko nepremostljivih fizikalnih preprek. Trenutni zeleni prehod lahko označimo kot obupne poizkuse, da bi iz starih tehnologij dobili povsem nove rezultate (Einstein), po možnosti seveda takšne, ki so v nasprotju z II: GZT? Naj omenimo, da je bila vodikova gorivna celica odkrita že leta 1838, pa se do danes še ni uveljavila? Kje je vzrok?

Prispevek obravnava možnosti pridelave hrane v Sloveniji na tradicionalni in povsem OVE način s človeško in živalsko delovno silo. Težko si namreč zamislimo, da bi polja obdelovali z električnimi obdelovalnimi stroji, zaradi pogostih prekinitev dela zaradi več urnega polnjenja baterij. Delovna obremenitev kmetijskih strojev je namreč trajno bistveno večja (večino časa vsaj na 80 % nazivne moči), kot pa električnih osebnih vozil. Tudi potrebne moči so bistveno večje npr. sekalnik lesnih sekancev, manjši kombajn; potrebuje moč ~500 kW. Ker bi uporaba električnih kmetijskih strojev kmetovalcem najbrž bistveno otežila obdelovanje polj, je zato najbrž bolj smiselna uporaba sintetičnih goriv. Pri teh pa je vložek energije za njihovo pridobivanje kar 3 do 4 krat večji kot njihova kurilnost. Zato v prispevku hipotetično obravnavamo kakšne so možnosti pridelave hrane na tradicionalen povsem OVE način, brez sodobnih tehnologij.

2 METODOLOGIJA

Iz podatkov o porabi dieselskega goriva v kmetijstvu, ki so zajeti iz Statističnega urada Slovenije (SURS) [3] je izračunana nadomestna količina mehanskega dela. To mehansko opravljeno delo se nato porazdeli na obnovljiva vira, človeško delo in delo živali. Pri tem je dodatno upoštevano povečanje samooskrbe s hrano iz današnjih ~40 % na ~80 % in zmanjšana uporaba fitofarmacevtskih sredstev in zato bolj ekološka pridelava poljščin, zaradi česar se pridelek glede na današnji nivo dodatno zmanjša za 25 %.

3 PORABA ENERGIJE V KMETIJSTVU V SLOVENIJI

Po podatkih SURS je letna povprečna poraba končne energije v kmetijstvu ~75.000 t dieselskega goriva, s katerim se obdeluje 1750 km^2 njiv, skupne kmetijske površine v uporabi so 4750 km^2 [3] Njivskih površin na prebivalca imamo najmanj v EU, samo 875 m^2, kar bi moral biti izredno močen alarm za politiko, ker še vedno dovoljuje gradnjo, večinoma ne življenjsko pomembnih objektov (nakupovalnih središč, nasedlih tovarn – npr. štajerska Magna) na prvovrstnih kmetijskih zemljiščih! Ob zelo grobi predpostavki, da se pridelki iz kmetijstva podvojijo do leta 2050 ob 25 % manjšem izplenu, bi se poraba goriv povečala na ~200.000 t dieselskega goriva. Ob tem bi se morale bistveno povečati tudi obdelovalne površine. Gozdnatost Slovenije je bila v 19 stoletju samo ~30 %, samooskrba s hrano je bila ~80 % za ~1 milijon prebivalcev. Če torej primerjamo takratno in sedanjo učinkovitost kmetijstva, je razvidno, da je sedanja pridelava bistveno bolj učinkovita (na manjši obdelovalni površini 40 % hrane za 2 milijona = 80 % za 1 milijon), ob tem, da je v prehrani bistveno več mesa, ki porablja za pridelavo bistveno več energije (npr. najprej pridelavo koruze za živinsko krmo). Učinkovitost se je povečala predvsem zaradi umetnih gnojil in fitofarmacevtskih sredstev.

Ob predpostavki, da je izkoristek pretvorbe dieselskega goriva v mehansko delo 25 %, iz 200.000 t dobimo 600.000 MWh mehanskega dela (iz 1 kg goriva ~3 kWh mehanskega dela). Če to preračunamo v delovne dni, kjer se upošteva, da človek lahko dnevno odda do 0,6 kWh [4] dobimo kar eno milijardo (10^9) delovnih dni. Nadalje lahko predpostavimo, da se je v preteklosti s pridelavo hrane ukvarjalo več kot 90 % prebivalstva, kar bi za trenutne Slovenske razmere pomenilo 1,8 milijona ljudi. Za 600 GWh mehanskega dela, bi moralo vseh 1,8 milijona ljudi težko fizično delati kar 555 dni, torej več kot eno leto. Dobljena ocena potrebnih delovnih dni, se načeloma dobro ujema z dejstvom, da so nekoč ljudje večinoma delali samo za hrano za preživetje. Pri tem so si pomagali tudi vprežnimi živalmi. Zelo groba ocena med oddanim delom konja in človeka je ~10:1, pri čemer je potrebno upoštevati, da konj v naših klimatskih pogojih poje četrtino "svojega" pridelka..

Tabela 1: Primerjava moči delovnih živali in človeka [5]

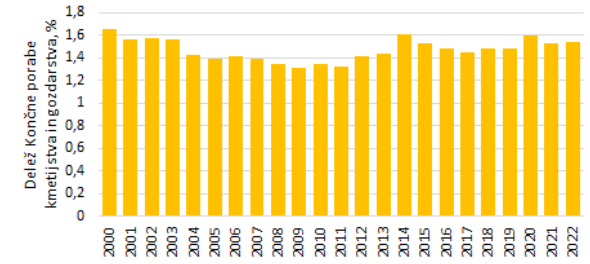
	vlečna sila, N	hitrost, m/s	moč, W	moč v HP
konj	600	1,2	650	0,86
vol	600	0,8	430	0,57
mula	300	1,2	321	0,43
človek	90	1,2	67	0,09

Prikazana groba ocena zamenjave fosilnih goriv z delom živali in ljudi v kmetijstvu pokaže, da je to možno (neizpodbiten dokaz je tudi v preteklosti, saj so naši predniki preživeli brez fosilnih goriv), toda cena zamenjave nazaj na OVE je visoka. Očitno je, da bi v tem primeru morali skoraj vsi obdelovati polja in se ukvarjati s kmetijstvom. Pri današnji stopnji urbanizacije, ko večina ljudi živi v velikih mestih (ali več milijonskih velemestih) je tak prehod nazaj popolnoma nemogoč zaradi transporta delovne sile na polja. Logična posledica je torej, da se človeštvo ne more odreči trenutni kmetijski mehanizaciji na fosilna goriva. Prehod na strojno obdelavo polj je bil temeljni pogoj za industrializacijo in splošni napredek [4] in današnji visok standard – izobilje dobrin. Delež delovnih mest v državah z visoko razvitim in mehaniziranim kmetijstvom je samo še 2 % do 3 %. Z večanjem produktivnosti se obseg produkcije linearno povečuje, poraba energije pa eksponentno. Sila trenja se povečuje navadno s kvadratom hitrosti (hitrejši proces pomeni večjo produktivnost, ki pa je vedno povezana z večjimi izgubami), moč za premagovanje trenja pa torej s tretjo potenco.

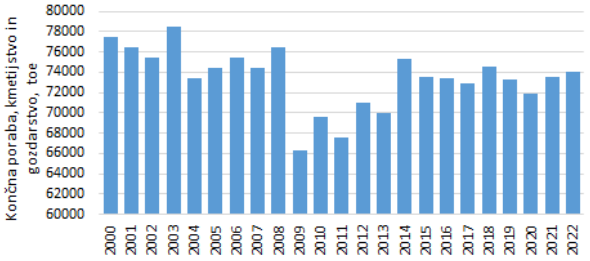
Delež porabe energije v kmetijstvu in živilski industriji je glede na celotno porabo kljub vsemu relativno majhen, toda izjemno pomemben "*conditio sine qua non*" (lat.: brez česar ne gre). Kljub relativno majhni porabi, je prehod na OVE izjemno težaven ampak dokazljivo mogoč (seveda ob bistveno nižjem življenjskem standardu in manj prebivalcih). Če bi hoteli fosilni diesel nadomestit z biodieslom, ki ima EROI 2, pri povprečnem izplenu 3 t/ha [6] in [7], bi za 200.000 t biodiesla potrebovali še dodatnih ~70.000 ha (700 km^2) obdelovalnih polj in ker je EROI

2, tudi še vložek energije za predelavo oljne ogrščice v biodiesel, ki je pa 50 % energije biodiesla. Zato bi se poraba biodiesla morala še dodatno povečati (npr. za oranje in obdelavo dodatnih 700 km^2…). Kot vidimo, je nadomeščanje z biogorivi bolj ali manj nesmiselno. Še enkrat boljši za nadomeščanje je konj, ki ima EROI vsaj ~4-5.

Poraba končne energije v sektorju kmetijstva in gozdarstva predstavlja le ~1,5 % porabe končne energije v Sloveniji, slika 1 in 2. Relativno zelo malo, toda zelo težko jo nadomestimo z obnovljivimi viri, tudi z OVE električno energijo, ker gre prvenstveno za mobilne delovne stroje velikih moči.

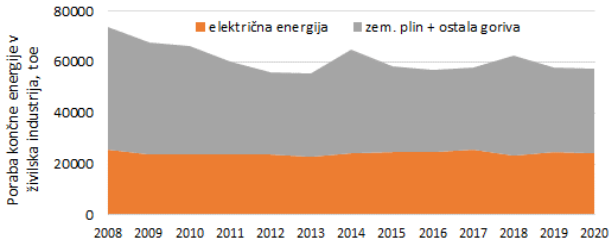


Slika 1: Delež porabe končne energije za kmetijstvo in gozdarstvo [3]



Slika 2: Končna poraba energije za kmetijstvo in gozdarstvo [3]

Poraba končne energije industrijsko predelovalnega sektorja proizvodnje hrane in pijač v Sloveniji je skoraj enaka porabi v kmetijstvu, to je ~70.000 toe, pri čemer pa je poraba razdeljena na dva glavna energenta, to je električno energijo in energijo goriv, slika 3, predvsem zemeljskega plina in nekaj malega ostalih goriv.



Slika 3: Končna poraba energije za živilsko predelovalno industrijo v Sloveniji [3]

Poleg te neposredne porabe je v kmetijstvu še veliko "posredne" energije v obliki umetnih gnojil, fitofarmacevtskih sredstev, izdelave obdelovalnih strojev,… Zelo lep pregled agro-ekonomskih faktorjev je prikazan v [8]. V tabeli 2 je navedenih samo nekaj najbolj zanimivih vrednosti.

Tabela 2: Nekateri agro-ekonomski faktorji povzeti iz [8]

skupna poraba za obdelovanje zemlje	kWh/(ha leto)	315-2060
produkcija pesticida/fungicida	kWh/kg	75-117
produkcija pest./fung. za škropljenje 1 ha	kWh/(ha leto)	140-550
produkcija dušikovih umetnih gnojil	kWh/kg	12-18
produkcija fosfornih umetnih gnojil	kWh/kg	1,4-9
produkcija kalijevih umetnih gnojil	kWh/kg	1,5-14
količina dušikovih gnojil za 1 ha	kg/ha	30-210

4 ZAKLJUČEK

V prispevku je raziskana možnost prehoda iz uporabe fosilnih goriv na druge obnovljive vire energije za sektor kmetijstva in gozdarstva. Osnovno izhodišče modela so statistični podatki o deležu samooskrbe s hrano in poraba končne energije sektorja. Rezultati zelo enostavnega modela pokažejo, da bi bilo mehansko delo iz fosilnih goriv hipotetično možno nadomestiti z delom ljudi in konjev, ob robnem pogoju, da bi morali skoraj vsi prebivalci, preko 80 %, trdo delati na poljih samo za preživetje. Predviden je tudi dvig samooskrbe s hrano iz današnjih 40 % na nekdanjih 80 %. Tovrstna zamenjava s povečanjem fizičnega dela ljudi je za današnji čas popolnoma nesprejemljiva, čeprav je v preteklosti, ko še niso imeli toplotnih strojev in kapljevitih fosilnih goriv, to bila edina in zelo samoumevna realnost. Druga alternativa je uporaba baterijskih kmetijskih strojev. Žal tudi ta alternativa tehnološko še ni zrela. Ti stroji so relativno bistveno bolj obremenjeni (glede na nazivno moč) in to v daljših časovnih intervalih (dnevno več ur), torej bistveno bolj kot npr. baterijska osebna vozila. Sredi polj bi morali postaviti zelo zelo hitre polnilnice? Torej je tudi ta alternativa zelo malo verjetna. Tretja alternativa je "klasični" konjski pogon. Ta je najbolj ekološki, deluje na lokalno pridelano hrano, proizvaja naravno gnojilo, konji se razmnožujejo sami,… Ta pogon ima torej vrsto prednosti. Edina slabost zakaj se ga ne uporablja več je pa specifična moč, ki je ~1 W/kg mase konja. Sodobni kmetijski stroji imajo nekaj stokrat večjo specifično moč. Četrta alternativa je pridelava biodiesla in njegova uporaba za obdelavo polj. Glede na to, da je EROI 2, to pomeni da je potrebni vložek energije za pridelavo biodiesla enak njegovi razpoložljivi energiji. Zato bi se poraba energije povečala ob sočasnem povečanju obdelovalnih površin, vsaj za 700 km^2, v realnosti pa najbrž še bistveno več. Kot peta alternativa ostanejo še vodik in sintetična goriva, npr. sintetični diesel, ki ima EROI 0,23 [9], kar pomeni, da je neto porabnik energije in je potrebni zunanji vložek energije za sintezo kar ~350 %? Kot je razvidno

je vseh pet "zelenih" alternativ v skladu z "Green Deal-om" realno (ne)izvedljivih iz česar sledi zelo neprijeten zaključek: če ne bomo uporabljali fosilnih goriv tudi hrane ne bo.

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Nemški energetski prehod ter njegove politične in gospodarske posledice

The German energy transition and its political and economic consequences

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POVZETEK

V prispevku na kratko opisujemo razvoj in položaj nemške Energiewende. Politiki so Energiewende načrtovali predvsem ideološko, ne da bi upoštevali možne posledice za življenjski standard ljudi, obstoj in razvoj gospodarstva ter socialno stabilnost države. Podane so posledice omenjenega energetskega prehoda, saj so te pomembne tudi za Evropo in države v njej, ki imajo tesne gospodarske odnose z Nemčijo in lahko pričakujejo podobne probleme.

ABSTRACT

The development and status of the German energy transition are briefly described. Politicians planned the energy transition primarily ideologically, without considering the possible consequences for people's living standards, the existence and development of the economy, and the social stability of the country. The consequences resulting from the energy transition are described. These are particularly important for Europe and the countries that have close economic relations with Germany and can expect similar problems.

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KLJUČNE BESEDE

Energetska politika, energetski prehod, Energiewende, Nemčija

KEYWORDS

Energy policy, Energy transition, Energiewende, Germany

1 ENERGIEWENDE

Zgodovina energetskega prehoda (Energiewende) v Nemčiji se je začela že veliko pred nastajajočim problemom podnebnih sprememb, domnevno zaradi izpustov CO2, ki jih povzroča človek. Razlog je bilo gibanje proti jedrski energiji kot posledica černobilske nesreče.

V poznih osemdesetih letih prejšnjega stoletja so izpusti CO2 postali glavna tarča okoljevarstvenikov, ki so jih videli kot glavni vzrok podnebnih sprememb. Leta 1988 je bil pod okriljem ZN ustanovljen IPCC Committee, ki od takrat igra vodilno vlogo v »boju« proti podnebnim spremembam. IPCC zbira raziskave in publikacije o podnebnih spremembah ter nato objavlja lastne zaključke.

Podnebni problem je postal eno najpomembnejših vprašanj svetovne politike. Od leta 1992 je bilo organizirano veliko število letnih podnebnih konferenc. Najpomembnejša je bil leta 2015 v Parizu, kjer so bile sprejete splošne (vendar nezavezujoče) zaveze za zmanjšanje CO2. Nemčija je bila ves čas gonilna sila te politike, ne glede na to, da predstavlja le okoli 2 % skupnih emisij CO2. To politiko je nato v celoti sprejela tudi EU [1]. Drugi v svetu gledajo na ta problem bolj realno. Bolj kot podnebne spremembe jim je pomembna blaginja lastne države.

Nemčija se je zavezala k zmanjšanju izpustov CO2 v primerjavi z letom 1990 za 40 % do 2020, za 65 % do 2030 (tukaj je Nemčija zaostrila svoj cilj EU na 55 %), za 80 % do 2040 in do 2045 za dosego podnebne nevtralnosti (EU do leta 2050). Poleg nujne strukturne spremembe v proizvodnji električne energije in prestrukturiranja omrežja, to pomeni tudi dolgoročno odločilne spremembe v industriji, pri toplotni izolaciji hiš, kmetijstvu in prometu.

Glavna usmeritev energetskega prehoda je bila gradnja vetrnih turbin in fotovoltaike. Želeli so zapreti vse elektrarne na premog in pokriti vse potrebe z električno energijo z obnovljivimi viri. Ker pa to tehnično ni izvedljivo, bo treba zgraditi veliko (40 do 50) dodatnih plinskih elektrarn. Nemčija se je kot edina država EU tudi odločila zapreti vse delujoče jedrske elektrarne, ki so desetletja zagotavljale poceni in varno električno energijo.

Od začetka energetskega prehoda do leta 2022 je bilo za subvencije porabljenih ogromno denarja. Toda največja, ideološko vodena napaka je bila zaprtje vseh jedrskih elektrarn. Študije [2] kažejo, da je bilo s tem izgubljenih 600 milijard EUR brez večjega zmanjšanja CO2. Seveda pa ta znesek ne upošteva morebitnih drugih dodatnih stroškov, povezanih z energetskim prehodom. Seveda pa ti ogromni zneski manjkajo za druge potrebne investicije in posebno na področjih razvoja, ki bi zagotovil konkurenčnost gospodarstva.

Izraz Energiewende se je razširil iz oskrbe z električno energijo na vsa področja vsakdanjega življenja, kjer prihaja do emisij CO2: industrija, promet, gradbeništvo in kmetijstvo.

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Dodatni stroški Energiewende do leta 2035 naj bi znašali 1,2 bilijona EUR. Primerljiv znesek se bo nato še potreben do leta 2045, če politiki medtem ne bodo prisiljeni spremeniti časovnice in vsebine energetskega prehoda.

Energiewende se nahaja že nekaj let v slepi ulici, čeprav tega politiki (še) nočejo priznati. Večina projektov za zmanjšanje CO2 je modificiranih, ustavljenih ali preloženih. Jasno je tudi, da cilji za leto 2030 ne bodo doseženi. In kaj se bo zgodilo pozneje, je politično vprašljivo.

2 POSLEDICE

Čeprav je še vedno vprašljivo, v kolikšni meri prispevek človekovih emisij CO2 prispeva k podnebnim spremembam, politiki zmanjševanje CO2 razglašajo za brezalternativno in kot vprašanje preživetja. In to brez predhodnega upoštevanja tehničnih, ekonomskih in sociooloških posledic. Energetski prehod se je začel z obljubo, da ne bo stal skoraj nič (morda ceno ene kepice sladoleda na mesec), ponudil pa bo veliko novih delovnih mest. Resničnost je popolnoma drugačna.

Cilj politike je bil neusmiljeno uveljavljanje ukrepov brez upoštevanja kakršnega koli nasprotnega mnenja in problemov, ki so se pojavili. Primeri tega so:

- Stroški energije, elektrike in plina so se v nasprotju z napovedmi politikov prekomerno podražili in močno obremenili standard ljudi. Trenutno ponovno prihaja sicer do znižanj cen plina, a cena električne energije (kar je bil cilj energetskega prehoda) dolgoročno ostaja visoka.
- Zakon o ogrevanju, ki naj bi dosegel prisilno zamenjavo ogrevalnih sistemov, ki bi povzročil enormne stroške za lastnike hiš in najemnike, je zaradi masovnih protestov propadel,
- Uporaba toplotnih črpalk zastaja, potem ko se je izkazalo, da povzročajo visoke stroške in ne prinašajo obljubljenih koristi. Za večstanovanjske hiše rešitve sploh ne obstajajo ali pa le z zelo visokimi dodatnimi stroški. Zaradi preobremenitev se pojavljajo težave v elektrodistribucijskih omrežjih.
- Električni avtomobili niso splošno sprejeti. Stroški so visoki (v primerjavi z avtomobili z motorji z notranjim izgorevanjem), težave z njihovim dosegom in dostopom do polnilnic ostajajo. Sledil je padec (40 %) prodaje teh avtomobilov in posledično ekonomskie težave v avtomobilski industriji (npr. v VW nameravajo zapreti 30.000 delovnih mest).
- CO2 emisije v prometnem sektorju še vedno naraščajo. Avtomobili so bistveni del življenjskega standarda in ljudje se jim nočejo odreči. V večini primerov tudi ni enakovredne alternative s javnim prevozom za ljudi izven mest.
- Stroškovni problemi za toplotno izolacijo hiš so visoki in bi bistveno povečali najemnine, predvsem za revnejše sloje.
- Če povzamemo; ni dvoma, da je oz. bo zaradi energetskega prehoda življenjski standard ljudi ogrožen. To pa ima izrazite (negativne?) posledice tudi na političnem področju (vzpon skrajnežev).

Posledice Energiewende za industrijo so alarmantne. Glavni razlog so visoki stroški energije (2 do 3 krat višji kot v USA ali na Kitajskem), ki nastanejo zaradi prisilnega opuščanja premoga, plina in nafte. K temu je gotovo prispevala tudi ruska vojna proti Ukrajini z izgubo poceni ruskega plina in trendi v svetovnem gospodarstvu. Toda politiki bi se morali pravočasno odzvati na te težave. Energetsko intenzivna industrija (jeklarska, kemična) v Nemčiji ni več konkurenčna. Tudi pomanjkljivosti lokacij (okoljski ukrepi, preregulacija, birokracija) prispevajo k temu, da se vse več podjetij izseljuje v države, ki ponujajo cenejšo energijo in boljše lokacijske pogoje. Energetski prehod na vodik kot vir energije, ki naj bi omogočil zeleni prehod industrije, je zelo zelo drag in negospodaren. Trajalo bo še mnogo let, preden bo sploh uporabljen v večjem obsegu.

Denar, porabljen, za energetski prehod torej ni bil voljo za druge naloge, predvsem za potreben razvoj novih tehnologij. Glavni tekmeci v svetu (ZDA, Kitajska, Indija), pa tudi nekatere druge države, so Nemčijo prehiteli na večini za bodočnost ključnih področij. To velja seveda tudi za EU. V avstralski študiji [3] je med 44 razvojnimi področji, ki so ključna za prihodnost, Nemčija navedena le na enem področju na 3 mestu, na nekaj področjih na 4 ali 5 mestu. Pri veliki večini pa je ni med prvimi petimi. Tudi to so alarmantni znaki negotove gospodarske prihodnosti Nemčije in EU.

- Nemčija je z vrha svetovne lestvice glede na BDP/prebivalca zdrsnila na 21. mesto. Prehitele so jo tudi manj razvite, a z viri bogate države.
- Nemčija je padla iz prve skupine na 24. mesto na svetovni lestvici po konkurenčnosti (kako privlačna je država za industrijo).
- Nemško gospodarstvo že dve leti stagnira in je blizu recesije in je pri tem na repu držav v EU. Izboljšanja v naslednjih letih ni za pričakovati.
- Glede na študijo Zveze nemških industrij (BDI) je 20 % nemške industrije v kritičnem stanju.
- Tuje investicije v Nemčiji so padle na minimum. Nemške naložbe grejo v druge države, ki ponujajo boljše pogoje.
- Številna, nekdanja vodilna industrijska podjetja odpuščajo delavce. Pričakujejo dvig brezposelnosti
- Izvoz (nekoč glavni steber nemške blaginje) je letos upadel za 15 %, tudi kot posledice nekonkurenčnosti.

Ekonomske težave povzročajo tudi težave v družbi (socialne pomoči, pokojnine, migracije). Nezadovoljstvo ljudi, ne le zaradi energetske tranzicije, ampak tudi na drugih področjih vsakdanjega življenja, vodi v nestabilne politične razmere. Razlike postajajo tako pereče, da ogrožajo demokracijo.

3 SKLEP

Energiewende je v krizi in vidne so posledice za življenjski standard ljudi, gospodarsko moč države in politične razmere. To velja tudi za EU in še posebej za države, ki so gospodarsko tesno povezane z Nemčijo. Konsolidacija razmer bi bila mogoča le, če bi podnebno strategijo vsaj bistveno upočasnili in politične prioritete preusmerili v okrevanje gospodarstva in ohranjanje življenjskega standarda.

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MITI IN RESNICE O ELEKTROMAGNETNEM SEVANJU /EMS/

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Povzetek

V Sloveniji »lobi« mobilnih operaterjev in elektro podjetji v zadnjih 30-ih letih ni želel nobenih pozitivnih sprememb na področju sevalne varnosti. Vsi uradni dokumenti in praksa na terenu se v zvezi z omenjenim varstvom sklicujejo na 26 let stare smernice Mednarodne komisije za zaščito pred neionizirnim sevanjem - ICNIRP in 28 let staro Uredbo o elektromagnetnem sevanju v naravnem in življenjskem okolju. Priporočila izpred več kot petindvajset let v teh smernicah določajo mejne vrednosti glede na dokazane zaznavne učinke, ki temeljijo na termičnem segrevanju živih organizmov oziroma njihovih tkiv pod vplivi umetnih izmeničnih elektromagnetnih polj. V času vse do danes , so bile v svetu objavljene številne študije, ki kažejo škodljive učinke na biološke oziroma celične procese znotraj živih organizmov. Rezultati teh študij dokazujejo, da se škodljivi biološki učinki umetnih izmeničnih magnetnih polj pojavljajo pri bistveno nižjih vrednostih v primerjavi z mejnimi vrednostmi, ki jih določajo smernice ICNIRP in omenjena uredba. Prav zaradi vseh novejših dognanj, ter rezultatov mnogih epidemioloških študij o vplivih elektromagnetnih sevanj na zdravje ljudi, predvsem otrok, je potrebno varovanju pred škodljivimi vplivi, ob rekonstrukciji oziroma gradnji novih virov sevanja kot so BAT, GSM, Wi-Fi v šolah in visokonapetostni daljnovodi visokih prenosnih moči, posvetiti bistveno večjo pozornost.

Ključne besede

neionizirna sevanja, uredba o EMS, previdnostno načelo, 1.cona varovanja,5G,WI-FI,BAT, DV, GSM

1 Uvod

V zadnjem času je zaradi uvedbe omrežja 5G prišlo do polemike o škodljivosti t.i. neionizirajočih sevanj, med katere spada tudi radiofrekvenčno sevanje mobilnih telefonov in druge brezžične tehnologije. Kot protiutež lobiju mobilne telefonije , ki javnost mirijo z razlago, da tveganja ni ; oziroma je kvečjemu zanemarljivo. V ZEG bi radi podali svoja mnenje , ko nas nekontrolirano širjenje novih tehnologij skrbi (tudi) z vidika škodljivosti EM sevanja.

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Zagovorniki varnosti brezžične tehnologije se sklicujejo na zakonsko dovoljene meje (strokovno zastarelo in proti ustavno Uredbo o elektromagnetnem sevanju iz leta 1996) , ki naj bi zagotavljale varnost pred negativnimi učinki sevanj, ne omenijo pa, da so te meje neustrezne (10 µT, napram 0.4 µT - mikro Tesla, ki ga priporoča WHO, NIJZ)) in kot take predmet resnih strokovnih pomislekov. Do danes se je namreč nabralo že ogromno dokazov, ki kažejo na škodljive učinke neionizirajočih sevanj daleč pod dovoljenimi mejami, zato bi morali po mnenju mnogih neodvisnih strokovnjakov nemudoma ukrepati in regulativo temu ustrezno prilagoditi, obenem pa bi morala Mednarodna agencija za raziskave raka (IARC) radiofrekvenčno sevanje označiti kot “potrjeno rakotvorno” (skupina 1).

Rakotvornost radiofrekvenčnih sevanj so v zadnjih letih potrdile še dodatne epidemiološke raziskave in več raziskav na živalih (tudi govedi, ovc ..) , vključno z raziskavo National Toxicology Program (NTP), eno največjih in najbolje zasnovanih tovrstnih raziskav. A rak je le “končna postaja”, prej pa lahko pride tudi do številnih drugih težav. Nekatere od bolje dokumentiranih so npr. poškodbe semenčic oziroma neplodnost pri moških in živalih , oksidativni stres ter poškodbe DNK, raziskave pa poročajo tudi glavobolih, vedenjskih motnjah, anksioznosti in težavah s spanjem. Vse kaže, da so najbolj ranljivi še nerojeni, dojenčki in otroci, škodljivi učinki pa so lahko kumulativni skozi več generacij.

2 Raziskave in »neodvisne« raziskave EMS

Žal so organizacije, ki bi skrbele za naše zdravje, pod močnim vplivom industrije; industrija pa je financirala tudi večji del raziskav, ki niso pokazale vpliva na zdravje. Mednarodna komisija za zaščito pred neionizirnimi sevanji (ICNIRP), ki določa mednarodna priporočila, na katerih temeljijo državne regulative, je bila pred časom s strani raziskovalnih novinarjev Investigate Europe označena kot “kartel” 14 znanstvenikov, katerih delo je izjemno pristransko in ne upošteva na tisoče recenziranih raziskav, ki so pokazale škodljive učinke. Ugotovitve komisije ICNIRP so v diametralnem nasprotju z izsledki več sto znanstvenikov, ki preučujejo vplive neionizirajočih sevanj na zdravje in so resno zaskrbljeni nad razvojem dogodkov, na kar tudi neprestano opozarjajo. Leta 2015 so npr. poslali poziv Združenim narodom, v katere zahtevajo nujno ponovno ovrednotenje mednarodnih priporočil in upoštevanje previdnostnega načela (pri nas 8. člen Zakona o varstvu okolja), ki pravi, da je uvajanje nove tehnologije dopustno le, če ni pričakovati nepredvidljivih škodljivih učinkov na okolje ali zdravje ljudi.

Tudi Resolucija 1815 Sveta Evrope iz leta 2011 pravi, da elektromagnetna sevanja predstavljajo tveganje za ljudi, živali in rastline, in da je potrebno sevalne obremenitve po načelu ALARA (ang. as low as reasonably achievable) zmanjšati na najnižjo možno raven. V resoluciji je zapisano, da imajo sedanja priporočila komisije ICNIRP, na katera se zagovorniki varnosti brezžične tehnologije sklicujejo, resne pomanjkljivosti, saj ne upoštevajo netermičnih učinkov, in bi jih bilo potrebno ponovno ovrednotiti. Resolucija priporoča zmanjšanje izpostavljenosti v notranjih prostorih na 0,2 V/m (gre za električno poljsko jakost), kar je pri nas pogosto preseženo v urbanih okoljih, številnih vrtcih, šolah, bolnišnicah, domovih za upokojence itd.

V resoluciji obžalujejo, da se kljub njihovim svarilom ukrepi za zmanjševanje izpostavljenosti odvijajo prepočasi ali pa se sploh ne. Opozarjajo, da čakanje na visoko stopnjo znanstvene zanesljivosti lahko pripelje do visokih zdravstvenih in gospodarskih stroškov, podobno kot se je zgodilo v primeru azbesta, osvinčenega bencina in tobaka. Po letu 2011 so se sevalne obremenitve zaradi novih baznih postaj, omrežja 4G, uporabe pametnih telefonov in drugih brezžičnih naprav močno povečale, z uvedbo omrežja 5G pa se nam obeta še dodatno povečanje, tudi z novimi, še neraziskanimi frekvencami.

Opažamo, da so se nekateri slovenski predstavniki elektro stroke v zadnjem času oddaljili od EU koncepta previdnostnega načela in na brezžično tehnologijo ter prihajajoče omrežje 5G gledajo skozi rožnata očala industrije, drugih obolenj. V Sloveniji namreč ta čas , žal nimamo neodvisne institucije za zaščito javnega zdravja (zadnja leta tudi ne v NiJZ) , ki bi opozarjala na potencialne nevarnosti elektromagnetnih sevanj.

Zakon iz leta 1996 , ki pri nas določa zgornjo dopustno mejo EMS, ni predvidel ne bliskovite ekspanzije brezžične tehnologije, niti njenega prodiranja v višja frekvenčna območja in porasta negativnih zdravstvenih posledic EMS. Do zdaj nam je na voljo na stotine neodvisnih znanstvenih raziskav, ki ugotavljajo korelacijo med bližino BAT in povečanim številom rakavih, hormonalnih in nevroloških obolenj, zato je pri uvajanju nove generacije brezžične tehnologije (5G) nujno treba slediti logiki načela previdnosti. Eden izmed dodatnih razlogov, zakaj je načelo previdnosti tako pomembno, so tudi znanstvena dognanja dr. Martina L. Palla, vodilnega ameriškega strokovnjaka za področje stranskih učinkov EMS, ki opozarja, da: »Varnostne smernice ICNIRP, FCC, ZDA in EU za področje EMS, temeljijo na prepričanju, da je za napovedovanje bioloških učinkov in s tem varnosti mogoče uporabiti povprečne jakosti EMS in povprečno SAR (specifična stopnja absorpcije). Izsledki analize osmih različnih vrst kvantitativnih ali kvalitativnih podatkov za preverjanje, če to drži ali ne, so pokazali, da so varnostne smernice v vsakem od teh primerov pomanjkljive, v večini primerov pa popolnoma zgrešene. Učinki se pojavijo že pri približno 100.000 krat nižjih ravneh, zato je predvidena struktura varnostnih smernic povsem neustrezna.«

A tudi če so INIS-ove meritve sprejmemo kot merodajne, ni nobenega razloga, zakaj bi se morala BAT nahajati tako blizu naseljene hiše ,šole ,vrtca ,igrišča in vikenda…

Pri ZEG podpiramo izključno uvajanje naprednih tehnologij, ne pa spornih novotarij, ki ogrožajo telesno in duševno zdravje njenih uporabnikov. Tehnologija omrežja 5G ne prinaša nobenih omembe vrednih izboljšav komuniciranja na daljavo, povzroča pa nepopravljivo duševno in telesno škodo, sploh ko gre za bližnje občane.

3. Moderna in zastarela zakonodaja na področju EMS

V ZEG si prizadevamo, da bi Vlada RS sprejela novelo Uredbe o elektromagnetnem sevanju (ta je že šesto leto leži v predalih MOP), s katero bi določila strožje mejne vrednosti od trenutno veljavnih. Poleg tega si prizadevamo, da bi Državni Zbor RS čimprej sprejel tako zakonodajo, ki bi določila širše preventivne varovalne pasove visokonapetostnih daljnovodov (DV) in odmika baznih antenskih postaj (BAT, 5G). Tako v mnogih članicah EU se mora mobilna telefonija, Wi-Fi umakniti iz učilnic. Trenutno veljavna uredba, ki je bila sprejeta leta 1996, določa mejno vrednost elektromagnetnega sevanja daljnovodov pri 10 µT. Številne tuje znanstvene raziskave kažejo, da je zdravju škodljiva že 50 krat nižja vrednost elektromagnetnega sevanja (WHO in SCENIHR, telo Evropske komisije). V tem času je znanost napredovala in vedno bolj se pritrjuje dejstvu, da je bivanje ali dolgotrajno zadrževanje blizu daljnovodov, BQAT, WI-FI, 5G zelo škodljivo.

V ZEG predlagamo, da se mejna vrednost elektromagnetnega sevanja zniža na vrednost primerljivo z zakonodajami razvitih držav. Predlagamo, da nova uredba mejno vrednost elektromagnetnega sevanja iz maksimalno dovoljenih 10 µT zniža na maksimalno 0,4 µT. Medtem, ko v primeru hišnih aparatov, kot virov EMS lahko sami odločamo v kakšni meri se bomo izpostavljali škodljivim učinkom, se v primeru energetskih objektov kot so 5G, daljnovodi in bazno-antenske postaje temu težko izognemo. Opozarjamo, da o škodljivih učinkih EMS govorimo predvsem v primeru dolgotrajne izpostavljenosti in da so negativni vplivi na zdravje posledica permanetnega delovanja BAT tudi v povprečnem oziroma komulativnem smislu. Zaradi fizikalnega pojava širjenja EMS in moči virov EMS je pomembno, da v smislu upoštevanja načela previdnosti pri načrtovanju sledimo odmiku od virov sevanja tako, da v nobenem primeru ne predstavljajo tveganja za zdravje ljudi, predvsem otrok, kot najobčutljivejše skupine prebivalcev. Da elektromagnetno sevanje vpliva na zdravje ljudi ni več sporno. Prav je torej, da bi se pri umeščanju novih virov takšnega sevanja v prostor ravnalo skladno z načeli previdnosti in da bi se v čim večji meri izogibalo možnosti nastankom škodljivih posledic na zdravju ljudi. Tem ugotovitvam pa mora slediti tudi sodna praksa in sicer tako pri obstoječih virih, kakor tudi pri umeščanju novih virov v prostor, saj bo le tako lahko sčasoma prišlo do tega, da bo državi in investitorjem načelo previdnosti postalo edino in osnovno vodilo pri sprejemanju odločitev v zvezi s tem.

Zakaj se pri umeščanju virov EMS ne upošteva načelo previdnosti ter poveča oddaljenost od virov oziroma išče optimalne rešitve umeščanja v prostor zaradi dokazanih bioloških učinkov na žive organizme, ampak se sklicujemo na

zastarelo zakonodajo, ki bazira na mejnih vrednostih na osnovi segrevanja tkiv?

V postopkih načrtovanja in umeščanja visokoenergetskih daljnovodov BAT, RTV oddajnikov, Wi-FI-ja v šolah, 5G … kot virov EMS je potrebno v interesu varovanja zdravja ljudi upoštevati načelo previdnosti.

V primeru načrtovanja in umeščanja npr. BAT in visokoenergetskih daljnovodov, katerih nazivna napetost je večja kot 100 kV, načelo previdnosti zahteva, da je potrebno poiskati prostorske in tehnične rešitve (kabliranje) , ki se ognejo oziroma v najmanjši možni meri obremenjujejo občutljiva območja stanovanjskih stavb . Izbrati je treba rešitev, ki predstavlja čim večjo možno oddaljenost od naštetih občutljivih območij in ki upoštevajoč načelo previdnosti zagotavlja varovanje zdravja, varnost in kvaliteto bivanja čim večjemu številu ljudi. Kadar se v prejšnjem odstavku navedenim občutljivim območjem ni mogoče v celiti izogniti, je med več možnostmi potrebno izbrati tisto, ki v najmanjši možni meri obremenjuje občutljiva območja oziroma se izogne čim večjemu številu ljudi.

4. Zdravstvene posledice neionizirnih sevanj

Znanstveniki že več kot 20 let pridno zbirajo podatke, delajo statistiko in povezujejo število bolnikov s kumulativnim številom ur dela z mobilnimi napravami ali računalniki. Očiten je porast obolenj, a kljub na tisoče znanstvenih člankov, ki dokazujejo škodljivost mikrovalovnega sevanja za zdravje ljudi, nekateri "znanstveniki" in tudi vlade mnogih držav še vedno "tiščijo glavo v pesek" in nočejo priznati očitna dejstva. Še naprej podajajo polresnice, favorizirajo sponzorje in »močnejše« stranke ter nočejo pogledati resnici v oči. dr. Henry Lai z Univerze v Washingtonu je nedavno naredil zbirko vseh objavljenih člankov o škodljivosti EM sevanja in ugotovil, da so rezultati raziskav zelo odvisni od tega, kdo je raziskavo plačal: če gre za neodvisno, pošteno raziskavo, potem več kot 70 % raziskav potrjuje škodljivost EM sevanja, če pa je raziskava sponzorirana s strani industrije, je situacija obratna, in sicer skoraj 70 % raziskav trdi, da EM sevanje ni škodljivo (slika). Več o tej študiji in njegovih raziskovalnih rezultatih na splošno na povezavah [1, 2].

Se sprašujete, kako je to mogoče, kako lahko znanstveniki "ponarejajo" rezultate? Tukaj je primer: med raziskovanjem literature na to temo smo naleteli na dela , ki so delali na primer poskuse z mišmi. Skupino miši so vsak dan za uro ali dve izpostavljali EM sevanju določene frekvence (običajno v območju med 0,5 in 2,5 GHz) dva ali tri tedne. Nato so miši secirali in iskali spremembe v možganskem tkivu, preverjali kakovost ali mobilnost semenčic itd. ter rezultate primerjali z enakimi analizami kontrolne skupine miši, ki niso bile obsevane. In seveda, rezultati so bili pričakovani: med rezultati obsevane in kontrolne skupine miši ni bilo razlike!! Kot smo že povedali, le dolgotrajna izpostavljenost EM sevanju potencialno povzroča zdravstvene težave... le nekajurna izpostavljenost seveda ne bo pokazala statistično pomembne škode. Komentar je nepotreben! Na žalost je takšnih »znanstvenih«, torej naročenih prispevkov, veliko in proizvajajo »hrup«, s katerim tisti, ki zastopajo interese industrije, zasenčijo resne in neodvisne znanstvene prispevke.

Najpogostejši, tako rekoč začetni simptomi EMS so: anksioznost in nespečnost, ki ju pogosto spremlja glavobol zvonjenje v ušesih - tinitus utrujenost, stres izguba spomina in osredotočenega mišljenja (možganska megla) veliko ljudi razvije pretirano občutljivost na EM sevanja. Glede resnejših obolenj bom navedel le tiste bolezni, ki so najpogosteje omenjene v literaturi: Porast raka glave pri ljudeh, ki že leta intenzivno uporabljajo mobilne naprave Porast raka na modih pri moških, ki imajo mobilne naprave v sebi. žepi in Povečanje raka dojke pri ženskah, ki imajo mobilne naprave v nedrčku Poškodba enojne in dvojne vijačnice DNK, nenormalno prepisovanje genov Zmanjšana sposobnost popravljanja DNK z matičnimi celicami Zmanjšanje števila radikalov v telesu Sperma morfološke spremembe in zmanjšana njihova gibljivost - kar ima za posledico drastično zmanjšano plodnost mlajših generacij itd. Vse te bolezni imajo dolgo latenco, kar pomeni, da se statistično značilen porast teh bolezni pojavi šele po 10-15 letih intenzivne uporabe mobilnih naprave. Zaradi tega dejstva mnogi uporabniki zanemarjajo izsledke znanstvenih raziskav, računajoč, da se to ne bo zgodilo »samo meni«, kot smo že rekli, imamo podoben pristop pri vožnji z avtomobilom, letalom ali pri katerikoli potencialno nevarni dejavnosti. Mnogi znanstveniki, ki že desetletja raziskujejo to problematiko, se zavedajo problema, zato imajo svoje spletne strani in YouTube kanale z namenom izobraževanja in ozaveščanja ljudi o potencialni nevarnosti EM sevanja. Za tiste, ki želijo vedeti več in znajo angleško, dajem nekaj dobrih povezav: Portal EMF Univerze v Aachnu, kjer najdete več kot 30 tisoč znanstvenih člankov in več kot 6 tisoč povzetkov teh člankov, ki govorijo o vpliv EM sevanja na ljudi in živali. Povezava: https://www.emf-portal.org/en BIOINITIATIVE 2012 – Neodvisna skupina znanstvenikov je na več kot 1500 straneh povzela rezultate 1800 neodvisnih študij, ki potrjujejo pomemben vpliv EM sevanja na številne zdravstvene vidike. Novejše rezultate lahko najdete na povezavi [3].

Trenutno veljavni predpisi v Republiki Sloveniji niso sledili izsledkom medicinske stroke, ki je v zvezi z vplivom EMS na zdravje ljudi, predvsem otrok, v zadnjih desetletjih pripisala pomemben vpliv. Prepoved mobitelov v šolah, predvsem zaradi EMS. Kot kažejo ugotovitve medicinske stroke, je vpliv EMS na zdravje ljudi zelo velik, saj lahko že izpostavljenost vrednostim, ki so kar 50x nižje od tistih, ki so trenutno predpisane v RS, bistveno poveča možnosti za nastanek malignih obolenj.

Ob dejstvu, da EMS od razdalj, (ki so pokazane v elaboratih kot vplivno območje) naprej pada počasi, so ob najslabših razmerah potrebni večji odmiki, če želimo zadostiti varovanju otrok kot najobčutljivejše skupine ljudi na vplive EMS. Nacionalni inštitut za javno zdravje v svojem mnenju z dne 22. 6. 2016 ugotavlja, da je pri izpostavljanju prebivalstva, predvsem otrok EMS zelo nizkih frekvenc, treba nujno upoštevati načelo previdnosti do dokončnega odgovora o vplivu tega dejavnika na zdravje – še posebej so izpostavili problematiko umeščanja BAT in daljnovodov v bližino naselij.

Zaradi fizikalnega pojava padanja jakosti EMS z razdaljo od vira je pomembno, da v smislu izpolnjevanja načela previdnosti pri umeščanju virov EMS v čim večji možni meri zmanjšamo zdravstveno tveganje tako, da zagotavljamo čim večji odmik

virov, čim večjemu številu ljudi, predvsem otrok. Zaradi različne občutljivosti ljudi na vplive EMS je to še posebej pomembno na območjih povišane koncentracije tam, kjer se dlje časa zadržujejo ljudje. Zdravstveno tveganje skratka pomembno zmanjšujemo, če se prednostno umikamo območjem, kjer se zadržuje večje število ljudi. Konkretizacija načela previdnosti v bistvu zagotavlja, da se v primeru umeščanja nevarnih in zdravju škodljivih objektov v prostor, kot so BAT, poiščejo in upoštevajo variante, ki imajo najmanjši vpliv na ljudi.

Znanstvene raziskave dokazujejo škodljivost elektromagnetnega sevanja električnih daljnovodov in BAT na zdravje ljudi. Te škodljive vplive priznavata tudi Svetovne Zdravstvena organizacija in Evropska komisija. Le-ta je ustanovila SCENHIR (the Scientific Committee on Emerging and Newly Identified Health Risks), posvetovalno telo Evropske Komisije, ki proučuje na novo odkrita oz. na novo identificirana tveganja za zdravje in okolje. V najnovejšem poročilu SCENIHR ugotavlja, da znanstvene raziskave potrjujejo škodljive vplive elektromagnetnih sevanj na zdravje ljudi.

Trenutno v Sloveniji velja, da v bivalnih objektih sevanje ne sme preseči 10 µT. Raziskave o otroški levkemiji pa ugotavljajo, da je povečana verjetnost levkemije že pri 50 krat nižji vrednosti sevanja. Prav tako to velja za otroško astmo in otroško debelost. Mimogrede, po naši zastareli zakonodaji oz. uredbi lahko stanovanjski objekti, šole, vrtci stojijo pri 400 kV DV že na 40 metrih oz. na 16 metrih pri BAT?! Po podatkih ZEG je v Sloveniji več kot sto BAT v neposredni bližini šol in vrtcev. Pod DV /110, 220, 400 kV/ pa živi na razdalji 100 m levo/desno približno 20.000 ljudi.

Napovedi obratovanja za desetletja vnaprej so nezanesljive. Z naraščanjem potreb po 5G in prenosa električne energije preko mednarodnih tranzitnih daljnovodov, ki bi bili postavljeni na občutljivih poseljenih območjih, ki imajo visoke prenosne kapacitete, jim zato zagotovo nihče nikoli v prihodnosti ne bo omejeval prenosnih moči zaradi negativnih vplivov EMS. Izračuni negativnih vplivov na osnovi povprečnih vrednosti napovedanih obremenitev imajo preveč neznank, zato so možne številne manipulacije in napačno prikazovanje rezultatov. Morebitne vplive na okolje bi morali v fazi načrtovanja vedno prikazovati na osnovi najneugodnejših pogojev obratovanja oziroma maksimalni možni vrednosti gostote magnetnega pretoka. Področje EMS, kot okoljski problem je zapisan v dokumentih : NPVO, NEPN

Viri, Literatura

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Urška Florjančič, Robert Blatnik, Špela Stres

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FOREWORD / PREDGOVOR

Dear guests, experts, panelists, and participants,
Welcome to the 17th International Technology Transfer Conference (17ITTC). Since its inception, the Jožef Stefan Institute has proudly served as the initiator and main organizer of this esteemed event, advancing innovation and knowledge transfer in Slovenia. This year, we are honored to host the conference in collaboration with 13 public research organizations, representing two national consortia of knowledge transfer offices (KTOs). The event is co-financed and supported by the Ministry of Higher Education, Science, and Innovation, as part of the "Mesec znanosti" campaign.

The ITTC has established itself as a crucial platform for exchanging ideas and fostering collaboration between domestic and international stakeholders, significantly contributing to the development of Slovenia's national innovation ecosystem. The conference has been instrumental in helping Slovenian public research organizations address challenges such as securing funding for spin-outs, updating national legislation on research and innovation, and building robust consortia for KTOs.

Collaboration among KTOs, both within and across the two consortia continues through joint activities aimed at promoting KTO initiatives, raising awareness, and encouraging networking and the exchange of best practices. These efforts focus on enhancing the skills and capabilities of all stakeholders—from KTO employees and researchers to students—while improving the implementation of intellectual property (IP) marketing and protection. Additionally, coordinated efforts will establish common metrics and indicators, enabling effective monitoring and evaluation of knowledge valorization processes at public research organizations, ensuring long-term success.

This year's conference theme, "Self-Evaluation of Research Organizations to Support the Development and Strengthening of Knowledge Transfer," aligns with our goal of bolstering the role of KTOs and improving the commercialization of intellectual property, as well as to promote the wider social relevance of knowledge transfer and the outputs and impacts of KTO work on the well-being of society as a whole. The theme is being explored in a keynote address focuses on the role of institutional self-evaluation within the Framework of proposed amendments to the General Acts of the Slovenian Research and Innovation Agency (ARIS), followed by a round table discussion. The panel will feature representatives from the Ministry of Higher Education, Science, and Innovation, ARIS, the Slovenian Rectors' Conference, KOsRIS, Leiden University, the Institute for Economic Research, and the University of Colorado Boulder.

We present several prestigious awards during the conference, including the Conference Prize for the Best Innovation in 2024, which aims to promote the commercialization of innovative technologies developed at public research organizations. The WIPO National Award for Enterprises is awarded to a Slovenian enterprise that has successfully developed a strategy for commercializing university-based innovations. In addition, the WIPO National Award for Inventors honors an individual researcher or a team of researchers from a Slovenian public research institute whose patented invention has significantly contributed to Slovenia's economic and technological development.

The conference also features sessions on Opportunities Arising from Publicly Funded Research Projects, where researchers and KTO experts showcase successful scientific projects

funded by the Slovenian Research Agency, highlighting their potential for innovation and commercialization. In the session on Connecting the Educational System with the Academic Sphere, presentations of selected research topics and collaboration proposals emphasize the importance of bridging the gap between academia and education, fostering greater cooperation and engagement.

We are especially excited about the ongoing growth of the conference, which, for the fifth consecutive year, includes peer-reviewed contributions from researchers specializing in knowledge and technology transfer. Since 2009, the entrepreneurial pitch competition for research teams and their inventions, evaluated by international teams of commercialization and investment experts, has remained a key feature, supporting over 100 research teams in developing business models, with more than 30 winners recognized to date.
Together, we look forward to exploring new opportunities, including collaborations with the Vesna DeepTech Fund, which plays a vital role in providing early-stage funding to spin-out companies emerging from public research organizations. Established by the EIF in partnership with Slovenian and Croatian development banks, the fund bridges the gap between research and commercialization, offering financial backing to help transform cutting-edge innovations into successful ventures. This collaboration fosters stronger partnerships between research institutions and industry, further boosting the commercialization of scientific discoveries.
Thank you for being part of this journey, and we look forward to an inspiring exchange of ideas at the 17ITTC.

Programme Committee of the 17ITTC

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Intellectual Property as a Success Factor for Startups: Systematic Literature Review

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ABSTRACT

This paper presents a systematic literature review on the impact of intellectual property on startup success. By reviewing 21 relevant articles published in the last five years, sourced from Google Scholar, it analyses the influence of intellectual property on key business factors such as financing, growth, competitiveness, and innovation. The findings show that intellectual property plays a significant role in startup success, though results vary regarding formal (patents) and informal (market advantage, trade secrets) protection methods. A balanced approach to intellectual property management, tailored to startups' needs and developmental stages, is recommended. The article emphasizes the need for further research on different forms of intellectual property, considering regional contexts and long-term effects. Its value lies in offering both theoretical insights and practical recommendations, particularly for policymakers, investors, and startup owners seeking to promote innovation and growth through effective intellectual property management.

KEYWORDS

Intellectual property, startup, trademark, patent, innovation, growth, business success

1 INTRODUCTION

The purpose of our research is to systematically review the literature on the impact of intellectual property (hereinafter referred to as IP) on the business success of startup companies. Through an analysis of existing research results, we aim to explore how IP contributes to achieving these success criteria. Our objective is to determine whether, and how, IP influences the business success of startups, which is crucial for understanding their growth in a dynamic business environment.

In the modern economy, there is a notable impact that new companies have on innovation [9, 15], and the economy as a whole [4, 10]. In particular, startups drive innovation, create new jobs and introduce competitiveness into the business world [17]. The influence of IP is particularly interesting, as it can be crucial for their success.

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Globally, the number of new companies, known as startups, is rapidly increasing daily [18]. Such companies, especially innovative startups, often lack historical financial data or a track record, making it more difficult to establish a market reputation. Their innovative products or business processes also lack prior experience or comparative standards [2]. This presents challenges that can lead to the failure of companies due to inadequate or non-existent business models, and insufficient business growth [4].

Díaz-Santamaría and Bulchand-Gidumal identify several factors that can influence the success of startups [6]. The results of their research indicate that the success of a startup can be measured in two ways: the startup achieves significant revenue, and the startup receives funding. In the following sections, we also highlight other indicators for measuring the business success of a startup.

Despite numerous studies in recent years on the impact of innovative practices on the business development and success of startup companies, no comprehensive and systematic analysis of scientific literature has yet been conducted that specifically focuses on the influence of IP rights on the business success of startups. This gap in scientific research indicates the need for an in-depth review of existing scientific sources that would enable a holistic understanding of the impact of IP on the business success of startups.

The research question is, how are a startup's IP and business success connected, i.e., does IP affect business success, and how? In this way, we can better understand how IP contributes to the competitiveness and long-term success of startups.

2 METHOD

For this research, we used the systematic literature review method, conducted between January and April 2024. During this period, we reviewed foreign literature, focusing on the impact of IP on the success of startup companies. We examined professional, scientific, and research publications published in the last five years to ensure the most up-to-date data and discussions in this field. We used the international bibliographic database Google Scholar to collect information, which allows for the search of scientific literature and the ranking of documents in a manner used by researchers. To identify relevant sources, we used the following set of keywords: "Intellectual Property," "Startups," "Start-ups," "Patents," and "Trademark." In total, we obtained 30 relevant articles. After excluding 9 duplicates, we retained 21 suitable articles for further analysis. The four data collection strategies were used to ensure a thorough and comprehensive review of the relevant literature, tailored to the

research question. Each strategy contributed to refining the search and eliminating irrelevant sources.

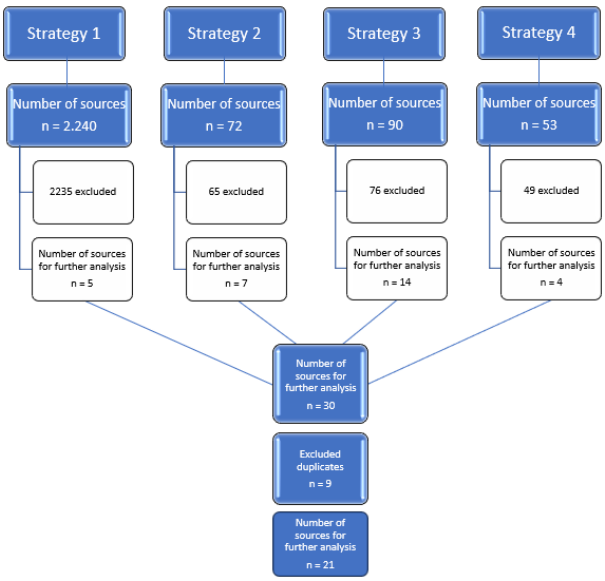

Figure 1: Diagram of the Results of the Systematic Literature Review

3 RESULTS AND DISCUSSION

Most research confirms that IP significantly influences the success of startup companies. Researchers have examined how IP affects various aspects of startups' operations, such as financing, growth, competitiveness, and innovation performance. Below, we summarise the key findings of these studies.

Hellström, Nilsson, Andersson, and Hakanson found that a combination of patents and secrecy positively influences the protection of innovations and market opportunities, thereby increasing companies' competitiveness [8]. Similarly, research by EPO-EUIPO reports that 29% of European startups invest in IP, which increases their chances of securing funding [7]. Krauss, Breitenbach-Koller, and Kuttenkeuler emphasise that IP is crucial for the success of biotech startups, as it enhances their value and attractiveness to investors [11].

The role of IP is particularly pronounced in international markets, where the protection of innovations is essential for the survival and growth of companies. Tula, Ofodile, Okoye, Nifise, and Odeyemi highlight that IP plays a key role in ensuring the business success of startups in a global context, as it prevents the copying and exploitation of innovations by competitors, with registered patents and trademarks serving as signals to investors of startups' innovation and credibility [23].

Brandt, Laibach, Kamrath, and Bröring also point out that IP increases the value of companies and attracts investors, which is crucial for success in corporate investments. Startups with well-protected IP find it easier to attract investors, as they perceive protected technology as a lower-risk investment with greater potential for profitability [3]. Additionally, IP enables startups to collaborate more easily with larger corporations, further strengthening their financial and strategic positions.

Schaberg explores various forms of IP protection and finds that startups with a diverse portfolio of protected rights grow and innovate more easily [19]. Various forms of protection, such as patents, trademarks and copyrights, provide comprehensive protection, increase investor confidence, and facilitate access to capital, which encourages further innovation. Ljungqvist, Hegde, and Raj add that the rapid granting of patents stimulates innovation and facilitates the acquisition of capital, while delays in patent granting negatively impact startups' growth [13].

Despite the numerous positive impacts of IP on startup companies, some research shows mixed results. Power and Reid caution that patents can negatively affect the success of startups, while trademarks and licensing have a positive impact [16]. Teixeira and Ferreira, as well as YunQi and Lin, find that formal methods such as patents often reduce companies' competitiveness, while informal mechanisms such as market advantage and trade secrets can improve competitiveness [22, 24].

Some studies recommend a balanced approach to IP management. Silva Júnior, Siluk, Neuenfeldt Júnior, Rosa, and Michelin believe that a combination of formal and informal protection mechanisms, such as patents, trademarks, and copyrights, is crucial for protecting innovations and enhancing competitive advantage [21]. Audretsch, Colombelli, Grilli, Minola, and Rasmussen emphasise that policies for innovation and IP protection must be tailored to the specific needs and stages of startups' development [1]. Chou adds that patents help in securing funding, but startups often face patent litigation, which reduces their productivity [5]. The solution lies in commercialisation patents, which would reduce the negative impacts of disputes and enable better protection and marketing of innovations.

Research by EPO-EUIPO, Krauss, Breitenbach-Koller, and Kuttenkeuler, Brandt, Laibach, Kamrath, and Bröring, Schaberg and Ljungqvist, Hegde and Raj emphasise the importance of effective IP management for startup success [7, 11, 3, 19, 13]. However, these studies primarily focus on specific sectors or particular cases and only certain forms of IP, which can lead to a limited understanding of the overall picture and strategies that would be beneficial for startups across different fields.

Some studies focus on specific countries or geographical areas, such as EPO-EUIPO on European startups or Li, Gan, and Zhang on Chinese startups [7, 12]. These studies highlight regional particularities in the use of IP, which can affect the innovation and competitiveness of companies in specific geographical environments.

University startups, as discussed by Shahidan, Latiff, and Wahab, represent a special category where innovation intertwines with academic knowledge [20]. These startups often face specific challenges in commercialising technologies, which can hinder the value creation process. Successful university startups must identify market opportunities, ensure entrepreneurial commitment, and continuously develop their technologies to meet market demands.

The inclusion of perspectives such as that proposed by Panagopoulos and Park, where patents serve as negotiation tools, highlights the potential for strategic use of IP in corporate negotiations, not just as a defensive mechanism [14].

Effective IP management generally has a positive impact on the success of startups, but some results indicate the need for a

balanced approach that also includes informal protection methods. Therefore, it is essential that future research expands existing methodological frameworks and includes analyses that capture the complexity and interdependencies of different IP rights, including on an international level.

4 CONCLUSION

Based on the review of existing research, we can confirm that IP is an important factor in supporting innovation and competitiveness of startups. IP protects ideas and innovations and contributes to securing capital and sustainable growth of companies.

Although most research confirms the positive impact of IP, there are also studies that suggest a negative impact of certain forms. Further research is needed to clarify the impact of different types of IP on the success of startups, including an analysis of specific geographical contexts and the long-term effects on company survival.

With the doctoral dissertation currently in preparation, we will explore the impact of IP on the success of innovative startups that have received funding from the Slovenian Enterprise Fund in the P2 tender between 2008 and 2023, analysing their operations and registered IP. We will adopt a mixed-methods approach, combining quantitative and qualitative strategies. Primary and secondary data will be collected from recipients of the P2 grant (2008–2023), using IP databases (Espacenet, Global Brand Database, DesignView), and conducting in-depth interviews with selected companies. Quantitatively, we will analyse the IP portfolios of these startups and assess their business performance through statistical analysis in JASP and Excel, using univariate, bivariate, and multivariate methods. Qualitatively, we will conduct 20 in-depth interviews—10 with startups that have registered IP and 10 with those that have not—to uncover insights that quantitative methods cannot fully address. This mixed-methods approach will allow us to comprehensively explore the impact of IP on startup success, offering both statistical analysis and qualitative insights into the broader role of IP in innovation and business growth.

Future research will thus contribute to a better theoretical understanding and offer practical recommendations for policymakers, investors, and startup owners regarding the optimal use of IP to promote innovation and long-term growth.

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The Reversed European Paradox: do European Patents have a High Market Value but Low Impact?

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ABSTRACT

The U.S. research institutions often serve as role models for European research institutions in knowledge and technology transfer. This paper investigates the widely held belief that European technology transfer performance is inferior to that of the U.S. To explore this, an analysis of the quality of patents from leading U.S. and European universities and research institutes was done. The methodological approach involves a comparative analysis of key patent quality indicators: number of patent family members, forward citations, backward citations, and claims. Results indicate that the dominance of U.S. organizations is not as clear as commonly perceived. The study adds value by providing an additional understanding of the technology transfer landscape, challenging the assumption of U.S. superiority.

KEYWORDS

Patents, patent quality, patent valuation, public research organizations, research institutes, universities, Europe-U.S. comparison, number of patent family members, forward citations.

1 INTRODUCTION

The European paradox is a term coined to describe that Europe is strong in basic science but lags behind some other developed countries in technological applications in world markets [1], specifically in the commercialisation of scientific findings or what we call knowledge and technology transfer (KTT).

Many scholars have studied why some public research organisations (PROs) – which include universities and research institutes – are more successful in commercializing knowledge. Most of the research on university knowledge commercialization has been conducted in the U.S., often identified as pioneers in this area [2].

In Europe, most university or PROs' technology transfer offices are still young, with half of them being established after 2000 [3]. However, this is probably not the only reason why "Europe is perceived to lag behind the U.S. in converting its academic results into economic outcomes" [4]. This lag may affect the economic growth of European countries and also their global competitiveness in industries that rely on technological innovation.

The aim of this study is to contribute to existing studies which deal with different aspects of KTT in Europe, especially in comparison to the U.S. For example, Crespi et al. [1] focused on a comparison of European and U.S. academic patenting systems and discovered that there is a difference between PRO-owned and PRO-invented patents (inventions). They discovered that EU PROs lag behind the U.S. because 80% of patents with academic inventors are in the EU owned by private firms rather than PROs, and they are statistically not recognized as PRO patents.

On the contrary, this study is not focused on the quantity of the patents, such as Crespi's et al. [1], but on their quality. The top European and U.S. PROs will be compared according to the value of their patents by indicators of patent value.

The research question is: If we compare the patents of the top European and U.S. PROs by indicators of patent value, such as the number of patent family members and forward citations, are there any differences between Europe and the U.S.?

Understanding this research problem is important because the effective commercialization of scientific knowledge directly impacts economic growth and innovation. If European PROs can enhance their KTT performance, it could lead to increased competitiveness in global markets. By focusing on patent quality rather than quantity, this study aims to provide some insights into how Europe might overcome the perceived lag behind the U.S.

2 INDICATORS OF PATENT VALUE

Methods for patent valuation can be qualitative or quantitative [5]. We will focus only on quantitative and non-monetary methods, i.e., patent indicators [5]. Typical indicators are legal status, international and technological scope, number of forward citations and the existence of opposition and litigation [5]. Such valuation has many advantages: the method is fast, objective and inexpensive and can be fully automated once the valuation system is set up [5]. International scope (size of patent family) and forward citations (citations received from patents applied later) are probably the most frequent measures for assessing patent value. Patent valuation using forward citations has been increasingly used by practitioners when a patent's value has not been otherwise established [6].

*Article Title Footnote needs to be captured as Title Note
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Og et al. [7] divide patent value indicators into *ex-ante* indicators (family size, backward citations, backward references to non-patent literature, number of claims, and number of inventors) and *ex-post* indicators (forward citations).

We will consider the following indicators:

- Number of claims
- Number of patent family members
- Number of backward citations
- Number of forward citations

According to Squicciarini et al. [8], claims define the extent of the exclusive rights granted to a patent holder, as only the technologies or elements specified within these claims receive legal protection and can be enforced. Consequently, the scope of a patent's protection is determined by the number and specifics of its claims. Additionally, since patent fees typically depend on the number of claims included, having numerous claims can result in higher costs. Therefore, the number of claims in a patent can indicate not just its technological scope but also its anticipated market value: more claims often suggest a higher expected value for the patent [8].

Patent family size – the number of countries in which the same invention is patented – is a very important indicator of patent quality [9]. Due to the expenses associated with obtaining patents in various regions, patent holders typically choose to protect their most valuable inventions internationally. Besides considering raw family size, such as in this case, one variation of this method is to look at triadic patents, which cover an invention in the three principal markets: the U.S., Japan, and the European Patent Office (EPO). Alternatively, transnational patents, defined as patent families with at least one filing with the EPO or under the Patent Cooperation Treaty (PCT), can be considered [10].

Backward citations reveal the prior art or existing knowledge that a new patent builds upon. They are added by patent applicants, examiners, and also by third parties (e.g. during opposition proceedings), and are often used as measures of knowledge transfer [11]. A patent with numerous and relevant backward citations indicates that the patent applicants or inventors or attorneys and examiners conducted a comprehensive search of prior art. Such patents may also be less vulnerable to legal challenges and can be protected from being invalidated due to overlooked prior art. Additionally, if a patent references foundational and high-impact prior patents, it suggests that the patented invention is building on well-established and important technology, potentially indicating a higher-quality patent.

Forward citations are commonly used to measure the technological impact of innovation [11]. We can say that this indicator is the most understandable to us, as we are already familiar with it from scientific articles: when later patents quote an earlier one, it suggests that the earlier patent has contributed to new developments in the field. The more forward citations a patent receives, the more significant its impact on subsequent technological improvements.

Among these four indicators, the two most important can be considered: 1) patent family size for reflecting the potential commercial success of an invention and 2) forward citations, which indicate the technological/scientific impact of the invention.

3 METHOD

For this study, the first methodological question was, how to determine the most important or innovative European and U.S. PROs.

For the U.S., the Heartland Forward's report (2022) was used [12]. From this report, five top PROs were chosen:

- Carnegie Mellon University
- University of Florida
- Columbia University
- Stanford University
- Harvard University

For Europe, the European Research Ranking list (2020) was used [13]. From this list, five top PROs were chosen:

- Centre National de la Recherche Scientifique
- Fraunhofer Gesellschaft zur Foerderung der Angewandten Forschung E V
- Commissariat a L'energie Atomique
- Eidgenoessische Technische Hochschule Zuerich (ETH)
- University Of Copenhagen

Additionally, two not listed here PROs from Reuters' Top 100 report (2019) were selected [14].

For the U.S.:

- Massachusetts Institute of Technology (MIT) which was ranked at the world's second place in this report.

For Europe:

- KU Leuven (which was the top rank in Europe and took seventh place on the Reuters' Top 100 report).

To access indicators of patent value for these selected PROs the Orbis Intellectual Property database (Orbis IP) was used. Orbis IP contains over 145 million patents linked to detailed company information and ownership structures [15].

Excel was used to sort the data and draw the chart, and the open-source program JASP was used for statistical analysis. We used the Student's t-test (also called T-test) to compare the means between two groups [16], in the presented case, Europe and the U.S.

4 RESULTS

From the selected institutions, we can first notice that in Europe, there are three research institutes listed and three universities, while in the U.S., there are five universities and only one research institute.

Figure 1 below shows that selected European PROs outnumber the U.S. PROs in patents in the last at least 65 years. However, since there are no reliable and comparable data about these organisations' date of establishment, size and income (which can all affect the presented number of patents), it is not possible to make any comparisons or conclusions.

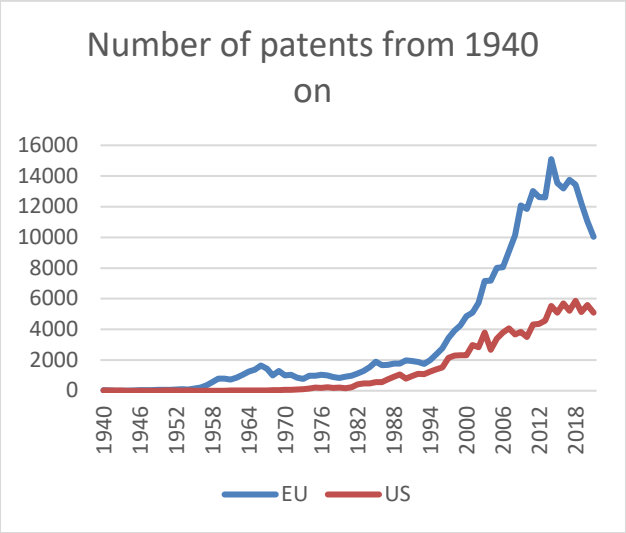

Figure 1: Comparison of no. of patents of current top PROs from 1940 on

Moreover, for the answer to the presented research question the past is not so important as in the current situation. Therefore, patents from these organisations only from the last ten years were selected, i.e., from 2014 on.

In Table 1 below, we can see the results of the T-test. All the differences in means are statistically significant ($p < 0,05$). Descriptive statistics in Table 2 show us that U.S. PROs are better than European in the number of claims and backward and forward citations. However, European PROs are better than the U.S. regarding the number of family members.

Table 1: Comparison of European and U.S. PROs (patents from 2014-2024)

Independent Samples T-test			
	t	df	p
Number of claims	-91,101	162668	< ,001
Number of family members	16,447	162668	< ,001
Number of backward citations	-40,025	162668	< ,001
Number of forward citations	-55,886	162668	< ,001

Table 2: Group descriptives (patents from 2014-2024)

	Group	N	Mean	SD	SE	Coefficient of variation
Number of claims	Europe	112918	14.082	13.774	0.041	0.978
	U.S.	49752	23.823	29.331	0.131	1.231
Number of family members	Europe	112918	10.099	18.835	0.056	1.865
	U.S.	49752	8.610	10.977	0.049	1.275
Number of backward citations	Europe	112918	3.027	9.733	0.029	3.215
	U.S.	49752	6.789	27.966	0.125	4.120
Number of forward citations	Europe	112918	0.806	3.649	0.011	4.526
	U.S.	49752	2.960	11.729	0.053	3.962

A closer look at individual PROs' patents reveals considerable differences between them. In the number of claims, MIT is the leading PRO with an average of 28 claims. In the number of family members (Table 3), Fraunhofer is the leader (with a mean of more than 17 family members), followed by KU Leuven (with more than 11 family members). PRO with the highest number of backward citations is MIT again, but the leading PRO in the number of forward citations (Table 4) is Carnegie Mellon University, with a mean of 4,18. The best European PRO in the number of forward citations is ETH, with a mean of 2,42.

Table 3: Descriptive statistics - Number of family members

	Atomique	Carnegie	Center National	Columbia	Copenhagen	ETH	Florida	Fraunhofer	Harvard	Leuven	MIT	Stanford
Valid	35282	2860	34168	8196	1427	26	10191	37257	236	4758	15640	12629
Mean	**5,035**	**4,144**	**7,328**	**8,590**	**8,473**	**9,846**	**6,076**	**17,335**	**11,169**	**11,387**	**9,539**	**10,481**
Std. deviation	3,680	4,733	7,298	10,217	9,001	7,412	6,777	29,953	11,778	15,114	13,095	11,641
Minimum	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Maximum	48,000	29,000	147,000	130,000	44,000	22,000	52,000	300,000	93,000	74,000	106,000	78,000

Table 4: Descriptive statistics - Number of forward citations

	Atomique	Carnegie	Center National	Columbia	Copenhagen	ETH	Florida	Fraunhofer	Harvard	Leuven	MIT	Stanford
Valid	35282	2860	34168	8196	1427	26	10191	37257	236	4758	15640	12629
Mean	**0,849**	**4,180**	**0,629**	**2,319**	**0,800**	**2,423**	**1,947**	**0,871**	**0,915**	**1,251**	**4,102**	**2,543**
Std. deviation	3,246	11,998	2,583	9,115	3,238	8,339	6,242	3,593	8,873	9,209	16,149	9,815
Minimum	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Maximum	162,000	260,000	117,000	232,000	53,000	41,000	181,000	126,000	130,000	396,000	410,000	259,000

5 DISCUSSION AND CONCLUSION

Results of this study show something quite the opposite of the European paradox, which suggests that while European scientific performance is on par with its main international competitors, Europe lags behind in converting research results into innovations and gaining a competitive advantage [17]. European

paradox is a term that describes Europe's strength in basic science but its perceived lag in technological applications in the global market (for example, compared to the U.S.).

In this study, the top European and U.S. PROs were compared. Results show that the U.S. top PROs are much stronger in the scientific performance of their patents: in the last ten years, an average patent from top U.S. organisations received 3 forward citations while a patent from top European organisations received only 0,8. Therefore, the scientific or technological influence of U.S. patents is more than three times higher than that of Europe.

On the other hand, European PROs demonstrate larger patent families than those of the U.S., which indicates a stronger emphasis on protecting intellectual property across multiple jurisdictions and, thus, also a broader market potential for patented inventions. That said, European inventions are much more focused on commercialisation or "competitive advantage".

U.S. PROs are also better than Europe's in the number of claims and backward citations, but these indicators may not be so important for commercial and scientific/technological success.

To help European PROs improve in terms of the number of patent claims, as well as backward and forward citations, and reduce the gap with the U.S., drafting patents more carefully with more detected prior art can be suggested. This will result in more backward citations of a particular patent and also in forward citations of quoted patents. It is also important to encourage collaboration between different PROs and between PROs and industry. Partnerships can create more comprehensive and impactful patents that include more claims and are more frequently cited.

In conclusion, while the study highlights significant differences between European and U.S. PROs in terms of patent performance, it also points to areas where European PROs can enhance their impact. Future research should focus on investigating the underlying factors contributing to these disparities, particularly by examining how patent drafting practices, collaboration networks, and industry linkages affect patent quality and citation rates. It should also be noted that this study referred to the top six PROs from each continent, and different results might have been obtained if all PROs were considered. But in any case, a methodological approach which can combine quantitative analysis of patent metrics with case studies of successful collaborations could provide deeper insights into the mechanisms that drive patent performance. Additionally, exploring policy interventions and strategies to strengthen technology transfer offices and foster innovation ecosystems in Europe could offer actionable solutions to close the gap with the U.S. The U.S., on the other hand, may close the gap with Europe by filing and enforcing its patents in more countries.

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The Importance of Technology Transfer Offices in University Industry Collaboration: KTÜ TTM Example

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ABSTRACT

Within the scope of the research, interviews were conducted with the participants on the subject in order to answer the question "What is the place of technology transfer offices within the framework of university-industry collaboration?" This study evaluated the place of Karadeniz Technical University Technology Transfer Application and Research Center (KTÜ TTM) within the framework of university-industry collaboration. In the study, qualitative research technique was used and "phenomenology" was used as the research design. The data in this research was examined with the descriptive content analysis method. Analysis was conducted in RStudio in order to analyze the collected qualitative data and determine emotional tendencies. According to the analysis results; It was seen that KTÜ TTM made significant contributions to raising the bar of success by using the potential of the university and had a positive effect in general. When similar studies in the literature are examined, it is seen that TTOs play an important role in university-industry collaboration. This study supports the theoretical discussions in the literature with a practical example. Since the study provides an evaluation specific to KTÜ TTM, it makes a local and specific contribution to the literature by examining the effects of TTOs in a different university and geographical region. This could fill the gap in the literature on the functioning of TTOs across different institutions and regions.

KEYWORDS

Technology, technology transfer office, university industry cooperation, KTÜ TTM

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1.INTRODUCTION

Technology Transfer Offices (TTOs) are organizational structures that play a role in directing academic research towards national and international research projects, facilitating its transfer to industry, and commercializing it. In general, TTOs located within universities act as intermediaries between universities, research institutes, students, investors, and companies. They engage in activities such as establishing connections and making matchings according to the necessary needs.

In Türkiye, TTOs provide consultancy and support to all stakeholders throughout the entire process, from transforming knowledge into products, selecting industrial partners, identifying appropriate funding sources, project development activities, intellectual property and industrial property rights applications, to commercialization and/or the establishment of academic-based firms [10].

As intermediary organizations, TTOs operate according to various strategies based on the past experiences of academic and industrial actors and the quality of the information conveyed in the university-industry collaboration process. TTOs particularly focus on enhancing cognitive and organizational domains. They play a crucial role in bringing together actors with different visions, ways of interpreting life, and perspectives on the world [11].

The collaboration between two distinct entities, universities and industry, can contribute to national development; however, this is achievable only if the process is managed with sound and appropriate strategies. Nowadays, while collaborations between universities and industry can occur through various

communication channels apart from the support of technology transfer offices, the outcomes of these collaborations are often quite weak [7].
A review of the literature reveals that technology transfer offices (TTOs) play a significant role in enhancing and sustaining university-industry collaboration.

1.1 University Industry Collaboration

University industry collaboration ensures that the knowledge gained from research activities conducted at universities is not only published but also transformed into practical applications. It is a collaborative method aimed at and implementing the transfer of technological developments and knowledge to production stages according to industrial needs [13]. The cultural differences between universities and industry contribute to the diversification of research approaches [9]. Effective collaboration between industry and academia requires a special alignment; understanding mutual interests, setting common goals, and focusing on complementary skills form the basis for achieving successful collaboration [6].
As a result of collaboration, industry, whose goal is to increase profits and expand its volume, has seen developments that positively impact production through the adaptation of technologically evolving and renewing processes to existing systems. The aim of the university in collaborating with industry is to develop a qualified human resource and support research with a strong knowledge base, leading to the transformation of theoretical work into practical applications and resulting in some modifications [5]. Science plays an extremely important role in facilitating university-industry collaborations. It is a process born from the mutual supply and demand between the university, which produces science, and industry, which converts science into economic benefits [2].
University-industry collaboration highlights a partnership that offers significant benefits for both parties. Through these collaborations, universities strive to address global problems using academic knowledge. Industry, on the other hand, benefits from universities' research, expertise, and laboratories, leading to the development of innovative products and improvements to existing products. As a result of this partnership, mutual gains are achieved in areas such as employment, education, innovation, and economic growth, which significantly impact life. Thus, these partnerships provide mutual benefits to the parties involved and contribute to society and the economy. In addition to their research mission, universities also have educational and societal missions. While the educational mission is clear, societal missions have gained increasing importance in recent years. This is reflected in factors such as the role of universities in university-industry technology transfer [4].

1.2 University Industry Collaboration Activities of KTÜ TTM

In order to increase R&D and innovation capacity and strengthen university-industry cooperation activities, KTÜ TTM establishes contacts with many new companies every year and develops bilateral cooperation. These efforts are not limited to the region but extend to firms across the country through online and face-to-face meetings, integrating new companies into the collaboration ecosystem. During these meetings, R&D topics and requests are gathered, the needs of the firms are identified, and numerous firms are matched with academicians from KTÜ for collaborative projects, involving online meetings and discussions.
Meetings are also organized with the boards of Organized Industrial Zones to discuss activities within the framework of university-industry collaboration. Firms are prioritized and analyzed, and guidance is provided based on current calls for proposals. Information on academicians' research that can be applicable in the industry or discussions on potential collaborations with industrial organizations are conducted.
During the application phase of university-industry collaboration projects, the entire process of project review, preparation, and submission of application documents is carried out. Legal matters and contracts are prepared jointly with the university's legal counsel. Once a project is approved for funding, support such as accounting transactions, completion of documentation, and signature processes are provided to firms and academicians by the administrative and financial affairs unit established within KTÜ TTM.

2. METHODOLOGY

2.1 Research Methodology and Research Design

In this study, the role of KTÜ TTM within the framework of university-industry collaboration was evaluated. A qualitative research method was employed, and the research design was based on "phenomenology." The phenomenological design typically focuses on phenomena that are recognized but not deeply or thoroughly understood. Phenomenology is a method that concentrates on understanding and evaluating lived experiences [8]. This methodology aims to deeply examine and comprehend individuals' experiences.
Although phenomenological data are obtained from the experiences of a few individuals, the information gathered from these individuals provides detailed insights into the phenomenon. The fact that the phenomenon is experienced by different individuals contributes to the provision of information from various perspectives by the research participants, thereby aiding in understanding the phenomenon from a broad viewpoint. In this way, the data obtained from the experiences of different participants support a comprehensive understanding of the phenomenon [3]. For such research, the number of individuals to be included in the sample should generally not exceed ten. It is normal to limit the sample size in this type of research since the interviews often require long and sometimes multiple meetings. The limited number of individuals who have experienced the phenomenon under investigation may also sometimes result in a restricted number of people who can be included in the sample [12].
In addition, sentiment analysis was performed using RStudio to automatically detect and classify emotional expressions present in the texts. This analysis employs Natural Language Processing (NLP) techniques to determine whether the sentiments in the texts are positive, negative, or neutral. During this process, words and expressions within the texts are analyzed to identify the emotional content.
To visually understand the key themes, topics, and word distribution in the texts, a word cloud was generated in RStudio. Word clouds, commonly used as part of text mining and data visualization techniques, provide a quick representation of the frequency of words in a text or text corpus, indicating which words are used more frequently.

2.2 Universe and Sample of the Research

The universe of this research consists of approximately 50 faculty members working at KTÜ who have been involved in university industry collaboration processes. To align with the research objectives, the sample group was composed of 8 faculty members who have both participated in university industry collaboration processes and are knowledgeable about the KTÜ TTM. The academic titles, faculty and department affiliations,

and the total number of projects funded by public and/or private sector capital for the faculty members included in the sample group are provided in Table 1.

2.3 Data Collection Processes and Interview Questions

Within the scope of the research, interviews were conducted with relevant participants to answer the question, "What is the role of KTÜ TTM in the context of university-industry collaboration?" Participants were informed that the interviews would be audio recorded by the researcher, but their personal data would not be shared with third parties. It was explained that the audio recordings would be used for the purpose of data collection and analysis. Initially, a pool of questions presumed to be relevant to the study topic was created. Subsequently, the questions within this pool were evaluated with experts deemed relevant to the research content, and the most appropriate eight questions for the study were finalized. The interview questions prepared for the participants are presented in Table 2. Before the interview questions were posed, a conversation with the participants was initiated to foster a mutual trust relationship. After the audio recordings were transcribed, with the permission of the participants, the next step was the analysis of the data. The collected data was analyzed using descriptive content analysis, and additionally, sentiment analysis was conducted, and a word cloud was generated using the RStudio program.

Table1: Characteristics of the Study Sample Group

Academic Title	Faculty/Departments	Number of Public /Private Sector Supported Projects
Professor	Forestry Faculty Forestry Industrial Engineering	10
Professor	Faculty of Engineering Mechanical Engineering	6
Professor	Faculty of Engineering Mechanical Engineering	2
Associate Professor	Faculty of Engineering Industrial Engineering	4
Assistant Professor	Faculty of Science Computer Science	6
Assistant Professor	Faculty of Science Computer Science	6
Assistant Professor	Vocational School of Health Services Medical Services and Techniques	3
Research assistant	Forestry Faculty Forestry Industrial Engineering	2

Table 2: İnterview Questions

No	İnterview Questions
1	What are your opinions about KTÜ TTM?
2	How would you define university industry collaboration?
3	Do you think KTÜ TTM is effective in the processes of university industry collaboration?
4	Why would you prefer KTÜ TTM to be an intermediary in university industry collaboration processes?
5	What are your expectations regarding KTÜ TTM's university industry collaboration module?
6	Is there any aspect of KTÜ TTM's university industry collaboration processes that you find lacking?
7	In your opinion, how could KTÜ TTM become more active in the context of university industry collaboration?
8	Has the solution/process of the problems you experienced in university-industry collaborations at KTÜ TTM become easier?

2.4 Research Findings

The findings of the study are summarized as follows:

KTÜ TTM has made significant contributions to raising the bar of success by utilizing the potential of the university. Active TTOs are essential units that every university must have. They are crucial in presenting the university as professional and institutional in industrial collaborations and play a critical role in reducing the risks researchers may encounter during the project development process.

KTÜ TTM has been highly effective in conducting one-on-one meetings with firms, matching academics, providing project writing support, analyzing industrial problems, and guiding both parties on the appropriate course of action throughout the process. It has also played a significant role in realizing many of the university's recent collaborations. However, it is observed that KTÜ TTM faces a disadvantage due to its location being far from major industrial areas. It is suggested that the center could become more effective by organizing events where industry professionals and academics can come together and by placing greater emphasis on institutionalization.

It is noted that KTÜ TTM is preferred as an intermediary because it instills confidence in the industrial sector during company visits and ensures that academics feel secure. Its professional and corporate identity during industry visits, which represents the university, leads to a more positive and moderate view of the project development processes among industrialists. Additionally, KTÜ TTM is favored for its objective approach to both academics and industry parties, its facilitation of smooth process progress, its role as a mediator, and its handling of accounting tasks.

KTÜ TTM is believed to be doing its best to achieve its goals. Additionally, there are expectations for bringing academics along on company visits, conducting matching processes more meticulously, collecting project topic requests from academics based on company activity areas, and matching academics with large-scale companies in the Technopolis where they have their firms.

It is generally believed that KTÜ TTM does not have significant shortcomings. However, suggestions have been made, including collecting R&D topic proposals from academics and forwarding them to companies, grouping companies sectorally to hold meetings with academics on specific days, providing support with sample project forms, and facilitating discussions and integration between academic entrepreneurs and companies.

To increase its activity, it is suggested that KTÜ TTM could increase its participation in fairs, fix the names of the companies it works with on its website, enhance materials for promoting TTO's module functions and staff, utilize international resources, and raise awareness among companies about TTO activities.

It is believed that TTO plays a facilitative role in reviewing and preparing contracts between academics and industrialists, managing financial obligations, handling bureaucratic processes, and establishing balances between the company and the academic. Additionally, it is noted that TTO helps eliminate problems by coordinating the project development processes for companies that are located far away.

The data obtained from the interviews was converted into a text file and sentiment analysis was performed using the RStudio program. The graph showing the sentiment scores obtained from the analysis is presented in Figure 1.

Subsequently, a word cloud was created using the Rstudio program to analyze frequently used words within the text. The resulting word cloud is presented in Figure 2.

Figure 1: Distribution of Sentiment Scores

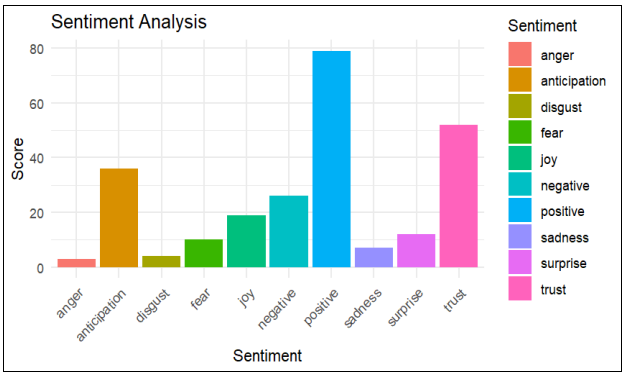

Figure 2: Word Cloud

3. CONCLUSION AND RECOMMENDATIONS

In conclusion, it has been observed that the activities carried out by the KTÜ TTM within the framework of university industry collaboration have yielded positive results, as noted by participants who are familiar with the structure and functioning of the TTO and have been involved in the university industry collaboration processes. Furthermore, it has been concluded that the TTO has positively influenced its corporate image. The study [1] supports this finding, as it concluded that TTOs positively impact the innovation capacity within firms, with 47% of firms' innovation capacity being provided by TTOs.

Upon evaluating the sentiment analysis scores presented in Figure 1, it is observed that a high score corresponds to a positive sentiment. This result indicates that the university-industry collaborations carried out with KTÜ TTM generally have a positive impact. It demonstrates that stakeholders being satisfied with the collaboration and experiencing positive outcomes.

The high level of trust indicates that KTÜ TTM has established a strong trust relationship between university and industry stakeholders and is recognized as a reliable partner. The high level of anticipation reflects the high expectations for future projects and potential opportunities in collaborations with KTÜ TTM.

Based on the sentiment analysis results, we can conclude that KTÜ TTM's role and significance in university industry collaboration are highly positive. The high levels of positive emotions and trust demonstrate that the collaborations are being conducted successfully and that stakeholders are satisfied, while the low levels of negative emotions suggest that the processes are running smoothly and are being managed effectively. This proves that KTÜ TTM is a reliable and effective interface that strengthens the collaboration between the university and industry.

In the word cloud presented in Figure 2, the words 'industry,' 'university,' and 'TTO' are prominently featured. The frequent occurrence of the word 'industry' indicates a strong focus on how KTÜ TTM interacts with and supports industrial partners. The frequent mention of the word 'university' underscores the importance of the academic side of the collaboration, suggesting that researchers view the university's role as critical in partnering with industry. The prominent presence of the abbreviation 'TTO' highlights the central role of KTÜ TTM in facilitating these collaborations. Overall, the word cloud demonstrates the significant role that KTÜ TTM plays in supporting and facilitating these interactions.

The current situation of KTÜ TTM has been evaluated, and the following recommendations have been proposed:

Increasing awareness of the services provided by TTO and conveying this awareness to the business ecosystem will enhance the sustainability of new collaborations. Organizing events that bring together universities and industry can foster more communication between them. The strong relationships established will increase the sense of trust, thereby creating opportunities for further collaboration. Additionally, such efforts will create internship and job opportunities for students trained at the university for the business world.

In future studies, the place of TTOs can be examined within the framework of commercialization of inventions within the university and/or increasing academic entrepreneurship. By increasing the number of study samples, the subject can be analyzed in depth with different analysis methods and theoretical frameworks can be tested. In addition, the role and impact of TTOs in different universities, regions and different countries in university-industry collaboration can be examined by conducting multiple case studies. It will be useful to compare different structures and operations of TTOs in terms of examining the impact of different regional and sectoral dynamics on collaboration processes.

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The Impact of International Networks on Grants, R&D, Knowledge and Technology Transfer - Case of COST Network and KTU

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ABSTRACT

It is essential that researchers collaborate with international colleagues and adhere to international standards to facilitate the transfer of technology resulting from their research. In order to participate in these projects, it is essential for researchers to have a broad international network and reliable collaborators to form international consortia. This study examines the strategy adopted by Karadeniz Technical University (KTU) in its pursuit of the COST (European Cooperation in Science and Technology) Programme and the subsequent results that enabled its researchers to engage in prestigious international consortia and access international funding sources. To increase the number of Karadeniz Technical University (KTU) members in the Management Committee (MC) and Working Group (WG) of COST Actions, which have limited slots, each Action was carefully reviewed, and individual meetings were held with researchers. Technical and administrative support was provided to facilitate researchers' participation in the Actions. A statistical analysis was conducted for researchers who participated in COST Actions over the past five years. The status of countries involved in the COST program from 2019 to 2023 was examined. Additionally, Türkiye's performance during this period was analyzed to assess the effectiveness of the developed strategy. As a result of these analyses, in COST Actions in which a limited number of KTU researchers were involved at the beginning of 2019, 252 researchers were involved in 528 actions by the end of 2023, becoming the first university in Türkiye in this context. Thanks to the researchers and activation included in the COST Programme, a 92.3% increase in the number of international project applications and a 366% increase in the number of project acceptances were observed between 2019 and 2023. The findings indicated that these exemplary practices could serve as an effective approach for the internationalisation of higher education institutions.

KEYWORDS

Technology Transfer, R&D, Internationalisation, COST

1 INTRODUCTION

The involvement of researchers in internationally funded projects presents a duality of opportunities and challenges. One of the most significant challenges encountered during this process is the formation of international consortia. Effective communication between researchers from different countries and disciplines is of great importance, as consortia require such a diverse group to come together [1]. Furthermore, operational challenges, including the sourcing of funding, the optimal utilisation of resources and the effective management of projects, represent significant obstacles in the context of such projects [2]. Nevertheless, the intricacy of these procedures and the presence of bureaucratic impediments can act as a deterrent for numerous researchers [3]. The existing literature frequently emphasises that participation in international projects has positive effects on researchers' career development, knowledge sharing and innovation [4]. In particular, the formation of international consortia hinges on the existence of reliable networks and cooperative networks, which are pivotal for the success of the projects. In this context, the effective utilisation of international cooperation networks facilitates the efficiency and sustainability of projects. Due to the inability of KTU researchers to engage in sufficient international cooperation, it was observed that the university was quantitatively and qualitatively insufficient in international projects, resulting in limited scientific output and weakened competitiveness at the global level. This deficiency prevented the university from fully exploiting its potential, especially in areas such as access to international funding, exchange of knowledge and experience, and development of innovative solutions. This study presents the internationalisation strategy of Karadeniz Technical University, which enables researchers to participate in qualified international consortia and access international funding sources, as exemplified by the COST programme.

The COST (European Cooperation in Science and Technology) programme was established in 1971 with the objective of promoting scientific and technological research in Europe. The objective of COST is to facilitate the exchange of knowledge and encourage innovation among researchers by fostering interdisciplinary networks. The principal objective of the programme is to facilitate international collaboration and enable researchers to collectively address global challenges. While COST does not provide direct support for research and development, it plays a significant role in facilitating the formation of international consortia, which allow researchers to collaborate on the advancement of their projects. Researchers may participate in the Actions in either the capacity of a member of the Management Committee (MC) or a member of a Working Group (WG). In these roles, they are afforded the opportunity to engage in in-depth strategic planning, project management, and the exploration of specific research topics. Those engaged in COST Actions enjoy significant advantages, including access to information and resources, opportunities for career development and the strengthening of leadership skills as part of an internationally recognised network. Such opportunities permit researchers to make significant progress in their careers and to become more prominent figures within the international scientific community. COST Actions facilitate the formation of new collaborative relationships and the expansion of existing networks, thereby enhancing the probability of securing additional funding and support for research projects. Furthermore, meetings, workshops and conferences organised by COST provide invaluable opportunities for researchers to disseminate their knowledge and experience [5].

2 METHODOLGY

In accordance with the internationalisation strategy for KTU to become more effective in the international arena, activities are being undertaken with the objective of enhancing international collaboration and increasing the quantity and calibre of project proposals submitted to international funding programmes. Given the crucial role that a broad international network plays in securing participation in internationally funded projects, concerted efforts have been made to direct students towards the COST Programme since late 2019, with ongoing initiatives still in place.

In this context, awareness-raising activities, which commenced with information events held at various locations across the university and its constituent departments, have yielded tangible outcomes through one-to-one interviews with academics. In this regard, the strategy pursued by KTU Technology Transfer Application and Research Center experts to enhance the involvement of researchers in COST Actions is outlined below.

- **Organisation of information events:**
- **Analysing current COST actions:** Existing COST actions are analysed and listed with details covering objectives, research areas, participation requirements, duration, etc.
- **Identification of researchers:** Researchers with fields of study compatible with COST actions are identified by analysing their academic profiles (research areas, project experiences, etc.).
- **Establishing contact with researchers:** The identified researchers are contacted and one-to-one interviews (telephone, e-mail or desk interviews) are conducted about the opportunities and benefits of participation in COST actions. It is assessed whether the researchers are suitable for the identified actions.
- **Providing technical support services:** Technical support is provided to researchers during the application process for COST actions (filling out the application form, preparation of necessary documents, follow-up of the application process, etc.) and the application evaluation process is followed.
- **Guidance to other COST-related support:** Researchers are provided with the opportunity to benefit not only from MC/WG assignments in actions, but also from other COST-related support such as Short-Term Scientific Visit (STSM) and ITC Conference Support. In addition, referrals were made to the COST 2515 Programme supported by TUBITAK, the COST National Coordinator in Türkiye, to provide R&D support to researchers.

The country-based data used in the study were obtained from the COST Annual Reports and the researcher-based data were obtained from the COST website.

In order to assess the status of the developed strategy, a mini survey with open-ended questions was conducted with KTU researchers participating in COST Actions. In the survey, the benefits of the participated actions for the academics were evaluated with questions such as to what extent they benefited from the action, what kind of effects it had at the academic level, what kind of activities they participated in.

3 RESULTS

The COST programme facilitates extensive involvement from a diverse array of countries, encompassing 41 member countries and cooperation countries. In addition to Europe's leading countries in science and research, such as Germany, France, Italy, Spain and the United Kingdom, Türkiye, Israel and some Western Balkan countries are also actively involved in this

programme. Table 1 presents detailed data illustrating the status of active participation in the COST programme between 2019 and 2023 [6-10].

Table 1: Status of Countries in COST Programme

Indicator	2019	2020	2021	2022	2023
Runnig COST Action	294	291	289	302	269
New COST action launched	80	45	40	70	70
Average number of COST Members per Action	30	30.8	31	33	33
Average number of non-COST countries per Action	-	4.3	6	5	6
Articles	479	921	1501	1253	-
Percentage of spin-off H2020* proposals approved	37%	39%	32%	-	-
Average value of spin-off projects per Action (€)	6M	5.8M	3.9M	9.5M	5.2M

*Horizon 2020 was the EU's research and innovation funding programme from 2014-2020

Türkiye plays a significant role as an active participant in the COST programme. Türkiye's involvement in COST Actions between 2019 and 2023, along with a comprehensive account of its contributions and accomplishments, is presented in Table 2 [11-15].

Table 2: Türkiye's Position in COST Programme

Indicator	2019	2020	2021	2022	2023
Individual participation in all action activities	1075	-	20	1113	1849
Training school/hosted	1	12	0	4	10
Short-term scientific missions/hosted	14	103	8	12	23
Short-term scientific missions/participant	72	380	43	90	158
Trainess/participant	197	1001	33	219	310
Trainers/participant	7	58	1	23	48
Budget received (€)	0.9M	4.9M	0.3M	1.5M	2.3M

Türkiye demonstrates a notable level of involvement in the COST programme, exhibiting a discernible increase in participation on an annual basis. The number of individual participants increased from 1,649 in 2019 to 103 short-term scientific missions in 2020, with 380 participants being sent to these missions. Furthermore, 12 training schools were conducted in 2020, with 1,001 individuals undergoing training at these institutions. In 2021, participation declined as a consequence of the impact of the pandemic. However, in 2022, there was a revival in participation and a success was achieved as in 2020. This success continued to increase in the following years. As evidenced by the participation statistics provided by the COST Organisation, Türkiye achieved notable success in 2022 and 2023. In 2022, Türkiye achieved the distinction of becoming the third most participating country, with a participation rate of 99% in all active actions. Additionally, the country reached a notable number of members, with 3,084 individuals participating in Working Groups. In the same year, Türkiye was the fifth most successful country in terms of individual participation in COST network activities, with 1,113 participants, and the fourth country with the highest budget allocation of approximately EUR 1.5 million. Türkiye was the leading country in terms of participation by young researchers, with a rate of 52.8%. In 2023, Türkiye sustained its efficacy by participating in 99% of all actions, thereby attaining the distinction of being the country with the highest number of working group members, with 7,096 working group members. Türkiye was the third most successful country in terms of individual participation in COST network activities, with 1,849 participants, and the third most budgeted country, with approximately EUR 2.27 million.

As a consequence of the activities conducted throughout this process, there has been an enhancement in the awareness of researchers, as well as an increase in the number of researchers who have submitted applications on an individual basis. Moreover, the support provided by COST was not confined to KTU but was also extended to TTO units and researchers at other universities, thereby contributing to an increase in Türkiye's participation in the COST Programme.

As the number of researchers engaged in the COST Programme and active in its actions has grown, the graph below illustrates the change in the number of international project applications and acceptances submitted by KTU between 2019 and 2023 (Fig. 1).

Figure 1. Statistics of KTU projects with international funding (2019-2023)

4 DISCUSSION AND CONCLUSION

The formation of international networks plays a pivotal role in the establishment of dependable and collaborative international project consortia. This is achieved by the creation of scientific networks comprising researchers and institutions, which subsequently leads to an increase in the number of international project applications and acceptances.

This study examines the strategy employed in the process by which KTU researchers were directed to the COST Programme, an international organisation with the objective of uniting scientists who are experts in their respective fields throughout Europe in scientific networks. This strategy facilitates the

integration of scientists engaged in national research projects into the international scientific community.

The strategy pursued has yielded notable results. At the inception of 2019, a modest number of KTU researchers were engaged in COST actions. By the conclusion of 2023, this number had grown to 252 researchers participating in 528 actions. With regard to the ongoing COST actions, KTU has been the most successful university in Türkiye, with 29 active members of the Management Committee. In the context of the ongoing actions, Türkiye is playing a pioneering role, with 252 researchers engaged in diverse academic pursuits. KTU has become a prominent hub for interdisciplinary studies, having participated in approximately 61% of the 305 actions initiated during its five-year internationalisation strategy.

The COST programme has been instrumental in facilitating a significant increase in the number of international project applications, with a 92.3% rise observed between 2019 and 2023. Additionally, there has been a notable surge in project acceptances, with a 366% increase during the same period.

Participation in COST Actions was not only associated with an increase in the number of project applications and acceptances, but also with the administration of surveys to KTU researchers who took part in the actions in 2021 and 2023. The objective was to ascertain the additional benefits that researchers derive from the COST Programme. The results of the surveys indicated that the researchers had participated in numerous training programmes, workshops and conferences, and had developed a network of contacts. They had also published more international collaborative papers, worked on multidisciplinary projects with researchers from other countries, and had access to research and laboratory facilities that would not otherwise have been available to them in their home countries. Furthermore, they had disseminated their work more widely.

The findings of this study demonstrate that the strategy employed by KTU has led to an increase in participation in COST actions. This, in turn, has resulted in KTU researchers establishing more robust international networks, which has directly influenced the number of international project applications and acceptances. In conclusion, the findings indicate that these exemplary practices may serve as an effective approach for the internationalisation of higher education institutions.

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The Effect of Evaluating Graduate Thesis Topics as Invention Notification Form on Industrial and Intellectual Property Applications: The Case of Karadeniz Technical University

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ABSTRACT

Industrial and intellectual property is an important structure that is popular all over the world. Each country has legal regulations in the field of intellectual and industrial property in order to protect one's invention. The 6769 Industrial and Intellectual Property Law, which entered into force in 2017, paved the way for universities in Türkiye to have rights in applications for inventions such as patents, utility models and designs. Thesis studies that young researchers start during their postgraduate period are focused solely on publication. The commercialization and patenting potential of theses determined without analyzing the needs of the industrial sector is low, and this makes the thesis work of many engineers inefficient. It is necessary for KTU that is the application authority, to develop new strategies to increase industrial property assets. This study aims to reveal the effect on the number of patent applications by Karadeniz Technical University (KTU) as a result of the evaluation of graduate thesis topics without request. Within the scope of the new strategy, a methodology was applied for the evaluation of patent and utility model application data in the KTÜ patent portfolio, the distribution of data by year, and patent registration documents. In this study, direct patent and utility model application data were evaluated. When the application data was examined, it was seen that the new strategy implemented increased the industrial property assets.

KEYWORDS

Industrial rights, Intellectual rights, patent, utility model, 6769 law, KTU

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1 INTRODUCTION

The concept of intellectual property refers to all rights that are the product of the human mind and have economic value even

if they do not have a tangible equivalent. In other words, it includes ideas that arise as a result of the creative efforts of a person or organization, inventions, literary and artistic works, symbols, names, shapes and designs used for commercial purposes. With the application of an intellectual product, the absolute right provided to the inventor in material and spiritual terms is recognized for a certain period of time [1]. If these rights are defined in a different term, intellectual property rights (IPRs) can be defined as the rights that enable sanctions to be imposed on the products created by the human mind [2]. It is necessary to analyze the concept of intellectual property in two separate sections. The first of these concepts includes industrial property rights including inventions (patents and utility models), trademarks, industrial designs, integrated circuit topographies and geographical indications. The second concept includes all intellectual and artistic works, including works of art, works of science, works of literature, music and musical works, fine art and cinematographic works, depending on copyright [3]. Intellectual and industrial property rights give the inventor the ability to manage all commercial activities thanks to the absolute rights it gives to the inventor. Both the desire of the inventor to protect his/her invention and the desire to prevent imitation in commercial activities increase the number of applications of Intellectual and Industrial Rights in legal protection processes. Patent, utility model, trademark, etc. industrial assets and copyrights are subject to very serious court-based sanctions in case of infringement of the intellectual assets in question. [4]. Violations or infringements of rights by third parties have legal and criminal sanctions to protect the rights of right holders [5].

The purpose of patents is to provide protection that facilitates technological development. A patent not only gives the inventor exclusive rights to create an invention, but also provides incentives for the technological development and commercialization of that invention. Instead of obtaining a patent, the inventor publishes the technical specifications of the invention, enabling others to make different new inventions based on the invention. An increase in the number of patents in a country indicates a high level of technological development in the country. The transformation of industrial and intellectual assets into the economy through the sale of inventions, the production of inventions and the sale of products positively affects the welfare of the country.

This research aimed to determine if recognizing master's and doctoral theses as invention disclosure forms, without requiring additional notifications, would lead to an increase in the number of granted patents. Since Karadeniz Technical University is a research university, the number of industrial property assets is significant. It is necessary to develop new strategies to increase industrial property assets. When the application data was examined, it was seen that the new strategy implemented increased the industrial property assets.

2 METHODOLOGY

The application change status was revealed by using the patent and utility model application data of Karadeniz Technical University. In addition, the registration numbers were evaluated with a similar method. Among the patent applications in the KTU patent portfolio, applications between the years 2017-2023 were evaluated. In the relevant years, student applications (Master and PhD) were filtered from patent applications for each year and the effect of the developed strategy on the applications was revealed. When the application data were examined, it was seen that the new strategy applied increased the industrial property assets.

3 HISTORICAL DEVELOPMENT OF PATENT RIGHTS IN TÜRKİYE

The first important legal arrangement regarding patent rights in Türkiye was made in 1879 during the Ottoman Empire. The French Patent Law of that time was amended and translated into the Ottoman Patent Law enacted in 1879. In parallel with the developments in the world, valid patent laws could not be enacted in Türkiye until 1995, except for the international agreements signed, and the patent laws of the Ottoman Empire continued to be applied with some changes until 1995. Subsequently, Türkiye became a party to the Paris Convention in 1925 and signed the WIPO founding treaty in 1976. Furthermore, Türkiye acceded to the London amendment in 1956, Articles 13 through 30 of the Stockholm amendment in 1976 and Articles 1 through 12 of the Stockholm amendment in 1995 [6]. Türkiye signed the Customs Union Agreement in 1994. With this agreement, the "TRIPS" agreement, the "Strasbourg Agreement on the classification of patents" (IPC) and the "Patent Cooperation Agreement" (PCT) and the "Agreement Establishing the World Trade Organization" entered into force. Later on, the "Budapest Agreement" on the international protection of microorganisms entered into force, as well as the "Patent Law Treaty" (PLT) and the "European Patent Convention" (Munich Convention) [6].

Table 1 presents data on Türkiye's status as a party to the conventions on intellectual property rights to which Türkiye is a party [7].

Tablo 1: International Agreements to which Türkiye is a Party [7]

Agreements	First Signature Date	Türkiye's Membership	Participation Date
World Intellectual Property Organization WIPO Articles of Association	1967	YES	12.05.1976
Treaty Establishing the World Intellectual Property Organization (WIPO)	1995	YES	26.03.1995
European Patent Convention (EPC)	1973	YES	01.11.2000
Paris Convention for the Protection of Industrial Property	1883	YES (10.10.1925)	Stockholm (Articles 1-12) 01.02.1995 (Articles 13-30 16.05.1976)
Patent Law (PLT)	2000	Signed 02.06.200	
Trademark Law (TLT)	1994	YES	01.01.2005

Singapore Agreement on Trademark Law	2006	Signed 28.03.2006	The agreement has not yet entered into force
BUDAPESTE Agreement on the International Storage of Microorganisms	1977	YES	30.11.1998
LAHEY Agreement on the International Registration of Designs (Geneva Text!	1999	YES	1.01.2005
Protocol to the MADRID Agreement	1989	YES	01.01.1999
Patent Cooperation Treaty (PCT)	1970	YES	01.01.1996
LOCARNO Agreement on the Restriction of Designs	1968	YES	30.11.1998
NIS Agreement on the International Classification of Goods and Services in Trademark Registration	1957	YES	01.01.1996
STRASBORG Agreement on the International Classification of Patents (IPC)	1971	YES	01.10.1996
VIENNA Agreement on the Classification of Figurative Elements of Marks	1973	YES	01.01.1996

2.1 INDUSTRIAL PROPERTY LAW NO. 6769

In Turkish law, industrial property rights were first regulated by the Decree Law No. 551 on the Protection of Patent Rights, No. 554 on the Protection of Industrial Designs, No. 555 on the Protection of Geographical Indications and No. 556 on the Protection of Trademarks, which entered into force in 1995. These Decree Laws were repealed by the Industrial Property Law No. 6769 ("IPL"), which entered into force in 2017.

According to the IPL No. 6769, Articles 113-122 include the provisions on "Employee Inventions". Especially with Article 121, universities and public institutions are entitled to have rights in patent applications [10].

ARTICLE 121

(1) Without prejudice to the provisions of special laws and regulations under this article, the provisions regarding the inventions of employees shall apply to the inventions made as a result of scientific studies or research conducted in higher education institutions defined in subparagraph (c) of the first paragraph of Article 3 of Law No. 2547 and higher education institutions affiliated to the Ministry of National Defense and the Ministry of Interior.

(2) When an invention is realized as a result of scientific studies or research conducted in higher education institutions, the inventor is obliged to notify the higher education institution in writing and without delay. If a patent application has been made, the higher education institution shall be notified of the application.

(3) The higher education institution is obliged to file a patent application if it claims right ownership over the invention. Otherwise, the invention becomes a free invention

On this occasion, studies for the protection of the knowledge accumulation in universities with intellectual and industrial rights have been carried out as of 2017.

4 KARADENİZ TECHNICAL UNIVERSITY INDUSTRIAL PROPERTY NUMBERS

Founded in 1954, Karadeniz Technical University is the first technical university established in Anatolia in Türkiye. In addition, as of 2021, it continues to produce science in the Research University category. New generation universities are universities that transform the knowledge they produce into added value while producing knowledge, coordinate these processes, and involve every individual from students to faculty members in innovation-based commercialization activities. Karadeniz Technical University has assumed an important role in serving this basic mission with the Technology Transfer Application and Research Center (TTC).

With the Industrial Property Law No. 6769, which entered into force in 2017, Karadeniz Technical University has made a total of 262 industrial property applications with 166 national patents, 28 national utility models, 16 national designs and 52 international patent applications with access to more than 300 inventors and more than 3000 students. With these applications, 39 national patents, 20 national utility models, 16 national designs and 5 international patents were registered. In addition, 6 copyright registrations and 24 trademark applications were also carried out by Karadeniz Technical University [8].

5 A NEW STRATEGY for INVENTION DISCLUSURE

As stated in subparagraph c of Article 121 of the Industrial Property Law No. 6769, there is an obligation to notify the university of an invention made at the university before applying for industrial property. This notification is referred to as the invention disclosure form in the literature [9]. As of 2017, universities collect invention disclosure forms and make patent applications by evaluating these forms according to criteria such as patentability, commercialization, etc.

As of 2023, a new strategy was developed by Karadeniz Technical University Technology Transfer Application and Research Center and it was decided to consider the thesis subjects of graduate and doctoral students as invention disclosure

forms without notification. With this decision, the technology and/or information of the relevant invention was protected at an early stage. The number of invention notifications received by Karadeniz Technical University since 2017 is shown in following figure 1.

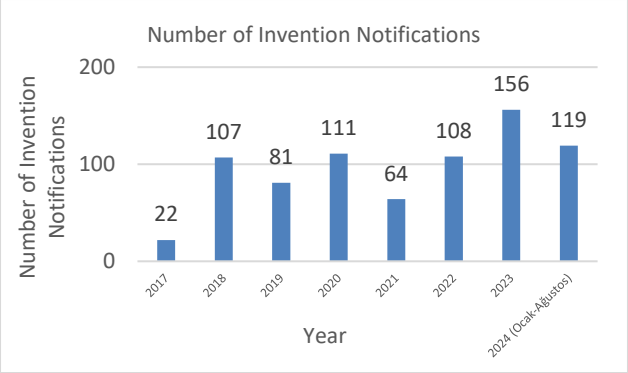

Figure 1 : Number of Invention Notifications Received at Karadeniz Technical University

The number of national patents, national utility model, national design and international patent applications applied as Karadeniz Technical University since 2017 is given in Figure 2.

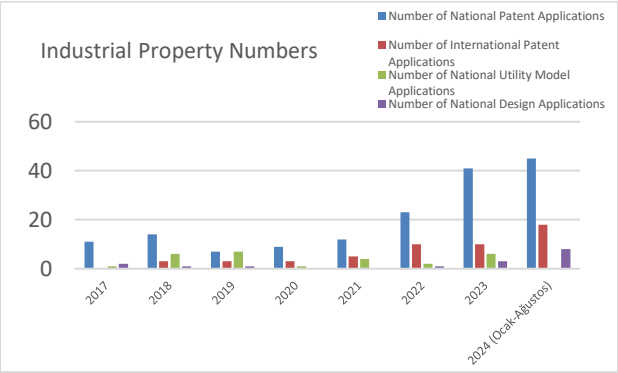

Figure 2: Karadeniz Technical University Industrial Property Numbers

Table 2 shows the comparative number of patent applications of Karadeniz Technical University compared to Trabzon province.

Table 2: Number of patents in Trabzon province - Karadeniz Technical University and the contribution of the university to the number of patents

		2017	2018	2019	2020	2021	2022	2023
Number of National Patent Applications	Trabzon (City)	48	28	29	24	28	51	51
	KTU	11	14	7	9	12	23	41
University Contribution		23%	50%	24,1 %	37,5 %	42,85%	45%	80,39%

6 CONCLUSION

Karadeniz Technical University continues its support in the field of Industrial Property with the 6769 IP Law published in 2017. Before 2017, the number of patents belonging to academicians at the university was 7, while 262 industrial property applications were realized under the university's ownership as of 2024.

In 2020, there was a global COVID-19 pandemic, the effects of which continued in 2021, and a national stagnation in industrial property applications in 2022-2021. However, even during these periods, the know-how at the university was transformed into industrial property assets. Figure 2 shows an increase in industrial assets with the normalization process after the pandemic.

The 25 national patent applications until 2022 increased to 31 national patent applications with the evaluation of the thesis subjects of master's and doctoral students in postgraduate education as invention disclosure forms without notification, which was put into effect in 2023. In the first 8 months of 2024, the number of national patent applications reached 45 applications, and 12 applications are based on given information from theses.

While international applications are examined, 18 international patent applications were submitted as of 2024.

In 2023, a new strategy was put into effect as a new strategy in which the thesis subjects of master's and doctoral students in postgraduate education were evaluated as invention disclosure forms without notification, and the knowledge accumulation at Karadeniz Technical University was protected at an early stage. It is thought that the use of this practice in all universities will produce positive results and increase the number of national and international patents.

The new strategy provides early awareness to young researchers and supports patent applications that adopt industrial needs and have high commercialization potential.

The strategy of evaluating theses as invention notifications was introduced to international partners (8 European Countries) as an example of good practice in the projects of strengthening technology transfer with innovative approaches, in which KTU is a partner, within the scope of the ERASMUS+ and INTERREG NEXT Programs.

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Using Open-Access Resources and Platforms to Create a Technology Transfer Ecosystem *

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ABSTRACT

Technology transfer is a complex process that requires up-to-date and reliable information on various aspects of a technological solution. Approaches to improving the efficiency of technology transfer systems through the use of open access resources and platforms are considered.

KEYWORDS

open access resources, open access services, digital ecosysytem, technology transfer office

1. INTRODUCTION

Improving the national innovation system is a key factor in increasing the country's competitiveness in the modern environment, often defined as a "knowledge economy" and focused on the commercialization of scientific results. Of particular importance in this context are studies aimed at improving technology transfer and organizing effective interaction between all participants.

Technology transfer is considered as one of the most important instruments for national and regional economic growth.

Much attention in Belarus is paid to improving the functioning of technology transfer offices (TTOs).

The activities of TTOs are aimed at commercializing the results of R&D, ensuring the acceleration of solutions for technical and technological problems of enterprises, improving the quality of their products, and mastering the production of new types of products.

The main activities of TTOs aimed at the implementation of a set of measures related to transferring innovations from the sphere of their development to the sphere of practical application. They include:

- conducting market research to identify opportunities for implementing innovations by universities, scientific and other organizations;
- performing work to ensure legal protection and introduction of innovations into civil circulation;
- providing engineering and consulting services.

The implementation of new technologies and research results from the scientific and technical sectors in industry is a traditional task, and often the main activity of technology transfer offices. There are several main approaches to technology transfer.

Business assistance: companies providing services on specific issues related to technology can be considered as specialized organizations working in the scientific and technical sectors. In order to correctly navigate among such companies, many TTOs have extensive databases.

Technology dissemination means the transfer of specific knowledge from research institutes to a group of small and medium-sized enterprises with common technology needs.

Technology search consists of analyzing the national and international market in order to acquire promising technologies and commercial opportunities that can be used by companies in a certain region.

This task is often carried out independently of specific industry needs.

In addition to these direct approaches to technology transfer, TTOs are increasingly focusing on the use of various indirect technology transfer mechanisms, such as technology exchange through networks of companies, technology and innovation support centers, product development centers, outsourcing, etc. This means that attention is paid not only to technology transfer from research institutes to industry, but also to stimulating technology exchange directly within industry.

Participation in network organizations allows TTOs:

- develop and maintain high standards for their services;
- significantly increase opportunities for finding partners for technology commercialization projects.
- implement innovation policy at the interregional and international levels.

TTOs, participating in the work of technology transfer networks, can more effectively provide their clients with the following services:

- search for partners for the joint implementation of technology commercialization projects for R&D, entry into new markets, etc;
- dissemination of technological information is a relevant service for scientific organizations that are interested in widely informing industry and companies about their research capabilities and competencies;
- promotion of technological projects using various networking tools;
- a primary analysis of supply and demand in certain subject areas of research.

The main role in the Belarusian technology transfer network infrastructure is played by the Republican Technology Transfer Center (RCTT).

The organizational structure of the RCTT network includes members, clients, partners and a coordinating organization.

Members of the network are research organizations, higher education institutions, enterprises and organizations of all forms of ownership that have TTOs or divisions responsible for

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technology transfer in their structure. Within the framework of the methodology adopted in the RCTT network, network members help their clients prepare proposals for cooperation, requests for the implementation of R&D. [1]. There are 3 options for disseminating them:

- they are posted by network members on the RCTT Internet portal;
- they are posted at the request of network members by the coordinating organization in foreign technology transfer networks;
- they are posted on the websites of foreign partners of the coordinating organization.

Network members help their clients prepare information on the products and services of the organization for posting them at a virtual exhibition on the Internet portal of the Russian Center for Technology Transfer. Network members also monitor external and internal markets to find the target consumers for the organizations. Clients of the network are suppliers and consumers of technologies (research and design organizations, educational institutions, enterprises and organizations of all forms of ownership).

The RCTT is a consortium for coordinating activities in the field of technology transfer, which includes

- head office in Minsk;
- 5 branches in the regions of the Republic of Belarus and 30 branches at research organizations, higher education institutions and enterprises of the Republic of Belarus;
- 97 foreign organizations in 23 countries.

The main objectives of the activities of the RCTT branches at manufacturing and industrial enterprises are:

improving the quality and reducing the cost of manufactured products;

assisting in the expansion of sales markets.

OPEN ACCESS SERVICES FOR INFORMATION SUPPORT OF TTOs

TTOs use various information system and resources to effectively manage and transfer technologies. Some of them are:

- Patent and invention databases: these resources help track and manage intellectual property.
- Scientific publications databases: these resources allow TTOs to stay abreast of the latest advances and innovations in various fields.
- Collaboration and knowledge sharing platforms: such platforms help researchers and developers exchange ideas, find partners, and collaborate on projects.
- Project management information systems: these systems help coordinate project work.
- Marketing and analytics tools: these tools are used to analyze the market and identify needs and opportunities for the commercialization of technologies.

To operate effectively TTOs need high-quality and timely information.

Although patent information has become more accessible in recent years, including through services provided via the Internet on a paid or free basis, the coverage and availability of patent data in some countries, including Belarus, remain limited.

Taking into account such limitations, in 2009 the World Intellectual Property Organization (WIPO) launched an international project to create a network of Technology and Innovation Support Centers (TISCs), the purpose of which is to simplify access to technical knowledge and improve the efficiency of using patent information.

The National Intellectual Property Center (NIPC) is creating a network of TISCs in the Republic of Belarus in accordance with the Agreement between WIPO and NIPC dated October 10, 2016. As part of its implementation, NIPC performs the functions of a coordinating body.

Currently, there are 29 TISCs operating in the Republic of Belarus.

The creation of the TISCs has improved information and scientific-methodological support for information and patent activities, increasing the efficiency of using IP objects.

High-quality scientific information is also one of the most important factors facilitating technology transfer.

Underdeveloped information infrastructure and the lack of objective data on advanced scientific knowledge and developments create serious barriers to the further development of science and its commercialization, significantly reducing the efficiency of TTOs. The so-called "serial publication crisis" [2] has a negative impact on the quality of information support for TTOs, caused by the fact that the traditional commercial economic model of scientific communication leads to a rapid increase in subscription prices with relatively unchanged budgets for organizations. The problem is that both TTOs specialists and researchers working in various subject areas face significant difficulties in the process of searching, obtaining and using information. In the context of the constant growth of scientific output and the simultaneous increase in the cost of access to information resources due to the fact that publishers seek to maximize their profits through the sale of subscriptions to scientific journals, scientists and other consumers of scientific information experience serious difficulties when it is necessary to find a potentially useful scientific result and get acquainted with it [3]. The deficit of high-quality scientific information resources deprives specialists of the opportunity to analyze and objectively evaluate the quality of research and development results.

The important place in the activities of the technology transfer offices is occupied by legal problems and issues of protecting intellectual property, including problems of legislative and judicial protection of copyright. The lack of relevant and up-to-date information in this area significantly reduces the effectiveness of the commercialization of scientific research [4].

To overcome these challenges, we suggest to use open access resources and platforms for facilitating information support of business processes during transfer knowledge and technology.

Open Access (OA) as a movement has been steadily gaining strength for roughly the last two decades. This is due to the following factors:

The number of publications in open access reaches 47% [5].

Research funding programs and foundations require that research results must be published in the OA repositories or OA journals.

Many organizations support the requirements for the openness of primary data and research results.

The citation rate of OA scientific publications is higher than that of those distributed by subscription [6].

Open access resources are increasingly considered like an option to replace expensive commercial databases necessary for the information services of TTOs [7].

Using OA resources can significantly improve the efficiency of Technology Transfer Offices (TTOs). Below are some of the ways in which they can be used.

1. Access to scientific publications. Open access provides free and unrestricted access to scientific articles and research. This allows TTOs to stay up-to-date with the latest advances and innovations in various fields of science and technology.

2. Analysis of patent information. Many patent databases also provide open access to information. This helps TTOs track new patents, analyze trends, and find potential partners for licensing and commercializing technologies. For example, Espacenet provides free access to millions of patents worldwide

3. Collaboration and knowledge sharing. OA platforms facilitate collaboration between researchers and developers. This allows TTOs to find partners for joint projects and share ideas. Examples of such platforms include ResearchGate and Academia.edu.

4. Training and professional development. OA resources can also be used for the training and professional development of TTOs. Online courses and webinars available on platforms such as Coursera and edX help TTOs staff stay up-to-date with new techniques and technologies.

5. Market Research. Using open data and analytics tools helps TTOs conduct market research. This allows for a better understanding of the needs and opportunities for commercializing technologies. Examples of such tools include Google Scholar and Microsoft Academia.

There are many integrated platforms and services for facilitating OA resources usage.

OpenAIRE (the Open Access Infrastructure for Research in Europe) enables the search, discovery and monitoring of the publications and datasets from 100,000+ research projects.

OpenAIRE actively supports the Open Science initiative. On the one hand, OpenAIRE is the network of dedicated Open Science experts promoting and providing training for Open Science.

On the other hand, OpenAIRE is a technical infrastructure harvesting research output from connected data providers. OpenAIRE aims to establish an open and sustainable scholarly communication infrastructure responsible for the overall management, analysis, manipulation, provision, monitoring and cross-linking of all research outcomes.

This combination of knowledge and a pan-European Research Information platform enables OpenAIRE to provide services for researchers, research support organizations, funders, content providers and TTOs such as:

- Integrate scientific information.
- Monitor and report on research outcomes for funders and partners.
- Train and support on all subjects related to OA.
- Discovery of OA output per project, funder, and data provider.

AMiner is a new generation of scientific and technological intelligence analysis and mining platform with completely independent intellectual property rights. It was established by a team led by Professor Tang Jie from the Department of Computer Science and Technology of Tsinghua University.

AMiner's scientific research data includes 331 million papers, 135 million scholars, 1.122 billion paper citation relationships and 8.79 million knowledge entities (this data is in dynamic change).

AMiner integrates academic data from multiple sources by data mining and social network analysis and mining technology to catch paper indexes.

AMiner cooperates with scholars and academic institutions to share papers and scholar data and purchase copyright.

CORE provides access to the world's largest collection of open access scholarly papers by collecting and indexing research from repositories and journals. It is a non-profit service dedicated to the open access mission and a signatory to the Principles for Open Scholarly Infrastructures (POSI) [8]. CORE serves a global network of repositories and journals by improving discoverability and preventing misuse of their content; ensuring that metadata records are uniquely identified; supporting data providers in applying best practices by providing tools for metadata validation, content management, enrichment, and OA compliance; and facilitating machine access to open research. CORE's mission is to index all open access research worldwide and make it accessible to all. In doing so, CORE:

- enriches scientific data using modern text and data mining technologies to make it easier to find;
- enables others to develop new tools and use cases based on the CORE platform;
- supports the network of OA repositories and journals with innovative technical solutions;
- promotes the creation of a scalable and cost-effective way to provide open scientific information.

CORE aggregates research papers from data providers around the world, including institutional and subject repositories and journal publishers. This process, also called data harvesting, enables CORE to offer search, text mining, and analysis capabilities not only on metadata but also on the full text of research articles, making CORE a unique service in the research community.

BASE is one of the largest search engines in the world, particularly for academic web resources. BASE provides over 300 million documents from over 10,000 content providers. Full texts of about 60% of indexed documents are available free of charge [9]. BASE indexes the metadata of all types of academically significant resources (journals, institutional repositories, digital collections, etc.) that provide an OAI interface and use OAI-PMH to provide their content. The index is constantly being expanded by integrating new sources/content providers. Database managers can integrate the BASE index into their local infrastructure (e.g., metasearch engines, library catalogs).

International research collaborations can bring TTOs new opportunities for collaborative research, increase the impact of their research, and boost the commercialization of scientific results. For instance, knowing which institutions globally work on similar research can help identify new partnership opportunities. Identifying existing connections among researchers between those institutions can help drive development opportunities. These data have come through costly subscriptions to restricted databases. OpenAlex now provides the data required for international intelligence freely to all users across the globe [10].

CONCLUSION

Open access platforms and services provide technology transfer offices with effective tools for searching, disseminating and using scientific publications for the purposes of commercializing research. Their use contributes to the acceleration of technology transfer and the increase in the efficiency of innovation activities. OA resources may be integrated using API into the structures of the digital ecosystem of technology transfer, which includes agents (scientific organizations and teams), objects (information and knowledge) and infrastructure (services and information systems).

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Fostering Open Innovation and Technology Transfer: Insights from the Euro-Mediterranean Innovation Camp (EMIC)

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ABSTRACT / POVZETEK

The global marketplace is rapidly evolving, demanding innovative approaches to technology transfer that can bridge the gap between research and commercial application. The Euro-Mediterranean region, with its diverse socio-economic landscape, presents both challenges and opportunities for such endeavors. This paper presents the Euro-Mediterranean Innovation Camp (EMIC) as a successful model for implementing open innovation and technology transfer, particularly within the strategic framework of the Jožef Stefan Institute (JSI) and its partner institutions. The analysis not only draws on the outcomes of the recent EMIC initiatives but also aligns these practical insights with the theoretical foundations of open innovation as discussed in the doctoral disposition on technology transfer.

KEYWORDS / KLJUČNE BESEDE

Open Innovation, Technology Transfer, Euro-Mediterranean Region, EMIC, Jožef Stefan Institute

1 INTRODUCTION

The global marketplace is rapidly evolving, demanding innovative approaches to technology transfer that can bridge the gap between research and commercial application. The Euro-Mediterranean region, with its diverse socio-economic landscape, presents both challenges and opportunities for such endeavors. This paper presents the Euro-Mediterranean Innovation Camp (EMIC) as a successful model for implementing open innovation and technology transfer, particularly within the strategic framework of the Jožef Stefan Institute (JSI) and its partner institutions. The analysis not only draws on the outcomes of the recent EMIC initiatives but also aligns these practical insights with the theoretical foundations of open innovation, as discussed in the doctoral disposition on technology transfer. The main purpose of the paper is to examine the application of open innovation and technology transfer within the Euro-Mediterranean region, using the Euro-Mediterranean Innovation Camp (EMIC) as a case study. The paper explores how EMIC serves as a successful model for bridging the gap between academic research and commercial applications in a region that presents both challenges and opportunities due to its socio-economic diversity. Overall, the paper contributes to the literature on technology transfer by providing a detailed exploration of how structured innovation programs like EMIC can drive economic growth, address pressing global challenges, and create marketable solutions, particularly in the complex and diverse Euro-Mediterranean context.

The EMIC initiative has attracted applicants from over 17 countries, with a significant portion of the applications coming from Egypt and Jordan. The charts below illustrate the diversity and distribution of applicants by country of residence across the two seasons of the program.

(1)

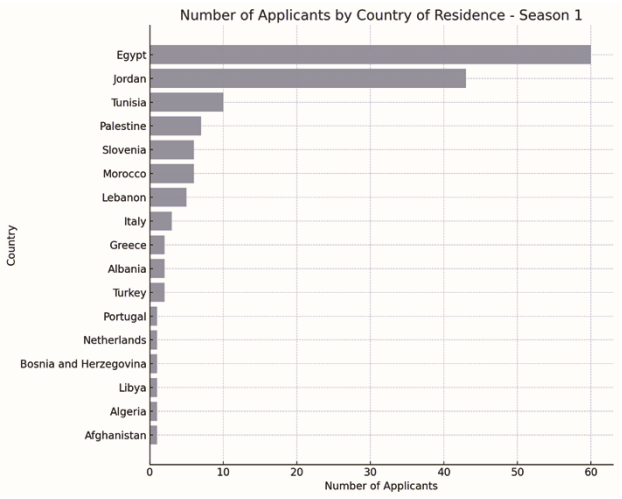

Figure 1: Number of applicants by country of residence – Season 1

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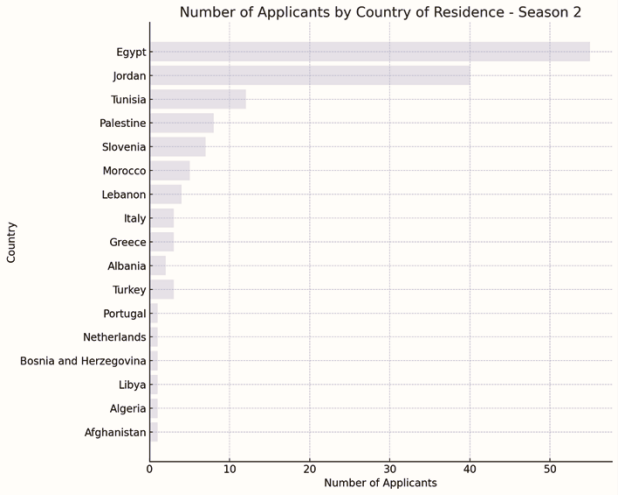

Figure 2: Number of applicants by country of residence – Season 2

Theoretical Foundations: Open Innovation and Technology Transfer

Open innovation, a concept popularized by Henry Chesbrough, has significantly reshaped our understanding of how innovation occurs in the modern business environment. Unlike traditional closed innovation models where companies rely solely on internal resources for R&D, open innovation promotes the use of both internal and external knowledge sources. This approach accelerates the innovation process and expands the potential market for new technologies (Chesbrough, 2005a). In the context of technology transfer, open innovation facilitates the commercialization of intellectual property (IP) through various channels, including licensing, joint ventures, and spin-offs, thus driving economic growth and enhancing competitiveness (Chesbrough, 2003b).

The Euro-Mediterranean region is a fertile ground for applying open innovation principles. However, the integration of public research outputs with industry needs has been a persistent challenge. Slovenia, for instance, excels in scientific output, ranking high in terms of research publications. Yet, as the OECD's 2012 report highlights, the country struggles with the commercialization of research findings, particularly in converting scientific discoveries into marketable products and services. This gap underscores the critical role of initiatives like EMIC, which aim to bridge the divide between academic research and industrial application through structured innovation programs.

The thematic focus of the EMIC projects aligns well with global challenges, as evidenced by the distribution of project types: 45% focused on health, 35% on renewable energy, and 20% on environmental issues, reflecting the alignment of participant interests with critical global needs.

The Euro-Mediterranean Innovation Camp (EMIC): A Model of Open Innovation

The Euro-Mediterranean Innovation Camp (EMIC) is a flagship initiative that embodies the principles of open innovation within the Euro-Mediterranean region. Launched by the Euro-Mediterranean University (EMUNI) in collaboration with the JSI and the EuroMed University of Fes (UEMF), EMIC provides a platform for young innovators to develop and showcase their ideas in response to pressing global challenges. The camp focuses on three critical areas: health, renewable energy, and climate change—fields that are not only relevant to the region but also globally significant.

The EMIC initiative is structured to promote iterative learning and development. Participants, who are selected through a rigorous process, receive mentorship and technical support from experts in their respective fields. This support is crucial in helping them refine their ideas and develop viable prototypes. The average age of participants was 24 years, with the youngest being 18 and the oldest 35, showcasing the youthful energy driving innovation in the Euro-Mediterranean region.

Selection Process of EMIC

The Euro-Mediterranean Innovation Camp (EMIC) follows a rigorous and multi-stage selection process to identify and support the most promising young innovators from across the Euro-Mediterranean region. Here's an overview of the selection process:

1. **Application Submission:**
    - **Eligibility:** Applicants must be between 18 and 35 years old, reside in one of the Euro-Mediterranean countries, and possess at least a high school diploma. The innovation they propose must address one of the three thematic areas: Health, Renewable Energy, or Environment (including Climate Change) and must be capable of being converted into a prototype within three months.
    - **Application Process:** Interested candidates submit their applications through an online form available on the EMUNI website. The application requires a detailed description of the innovative idea or invention, highlighting its novelty, feasibility, and potential for commercialization.
2. **Initial Screening:**
    - A panel of experts reviews all submitted applications. The review process evaluates the novelty of the idea, its practical applicability, and the feasibility of implementation within the specified timeframe.
    - **Shortlisting:** Based on the initial screening, a subset of applicants is shortlisted to advance to the next phase. For instance, in Season 2, out of 124 applications, approximately 40 candidates were

shortlisted for the online pitching phase (EMUNI).

3. **Online Pitching:**
    - **Pitch Preparation:** Shortlisted candidates prepare a pitch presentation, which they deliver via an online platform. During this phase, they present their ideas to a jury comprising experts from relevant fields.
    - **Jury Evaluation:** The jury evaluates the pitches based on several criteria, including innovation, feasibility, potential impact, and the candidate's ability to articulate and defend their idea. The most innovative and viable projects are selected to move forward.
4. **Innovation Bootcamp:**
    - **Workshops and Mentorship:** The selected finalists, known as the "Innovation Squad," are invited to participate in a 10-week bootcamp held at facilities like the Jožef Stefan Institute in Slovenia or the EuroMed University of Fes in Morocco. During this period, they receive technical assistance, mentorship from subject matter experts, and support in refining their prototypes.
    - **Elimination Stages:** Throughout the bootcamp, participants go through multiple elimination stages. These stages are designed to progressively challenge the innovators, focusing on proof of concept, engineering, prototyping/testing, and customer validation. The best performers in each stage advance to the next round (EMUNI).
5. **The Finale:**
    - **Final Presentation:** The competition culminates in a live finale event where the remaining candidates present their fully developed prototypes. This event is attended by a live audience, including mentors, representatives from partner institutions, and other stakeholders.
    - **Scoring:** Final scores are determined by both the jury and audience voting, with each accounting for 50% of the final score. The winners are announced based on the combined results of these evaluations (EMUNI).

This selection process is designed to ensure that the most innovative and feasible ideas are given the support they need to develop into successful market-ready products. It also emphasizes the importance of mentorship and iterative development, helping young innovators turn their ideas into impactful solutions.

Case Studies: Innovations from EMIC Season 2

The impact of EMIC is best illustrated through the success stories of its participants. The most recent season of EMIC, concluded in June 2024, showcased a range of groundbreaking innovations that have the potential to address significant challenges in health and sustainability.

The Euro-Mediterranean Innovation Camp (EMIC) Season 2 brought together some of the brightest minds across the region to develop innovative solutions addressing critical challenges. This section highlights the top three projects that stood out for their creativity, technical expertise, and potential for real-world impact.

1. **Muhammad Mounir (Egypt) – "SugarHeal"**
    - **Project Overview:** Muhammad Mounir, a Molecular Biotechnology student from Galala University, developed "SugarHeal," an innovative wound dressing material designed to accelerate the healing process of chronic and acute wounds. During his time at the Jožef Stefan Institute (JSI), Muhammad explored two main fabrication techniques:
        - **Electrospinning:** He created a cellulose-based solution with antibacterial properties for electrospinning, resulting in a biodegradable wound dressing that promotes faster healing.
        - **3D Bioprinting:** Muhammad also developed a cellulose-based ink enriched with natural antibacterial extracts, which was used in 3D bioprinting to produce customizable wound patches.
    - **Current Stage:** Muhammad has successfully developed prototypes of the wound dressing through 3D bioprinting, which have shown promising results in terms of mechanical stability and biological response. His next steps include further optimization and exploring commercial applications (EMUNI).
2. **Rahma M. Tolba (Egypt) – "Interactive Augmented Reality for Lisp Correction"**
    - **Project Overview:** Rahma Tolba, a PhD researcher from Ain Shams University, developed an interactive Augmented Reality (AR) application designed to assist in speech therapy for individuals with a lisp. Her project focuses on improving phonetic learning through the use of 3D animated models that demonstrate correct tongue movements. The app guides users through pronunciation exercises, providing real-time feedback through an AI-based Automatic Speech Recognition (ASR) system.
    - **Current Stage:** Rahma has developed a fully functional prototype for Android devices, which has been tested on a small group of individuals. The next steps involve gathering user feedback from speech therapists and phoniatricians to refine the design and functionality (EMUNI).

3. **Med Aziz Mhalla (Tunisia) – "Drowsy Driver Detection System"**
    - **Project Overview:** Med Aziz Mhalla, an electronics engineering student from the National Engineering School of Sousse,

created the "Drowsy Driver Detection System" (DDDS). This system leverages machine learning, computer vision, and embedded hardware to monitor drivers in real-time, detecting signs of drowsiness, distraction, and sleep onset. The system uses a Convolutional Neural Network (CNN) model to classify eye states and detect blinks and yawns, which are key indicators of drowsiness.

- **Current Stage:** Med Aziz has successfully developed a proof of concept and prototype that has been tested in controlled environments and on a laptop. He is currently optimizing the system for real-time performance using NVIDIA Jetson Nano and preparing for on-road testing (Med Aziz - Drowsy Driver…).

These projects not only exemplify the innovative spirit fostered by EMIC but also demonstrate the potential for significant contributions to healthcare, road safety, and speech therapy. Each of these top three finalists utilized the mentorship and resources provided during the EMIC bootcamp to bring their ideas closer to real-world application.

The diversity of innovations emerging from EMIC highlights the program's success in fostering creativity across different fields. These projects are not just theoretical exercises; they represent tangible solutions that can have a real-world impact, addressing some of the most pressing challenges in the Euro-Mediterranean region and beyond.

Challenges in Implementing Open Innovation

Despite its successes, the implementation of open innovation within the EMIC framework has not been without challenges. One of the primary challenges is the alignment of the diverse objectives of the program's international partners. The Euro-Mediterranean region encompasses a wide range of economic, social, and political contexts, each with its unique set of challenges. Coordinating efforts across such a diverse region requires careful planning and robust frameworks for collaboration.

Intellectual property (IP) management is another critical challenge in open innovation environments. While open innovation encourages the sharing of ideas and resources, it also raises questions about how IP is managed and protected. In the context of EMIC, ensuring that participants retain control over their innovations while still benefiting from the collaborative environment is crucial. This requires clear guidelines and agreements on IP management, which can be complex to negotiate across different legal and regulatory frameworks.

Another challenge is the scalability of the solutions developed through EMIC. While the innovations produced during the camp are often groundbreaking, bringing these solutions to market on a larger scale requires resources that may not be immediately available to the participants. This is where the support of institutions like JSI and the involvement of industry partners become critical. By providing continued support beyond the initial stages of development, these institutions can help ensure that the innovations produced at EMIC reach their full potential.

Opportunities for Enhancing Open Innovation

Despite these challenges, the EMIC model also presents significant opportunities for enhancing open innovation in the Euro-Mediterranean region. One of the key opportunities lies in the potential for cross-border collaboration. By bringing together participants from different countries and backgrounds, EMIC fosters a rich exchange of ideas and approaches. This diversity is a strength as it allows for the development of solutions that are informed by a wide range of perspectives and experiences.

The full cycle of open innovation and technology transfer has yet to be fully achieved, as both processes require more than just innovative ideas and technological breakthroughs. For these cycles to reach their full potential, business entities must engage early and consistently, starting from the initial stages of research and development. Their investment and involvement are crucial in ensuring that ideas and technologies not only progress beyond the conceptual phase but also successfully transition from labs to the market. Without the proactive participation of businesses, the promise of open innovation and effective technology transfer may remain unfulfilled, with many promising projects never realizing their full impact.

The collaborative model of EMIC, supported by the JSI's extensive research infrastructure, offers valuable insights into how open innovation can be effectively implemented in a complex and diverse region. The partnerships between academic institutions, industry players, and government bodies are crucial in providing the necessary resources for young innovators to translate their ideas into impactful technologies. These partnerships also help to ensure that the innovations produced at EMIC are aligned with market needs, increasing their chances of success.

Another opportunity for enhancing open innovation in the Euro-Mediterranean region is through the development of stronger networks and ecosystems. By fostering closer ties between research institutions, industry, and government, it is possible to create a more supportive environment for innovation. This includes not only providing funding and resources but also creating opportunities for mentorship, networking, and collaboration. Such ecosystems can help to sustain the momentum generated by initiatives like EMIC, ensuring that the innovations produced continue to evolve and have a lasting impact.

Conclusion

The Euro-Mediterranean Innovation Camp (EMIC) serves as a compelling example of how open innovation can be successfully implemented within a structured technology transfer framework. By leveraging the strengths of regional partnerships and focusing on critical areas such as renewable energy, health, and climate change, EMIC has successfully fostered a culture of innovation across the Euro-Mediterranean region. The initiative has not only provided a platform for young innovators to develop their ideas but has also facilitated the transfer of these ideas from research

to market, demonstrating the potential of open innovation to drive economic growth and address global challenges.

Moving forward, it will be crucial to address the challenges of IP management and resource allocation to sustain the momentum generated by these initiatives. The ongoing collaboration between academic institutions like JSI, industry partners, and government bodies will be key to enhancing the commercial viability of the innovations emerging from EMIC. As Slovenia and the broader Euro-Mediterranean region continue to refine their approaches to technology transfer, the lessons learned from EMIC will serve as a valuable guide for future innovation policies and practices.

The success of EMIC highlights the importance of fostering innovation among young people across the Mediterranean region. By providing the necessary support and resources, initiatives like EMIC can help to unlock the full potential of the region's young innovators, driving economic growth and addressing some of the most pressing challenges of our time. As we look to the future, it is clear that open innovation will continue to play a critical role in shaping the global innovation landscape, and initiatives like EMIC will be at the forefront of this exciting journey.

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Research Organisation-Industry Cooperation and State Aid Rules in Slovenia and Europe

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ABSTRACT

This study provides an international comparative view on state aid regulation in infrastructure use and intellectual property rights transfer in cooperative research and development projects within the European Research and Innovation Ecosystem. Technology transfer officers or similar profiles at research organisations were interviewed. Additionally, a desk research was performed. Annual reports were studied in order to identify the differentiation of economic and non-economic activity as well as good practices. Desk research included also rulebooks and related Slovenian & EU legislature in the field of contract and collaborative research.

KEYWORDS

research organisation – industry cooperation, research services, intellectual property rights transfer, state aid rules, Slovenian and European research organisations, research and innovation ecosystem

INTRODUCTION

The European Commission has set specific rules in the field of research, development, and innovation (R&D&I) to prevent market distortion. These rules are described in the European Framework for State aid for R&D&I (2022/C 414/01 [1]) and relate to the Article 107 (1) Treaty on the Functioning of the European Union.

We believe that knowledge and implementation of state aid rules regarding research services (economic activity), collaboration projects (non-economic activity) and intellectual property rights (IPR) are insufficient and could be improved, which was identified also by other authors [2], [3].

1 METHODOLOGY

In order to understand how state aid rules in academia-industry cooperation work in practice, we have performed a detailed analysis with an international comparative view. Experience and good practices have been collected from different types of groups, i.e. researchers, industry, technology transfer managers, contract research managers and accounting officers. We have focused on Slovenian research organisations, in addition to which we included two European research organisations in order to make international comparison. In spring 2024 we concluded 8 in-person or online semi-structured interviews with R&D managers from 7 research organisations.

2 DESK RESEARCH RESULTS

2.1 Share of economic activity, rulebooks and pricelists

Our study comprised 13 Slovenian, 1 Czech and 1 Italian public research organisation (Table 1). As foreseen in articles 16 (ff) and 19 of EC Communication (2022/C 414/01), the research organisation has to account for the costs and the revenues of the economic activities separately. Different practices on how to do this exist among European research organisations. It was observed that most research organisations generate up to 20% of their revenues from economic activities. This correlates well with the maximum 20% capacity limit as foreseen in 2022/C 414/01 (it should however be noted that % of income may differ from % of capacity, which is the actual threshold value).

Some organisations in the study have around 50% of their activities classified as economic in nature. They most likely surpass 20% of economic activities' capacity limit. For this reason, they as whole cannot be considered as research organisations according to 2022/C 414/01. Only departments, laboratories or similar subunits of such organisations which do not surpass 20% of economic activities' capacity limit can be considered 'research organisations'.

In Slovenia, the new Law on Scientific Research and Innovation Activities (ZZrID) entered into force on 1 January 2022 [15]. In the same period, a Rulebook on procedures for implementing the budget of the Republic of Slovenia was updated. Article 119(b) requires each public research organisation to have an internal rulebook and pricelist regarding sale of products and services, i.e. economic activity [16]. Up to date, several Slovenian research organisations have prepared their rulebooks and pricelists, while many have not yet (at least they are not publicly available).

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The sizes of analysed organisations vary a lot, i.e. from 58 to 9560 employees. This strongly affects the organisational structure and extent of experience in a specific organisation.

Table 1: Selected Slovenian and European research organisations and their info on economic activities.

Organisation	Country	Share of economic activity in 2023	Rulebook for sale of products and services	Pricelist of products and services	Number of employees in 2023	Source
Slovenian National Building and Civil Engineering Institute	SI	53.6%	16.08.2022	11.01.2022	254	[4], [5]
University of Ljubljana, Faculty of Medicine	SI	48.2%	unpublished / under preparation	unpublished / under preparation	829	[4]
Agricultural Institute of Slovenia	SI	23.7%	unpublished / under preparation	28.11.2023	258	[4], [6]
Geological Survey of Slovenia	SI	15.0%	11.08.2022	23.02.2023	124	[4], [7]
Institute of Metals and Technology	SI	14.9%	unpublished / under preparation	unpublished / under preparation	58	[4]
University of Ljubljana, Faculty of Electrical Engineering	SI	12.0%	unpublished / under preparation	unpublished / under preparation	362	[4]
Jožef Stefan Institute	SI	10.2%	under preparation	unpublished, to be updated	1206	[4]
University of Ljubljana, Faculty of Mechanical Engineering	SI	10.0%	unpublished / under preparation	unpublished / under preparation	433	[4]
National Institute of Biology	SI	8.7%	3.11.2023	9.02.2023	194	[4], [8]
Czech Academy of Sciences	CZ	7.4%	different guidelines, decentralised	not identified, decentralised	9560	[9], [10]
University of Ljubljana, Faculty of Pharmacy	SI	6.2%	unpublished / under preparation	unpublished	199	[4]
National Institute of Chemistry	SI	5.0%	24.08.2022	24.08.2022	437	[4], [11]
University of Maribor	SI	4.5%	unpublished / under preparation	6.11.2023 (UM-FVV), decentralised	2121	[4], [12]
Consiglio Nazionale delle Ricerche	IT	0.47%	not identified, decentralised	not identified	8457 (year 2022)	[13], [14]
Faculty of Information Studies in Novo mesto	SI	0.03%	under preparation	under preparation	82	[4]

2.2 Good and bad examples of transparent bookkeeping and economic activity management

The transparency of studied research organisations is good. Yearly reports support this observation. However, due to differentiation in the reports' structure, the comparison is sometimes difficult. An additional challenge is the lack of standardisation in terminology.

One of the important messages of EC Communication 2022/C 414/01 is the requirement to differentiate economic (such as research service) and non-economic activities (such as collaborative research and knowledge transfer activities). It should be noted that in the Slovenian legislature and consequently other documents, terminology 'market activity' is used, which is not well defined. Sometimes it is used as 'economic activity' and sometimes as activity on the 'market', with again different interpretations ('market' as everything outside Slovenian Research and Innovation Agency – ARIS; or everything related to for-profit organisations).

Several Slovenian institutes, such as National Institute of Biology, Institute of Metals and Technology, Slovenian National Building and Civil Engineering Institute, National Institute of Chemistry, and Agricultural Institute of Slovenia present their contract and collaborative research activities well. Some unclarity persists, which is also highlighted below in the translated sections of the annual reports. We assume that this is caused due to the use of vague terminology, as explained above, and the lack of differentiation between economic and non-economic activities.

The Consiglio Nazionale delle Ricerche defines its income and outcome well, but unlike other annual reports, its annual report is not supplemented with qualitative description. The annual report of the Czech Academy of Sciences (CAS) is very informative. Subunits (i.e, institutes of CAS) have their own

annual reports, which present their technology transfer activities well, while contract and collaborative research are inadequately described. Additionally, the financial part contains non-machine readable text, which cannot be easily translated.

Examples

At the Jožef Stefan Institute, Horizon 2020 and Horizon Europe projects were classified as market projects, which were changed in 2022. From the total number of market activities' income, it was thus unclear which activities were economic and which non-economic.

At the National Institute of Chemistry, royalties and other revenues from patents are classified as a group of market revenues instead of a group of non-economic activities. In the case that market revenues are considered economic activities, this classification is false.

At the National Institute of Biology as well as some other Slovenian research organisations, collaboration projects with industry such as ARIS applied projects (TRL1-4) are classified as a market activity in the annual report 2023. However, it is not clear from the annual report that this is a non-economic activity.

In Table 2, we can see a very good delimitation between contract research ('laboratory services') and collaborative research ('research projects with industry'). However, these two categories are later wrongly joined into one category, 'income from goods and services on the market' (Table 3). We believe this is not an isolated case among research organisations.

Table 2. Income from market activity of the Institute of Metals and Technology (IMT). Annual report of IMT for 2023, p. 99 [1].

	2023
Laboratory services	326,756.14
Research projects with industry	325,486.68
The rest	9,267.83
Market together	**661,510.65**

Table 3. Statement of income and expenses of the Institute of Metals and Technology (IMT). Annual report of IMT for 2023, p. 80 [1].

Breakdown of subgroups of accounts	Account subgroup name	Label for AOP	Amount	
			AMOUNT-Income and implementation expenses public services	AMOUNT-Income and sales expenses goods and services on the market
1	2	3	4	5
	A) INCOME FROM BUSINESS (661+662-663+664)	**660**	**3,668,755**	**652,828**
760	INCOME FROM THE SALE OF PRODUCTS AND SERVICES	661	3,668,755	652,828
	INCREASE IN THE VALUE OF INVENTORIES OF PRODUCTS AND WORK IN PROGRESS	662	0	0

3 QUALITATIVE ANALYSIS

Awareness and knowledge about state aid legislation varied among the interviewees. Most of them are well acquainted with EC Communication 2022/C 414/01, especially those whose main profession is technology transfer or accounting. In accounting, managers get familiar with state aid rules when there are investments in bigger infrastructure and financer monitors the economic/non-economic activities of the unit using the infrastructure.

During the semi-structured interviews, the organisational structure of academia – industry cooperation management was discussed. Intellectual property management (patenting, licensing etc.) is often centralized, even at large research organisations such as Consiglio Nazionale delle Ricerche, University of Ljubljana and University of Maribor. On the contrary, contract research is decentralised and managed in smaller units. Comprehensive and standardised management, established rulebooks and pricelists often lack at the institutions that have a very low percentage of contract research. The management is often left to departments which leads to different approaches in price setting etc. Interestingly, there are still some researchers that are surprised to hear that economic activity is allowed to be performed, and accountants that believe there should be no margin included in prices of public research organisations' services.

3.1 Contract research

Different approaches to establish a pricelist of services and goods exist. They can be structured using either a cost based approach or market based approach. In a market based approach, organisations observe the prices of other service providers, while in a cost based approach, the costs are summed up and a margin is added.

In a cost based approach, direct costs are sometimes joined in cost blocks composed of work costs, depreciation of the cost of the infrastructure, costs for maintenance and running of the infrastructure (electricity, water, heating, ventilation ...) and materials. Such cost blocks are then multiplied based on the number of samples or complexity of the task. Some organisations add direct costs in % of work, while others in % of all direct costs. Both options can be found in public funded calls.

Prices are often established and then regulated by the inflation rate or other changes in cost structure. Sometimes this does not take place, especially when the activities are less important for the department or institute.

3.2 Intellectual property in collaboration projects and start-up companies

Management of intellectual property rights (IPR) in collaboration projects was discussed with technology transfer managers. In most cases it is advised to discuss and agree to IPR in advance. Sometimes even the IPR' price is evaluated in advance. Internal policy of one interviewed research organisation regarding the 2022/C 414/01 article 29(c) is that a company can be co-owner of invention or other IPR only when they provide intellectual contribution, not financial or other in-kind contribution such as equipment usage. Another research institute has interpreted this article in a way that a financial contribution of the company to the project, for example 25% in cash, can result in an automated 25% co-ownership of IPR, generated in the project. It is important to note that this institute has a policy that in case of IPR exploitation, the co-owner has to (financially) compensate the other co-owner(s).

The most common procedure to conclude a licence or sale agreement is thus to use arm's length negotiations – article 30(c). The licence agreement commonly involves lump sum and royalties. One research organisation mentioned that they negotiate with their spin-out companies in the same manner as with other companies, which is fair. However, the specific characteristics of start-up companies should be taken into consideration.

With the implementation of the new Law on Scientific Research and Innovation Activities, research organisations in Slovenia are now permitted to establish spin-off companies, which they enter into ownership with equity. To our knowledge, no such companies have yet been established in Slovenia. In the last 2 years, CAS has established 5 such companies encountering many difficulties throughout the process. One of the main concerns is the accuracy and changeability of IPR price.

4 CONCLUSIONS

Differentiation between contract research and collaborative research in Slovenian research organisations is not well known and could be improved. There are many projects between research organisations and companies that fall somewhere between contract research and collaborative research. For example, different methodologies in literature were tested ([17], [18]), which produced two different results for the same project. Nevertheless, due to the obligation to account for the economic activities separately, each such project should be labelled as either (i) a contract research or (ii) a collaborative research. According to our discussion, this happens only rarely. As discussed above, the activities in Slovenia are divided into public service and market activities which makes it more complicated to introduce another set of classification. Label 'economic activity' or 'non-economic activity' should be assigned during the process of bookkeeping, i.e. when the invoice is issued or contract concluded. A more significant, but important change of replacing wording 'public service/market activity' with 'economic/non-economic activity' in Slovenian legislation should be made. We communicated this with representatives from the Slovenian Ministry of Higher Education, Science and Innovation, which will consider this recommendation.

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Feasibility Analysis for the New Mechanism of Knowledge Transfer within the INDUSAC Project

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ABSTRACT

In September 2022, the Horizon Europe INDUSAC project introduced a novel mechanism for knowledge transfer, extending the usual company-researcher partnerships to include students as well. Between March and May 2024, thirteen co-creation projects involving international teams of students and researchers solving companies' challenges, were carried out. This study describes results of surveys given to companies, students and researchers about their experience in the projects, and the level of usefulness of solutions made possible by the collaboration. We analyzed data collected from 10 companies, 57 students and 4 researchers. Measured on the Likert scale, satisfaction of companies with technical aspects of the methodology ranged from average to good (average values between 3.1 and 4.2), whereas their satisfaction with the solution to their challenge, and with the work done by the team, had a narrower range between 3.2 and 3.8. Financial support to student members of co-creation teams, in the amount of up to 1,000 EUR gross per student, was perceived as sufficient by 67% of students. Initial results indicate that the INDUSAC mechanism is relatively well accepted among companies, with room for improvement in certain aspects such as the user-friendliness of the platform and the time allowed to solve a challenge. Overall, around 30 % of co-creation projects have demonstrated true value to the company involved, and there is potential in the further 50 %. Selected testimonials from companies, complimenting the work of students and expressing their own belief that the students are richer for the experience as well, demonstrate that the INDUSAC mechanism shows promise in knowledge transfer.

KEYWORDS

INDUSAC project, international cooperation, student-industry cooperation, knowledge transfer

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1 INTRODUCTION

In September 2022, the Horizon Europe INDUSAC project (www.indusac.eu; EU project number 101070297) introduced a novel mechanism for knowledge transfer, extending the usual company-researcher partnerships to include students as well. It comprises a methodology that would allow for a streamlined facilitation of collaboration between industry and academia, and an online platform to support that methodology [1]. In November 2023, the INDUSAC project, coordinated by the Jožef Stefan Institute, commenced its piloting phase wherein universities, public research organisations, and companies were invited by the international project consortium to join the project. The idea behind the methodology is to bring together a company and an international team of 3-6 students and/or researchers to solve a company challenge within 4-8 weeks, with the company providing assistance during regular meetings with the team. The team delivers results in the form of pre-defined types of deliverables specific for the type of challenge, and the deliverables are evaluated by companies. Being the main target audience, during the project, special attention was given to students / researchers from EU widening countries, and geographical and gender balance was ensured by the criteria that team members must be from at least three different countries, and must include representatives of at least two gender groups; student members of the co-creation teams were financially rewarded for successfully completing the project. First such collaborations started in March 2024 and wrapped up in May 2024. This study describes results of surveys given to companies, students and researchers about their experience in the project, and the level of usefulness of solutions made possible by the collaboration. Implications for the feasibility of this concept of knowledge transfer are discussed.

2 METHODS

As per the methodology of the project, students and researchers were surveyed before they started working on the solution to the company's challenge, and after they finished. Topics in the survey, relevant to the scope of this study, included the students' feedback on how the collaboration affects social impact, and how appropriate the funding is. In addition, companies were surveyed

after the project, mainly about the quality of work performed by the students / researchers, and the impact that their work has. All surveyed individuals were asked to provide short testimonials about their impressions and satisfaction. Students / researchers were asked to fill in separate surveys for separate co-creation projects (maximum three) and companies were likewise asked to fill in separate surveys for each team they worked with. Further details are indicated in the Results section. In this study, we analyzed data collected from 10 companies, 57 students and 4 researchers.

3 RESULTS

In the first round of the INDUSAC co-creation projects, taking place between March and May 2024, thirteen co-creation projects took place that resulted in proposed solutions, two of which were rejected and eleven approved by companies. Companies' overall satisfaction with the INDUSAC process after the projects, expressed as various aspects of the methodology, is shown in Figure 1. Satisfaction was evaluated on a Likert scale from 1 to 5. On average, the processes of registering on the platform, publishing Challenges, and reviewing Motivation Letters (ie., students' applications) ranked highest at 4.0, 4.0, and 4.2, respectively, while the user-friendliness of the INDUSAC platform and the time allowed to solve a challenge ranked lowest, each at 3.1.

Companies' overall satisfaction with the solution to their challenge, and with the work done by the team, expressed as various attributes, is shown in Figure 2. Satisfaction was evaluated on a Likert scale from 1 to 5. On average, relevance of the solution, quality of work of the team, and satisfaction with the work of the team ranked highest at 3.8 each, while the market potential of the solution ranked lowest, at 3.2.

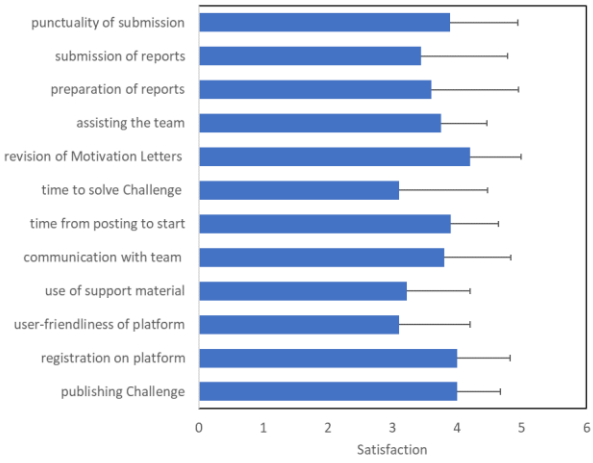

Figure 1: Satisfaction of companies with technical aspects of the methodology. Average values ± sd are shown (n = 8 for assistance to the team, n = 9 for support material, submission of deliverables and punctuality of submission, and n = 10 for the other nine categories). Satisfaction was measured on a Likert scale: 1 – very poor, 2- poor, 3 – average, 4 – good, 5- very good.

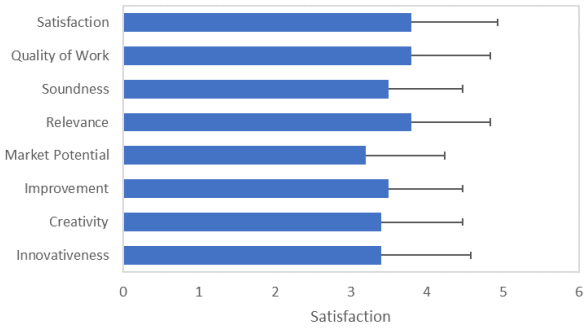

Figure 2: Satisfaction of companies with work of the co-creation team and the solution delivered. Average values ± sd are shown (n = 10). Of the categories surveyed, Satisfaction, Quality of Work, and Soundness refer to the work done by the co-creation team, whereas Relevance, Market Potential, Improvement over existing solutions, Creativity, and Innovativeness refer to the solution delivered. Satisfaction was measured on a Likert scale: 1 – very poor, 2- poor, 3 – average, 4 – good, 5- very good.

In terms of delivery of results, the companies have reported that all requested deliverables had been delivered by the co-creation teams in all cases except one (representing one of the projects where the solution was rejected). In terms of follow-up on the solution within the company, indicating its usefulness, two companies have already started, a third company has confirmed that they will follow up on the solution, while 5 have not yet decided and in two cases it will probably not happen.

Since the INDUSAC project put a fair amount of emphasis on social aspects such as geographically and gender-balanced collaboration, the survey for students and researchers included questions on agreement with (i) incorporation by the co-creation process of customer research and insights to understand the end-users' needs and preferences, (ii) solutions that specifically addressed gender-related issues or considerations, and (iii) successful prioritisation of the human aspect (Inclusivity, Gender dimension, Interdisciplinarity, User Perspective, Collaboration, Iterative Feedback, Ethical Considerations) and creation of a meaningful and inclusive environment. Results are shown in Figure 3. Agreement was evaluated on a Likert scale from 1 to 5. On average, all three categories ranked fairly high, between 4.0 and 4.5.

Lastly, questions about the adequateness of financial support to students, were also included in the survey. As per the INDUSAC methodology, each student received up to 1.000 EUR gross for a successfully finished project, and this amount was reduced as the number of students per team increased, as each team received up to 3.000 EUR gross. Results, demonstrated as distribution of opinions among different geographical groups (ie., EU member states, widening countries, and EU associated countries), are given in Figure 4, and indicate that overall, between 58% and 70% of students agree that funding was sufficient.

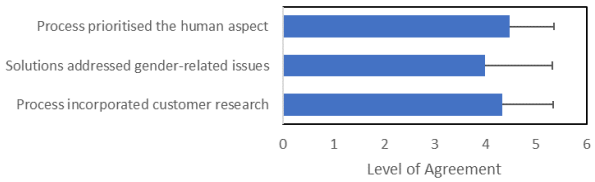

Figure 3: Agreement of students / researchers with incorporation of customer-oriented and human-focused elements in the projects. Average values ± sd are shown (n = 61). Agreement was measured on a Likert scale: 1 – very poor, 2- poor, 3 – average, 4 – good, 5- very good.

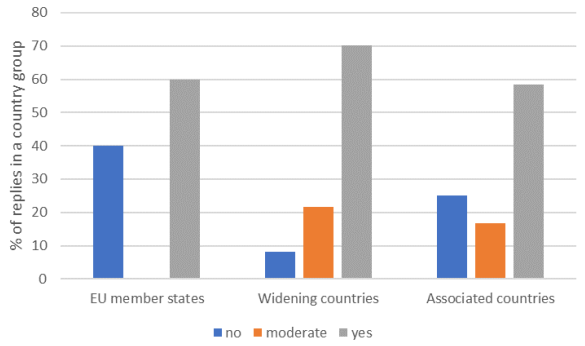

Figure 4: Perception of adequacy of funding within the scheme in the INUDSAC project, as surveyed among students and researchers from different countries of residency. Within EU member states, there were no opinions towards [moderate]. Total number of individuals responding was 5 in EU Member States, 37 in widening countries, and 12 in associated countries.

4 DISCUSSION

The INDUSAC approach set out to bring several advantages to the existing landscape of knowledge transfer practices, such as inclusiveness represented by gender balance, international cooperation by mandatory geographical diversity, enhanced support to widening countries by mandatory representation in the teams, and expansion to include students via mandatory participation of at least one student per team solving companies' challenges; some of these have already shown to be advantageous for companies [2-4]. Our results point to initial indications that the INDUSAC mechanism, comprising the methodology and the platform, is relatively well accepted among companies (Figure 1), with room for improvement in certain aspects such as the user-friendliness of the platform and the time allowed to solve a challenge. The latter points to a general enthusiasm among companies to engage in finding solutions for more serious challenges as well, which is encouraging – in two cases, work is already under way to continue with the projects, and overall, around 30 % of co-creation projects have demonstrated true value to the company involved, and there is potential in the further 50 %. So even with the constraints given, and taking two out of thirteen solutions rejected into account, companies have expressed a fair level of general satisfaction with the solutions and the work done by the teams (Figure 2). It is likely that this was aided by the methodology sections which defined interim reviews and evaluation steps (eg., reviews of challenges before publishing, reviews of Motivation Letters before starting, etc.), and regular communication between companies and co-creation teams during the project. In all except in one case, all deliverables were satisfactorily produced by the teams, indicating that the supporting documents that comprised the deliverables, and which were developed within the INDUSAC consortium, served as useful guidelines for particular type of challenge.

Having the project open to a wide range of challenge types also proved beneficial as among the 13 projects for which solutions were provided, seven out of nine possible challenge types were represented, and distribution among different challenge types was fairly even, with 'Marketing campaigns' and 'Service and product ideas' being most preferred.

An additional advantage was presented by the fact that the efforts to facilitate knowledge transfer between industry and academia are financially supported within the INDUSAC scheme. This type of support is particularly welcome, as the lack of funding is a frequent barrier for student-industry collaboration [5,6]. Around two thirds of surveyed students found funding to be adequate, and the largest percentage of this opinion was found among students from widening countries (Figure 4) indicating that the funding scheme shows promise for the major target group of the project.

There is, however, room for improvement – not least based on comments given by the companies themselves. Geographical balance, for example, may in some cases be an obstacle, as, in one company's opinion, having a team with members from different countries can make it difficult to work on projects that require physical experience with a product. It is likewise important to be able to streamline the process, which needs to be backed by a reliably functioning platform, as well as to unify the working space, as it was, in one company's opinion, difficult to keep track which information they received from which platform. Lastly, as mentioned, companies have expressed interest in a more flexible data management, as the project's timeline may prove too rigid. In terms of funding, one student pointed out that it would have been preferable to receive funding during the project rather than after, to allow for traveling to companies and collecting data. The problem of limited mobility was also perceived by companies, two of which stated that the biggest challenge in projects related to physical products was that the participants cannot get to know and test the products live, and that creativity may be limited due to the lack of face-to-face interaction with products and colleagues.

5 FUTURE PERSPECTIVES

The INDUSAC project set out to show that companies benefit from a particular type of knowledge transfer in the form of creative young minds, that this knowledge transfer brings satisfactory results and useful solutions, and that the gender and geographical balance, as well as the inclusion of social elements

(Figure 3) have a positive effect on the overall process (satisfaction by teams, satisfaction by companies). While we did not perform any control studies (for example, with single-gender teams) to truly test the effect of gender balance, there was a slight positive effect of (i) number of team members and (ii) ratio of female-vs-male team members, on company's satisfaction with results and quality of work (unpublished data). Other results and selected testimonials from companies, complimenting the work of students and expressing their own belief that the students are richer for the experience as well, demonstrate that the INDUSAC mechanism shows promise in knowledge transfer, and the rejected solutions stand as reminders that even following the careful process of team assembly and selection, monitoring of the work done needs to be vigilant for it to lead to satisfactory results. With this in mind, the INDUSAC methodology is continuously improving and mechanisms are put in place to minimize such occurrences. The challenges that remain also include attracting larger numbers of companies and students / researchers to engage into cooperation, but the level of success described here represents a strong starting point.

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Approaches to Monitoring and Impact Assessment in Research Infrastructures

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ABSTRACT

Impact assessment is a critical process in understanding the broader effects of research infrastructures (RI) on various sectors such as science, society, the economy, and policy-making. It helps RI identify their strengths, weaknesses, and areas for improvement. The paper addresses the challenges of monitoring and evaluating the impact of RI, focusing on the distinction between performance monitoring and impact assessment. It emphasizes the importance of demonstrating the broader societal, economic, and scientific impacts of RIs to inform public policy and secure funding. In the article we address different methodological approaches to impact assessment and self-evaluation of RIs as well as the possible challenges in these processes. The paper advances the integration of multiple evaluation approaches to provide a robust and detailed assessment of the contributions RIs make to society, the economy, and scientific development.

KEYWORDS

Impact assessment, monitoring, research infrastructures

1 INTRODUCTION

Research Infrastructures (RIs) are essential facilities that offer resources and services to research communities, enabling them to conduct research and drive innovation. Beyond their primary role in research, these infrastructures can also support education, public services, and other non-research activities. They may take various forms, including single site, distributed, or virtual setups. RIs encompass human resources, major equipment, and/or sets of instruments, as well as resources containing knowledge, such as collections, archives, and databases. They are used by scientists from various disciplines – e.g. astronomy, biology, chemistry, physics, human and social sciences, etc. RIs can maintain their competitive advantage only if they keep pace with the latest advancements in relevant scientific fields and the newest techniques and technologies. Therefore, it is crucial for RIs to connect with the research community and industry to stay aligned with developments in both science and technology. [1]

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In recent decades the significance of research infrastructures has become increasingly evident across all fields.

Although RIs are primarily designed to meet research needs, their influence extends well beyond promoting scientific excellence. The advanced technological capabilities and concentration of skilled expertise they provide can stimulate innovation, create or expand markets, attract foreign investment, boost economic activity, and potentially enrich the social and cultural life of a region. [2]

RIs necessitate relatively large and long-term financial investments, making it crucial for investors, policymakers, and other stakeholders to ensure that these infrastructures operate successfully and effectively, contributing to scientific advancement and addressing societal and economic challenges.

Although reflections and publications on defining and measuring impact have increased in recent years, there is still no unified framework or consensus on how to assess the impact of RIs. Therefore, it is crucial to explore the potential for developing such a framework and investigating its practical application.

2 PERFORMANCE MONITORING AND IMPACT ASSESSMENT

To this end, various solutions have been developed to enable stakeholders to monitor performance and evaluate the impact of RIs. However, there is a distinction between these two activities, which this paper aims to clarify. The concepts of performance monitoring and impact assessment represent two distinct yet related processes for evaluating the activities of institutions. Although both processes involve data collection and analysis of RI performance outcomes, their focus, scope, and objectives differ.

Performance monitoring, often simply referred to as "monitoring", involves the systematic and regular collection and analysis of data related to activities and outcomes. This process is crucial for assessing progress toward predefined goals, identifying areas where activities are achieving success, and pinpointing areas that require improvement. Typically, performance monitoring focuses on tracking key performance indicators (KPIs), which serve as measurable values that reflect the effectiveness and efficiency of the activities being evaluated (e.g. Number of publications, Number of master and PhD students using the RI, Outreach through media, ...).

Impact assessment, in contrast, focuses on identifying and evaluating the changes within the broader ecosystem that result from the activities and outcomes of RIs. This process aims to determine which specific RI activities lead to impacts across

various domains. A well-established approach, developed through European initiatives (such as the RI-PATHS [3] project), is the concept of "impact pathways". This method enables evaluators to trace the different routes through which activities translate into impacts at various socio-economic levels.

Impact assessments can be conducted either before or after the implementation of RI. When carried out during the planning phase, this process is known as an "ex-ante" impact assessment. Its purpose is to forecast the potential impacts of the RI, anticipate its effects, and inform strategic planning to ensure those outcomes are realized. This type of assessment is largely conceptual and, to some degree, abstract. Once the RI is established and fully operational, an "ex-post impact assessment" is conducted to evaluate whether the RI has successfully met its intended objectives.

When determining criteria and indicators for monitoring and evaluating (e.g., research infrastructures, measures, programs, policies), it is crucial to recognize the differing roles of these two processes. Monitoring focuses on real-time oversight of implementation: as a funder, one needs to know the current status, whether progress is on track, whether funds have been appropriately allocated, whether a sufficient number of target audiences has been engaged, etc. While monitoring can alert us that things are not proceeding as planned, it does not reveal the causes of deviations nor provide adequate information for making necessary corrective actions [4].

On the other hand, the role of evaluation is to explain how the institution/measure/program/policy functioned, how successful it was in achieving its objectives, and what its impacts were. Evaluation allows us to determine success, identify what worked and what did not, and, if not, what changes need to be made in future planning. The focus of evaluation may be on assessing the degree to which objectives are achieved, or it may focus on the process of implementing the instrument/program/policy itself.

Impact assessment is beneficial for RIs when used to evaluate and enhance their functioning. It plays a crucial role in the strategic planning of an RI by informing decisions on internal resource allocation and driving continuous improvement and alignment of services with the needs of users and other stakeholders. Additionally, impact assessment fosters accountability and transparency, thereby enhancing the legitimacy, visibility, and overall value of the RI. Furthermore, it serves as a platform for meaningful dialogue and exchange among relevant stakeholders regarding the objectives, direction, and operations of RIs, which can be exceptionally valuable. [5]

The OECD defines impact as "the extent to which an intervention has produced, or is expected to produce, positive or negative, intended or unintended effects at a higher level." [5] The European Commission mandates the implementation of impact assessments for every policy intervention or law (including investments in research infrastructure and their activities) expected to cause significant effects or require substantial financial resources. Impacts represent all "direct or indirect changes" relative to the baseline scenario. Such impacts may occur over different time periods, affect different stakeholders, and be relevant at different levels (local, regional, national, and EU) [6].

2.1 Defining Areas for Impact Assessment

Impact assessment becomes especially crucial in times of limited public funding for science. By highlighting the effects of RIs on science, society, the environment, the economy, and other sectors, impact assessments can demonstrate the value of both potential and actual investments in RIs. This analysis helps to underscore the relevance of these investments in addressing societal needs. Moreover, impact assessments provide policymakers with a clear picture of the broader benefits that RI activities offer, thereby supporting the development of informed public policies and decision-making.

Impact assessment is closely tied to the goals of RIs and the expectations they set. The ESFRI [1] working group on RI performance monitoring has identified nine objectives which are relevant to RIs [7], and largely correspond to the following five impact areas:

- **Contribution to Scientific Excellence**: At the heart of every RI is the drive for scientific excellence. RIs contribute in numerous ways, including data collection and preservation, providing access to infrastructure and databases, sample collection and dissemination, facilitating analytical experiments, offering software, and providing general support to researchers. These activities are fundamental to the research process, fostering scientific progress by advancing innovative research, expanding the frontiers of knowledge, and generating new insights and discoveries.
- **Addressing Societal Challenges**: In recent years, addressing societal challenges has become an increasingly important focus for RIs. Their impact ranges from contributing to the United Nations' Sustainable Development Goals and the European Green Deal to enhancing public understanding of science.
- **Contribution to Innovation and Economic Development**: Given the substantial financial investments required by RIs, it is crucial to highlight their role in driving innovation and economic growth. This can be reflected in job creation, economic development, or increased competitiveness, particularly at local, regional, and national levels. Large RIs, in particular, employ a significant workforce and, in some cases, make substantial investments in constructing and offering high-value-added components.
- **Contribution to Policy-Making**: Research facilitated by RIs can significantly inform policy-making across various thematic areas. This is especially important for organizations responsible for policy development at the European or national level.
- **Contribution to Human Resource Development**: Many RIs also focus on education and training, often dedicating significant resources to these efforts. As centers of scientific excellence, they play a crucial role in developing human resources and training the next generation of scientists. They impact their users and their careers through enhanced scientific excellence, productivity, networking, and training opportunities.

[1] European Strategy Forum on Research Infrastructures

Listed areas are not relevant only to RIs, but can be relevant also to other research organizations.

3 METHODS AND APPROACHES FOR MEASURING IMPACT

In the RI-PATHS project [3] a comprehensive review of literature was conducted on methodologies for evaluating and measuring the socio-economic impacts of RIs. The project focused on ex-post impact evaluation methodologies, which are employed during the operation of RIs when it is possible to ascertain whether they are creating certain impacts and in what manner. The effectiveness of the analysis is demonstrated quantitatively (e.g., through indicators) or qualitatively (e.g., through case studies). [8]

Six main approaches/methods for measuring impact based on the literature review were identified:

1. Socio-economic assessment based on impact multipliers: This approach evaluates the socio-economic impact of a policy or project by quantifying the effects on various economic sectors. The assessment is based on impact multipliers that estimate the indirect effects of the policy or project on the economy. This approach expresses impacts on aggregated macroeconomic variables such as GDP, gross value added, or employment. The main advantage of this methodology, which is grounded in a well-established theory and uses input/output analysis tools, is its reliability in producing reproducible and comparable project results. However, its limitation is its restricted validity, as it often cannot reliably measure non-monetary effects (e.g., cultural, social, and environmental).

2. Methodologies utilizing the knowledge production function: This approach focuses on the impact of research and development activities on the economy. The knowledge production function method quantifies the relationship between research and development investments and economic growth. The approach focuses on only a small portion of the expected socio-economic impacts of RIs.

3. Cost-benefit analysis (CBA): This approach compares the advantages and disadvantages of a policy or project and determines whether the benefits outweigh the costs. The analysis considers both quantitative and qualitative factors to enable well-informed decision-making. All costs or benefits are monetized, even if the effects are not solely financial. Governments and economists frequently use this approach to assess the impact of various investment projects. It is reliable for comparing positive and negative effects and can capture numerous RI impacts. However, it can be expensive and time-consuming and has limited causal explanatory power. Additionally, it may not always capture all drawbacks.

4. Multi-methods multiple partial indicators: This approach combines multiple methods and indicators to evaluate the impact of policies or projects. Methods can include surveys, focus groups, and statistical analysis, while indicators encompass economic, social, and environmental factors. An example of this approach is the OECD framework for socio-economic impacts, which includes a list of 25 essential impact indicators and 58 additional standard indicators.

5. Theory-based approaches: These approaches rely on established economic or social theories to evaluate the impact of a policy or project. They depend on theoretical models and empirical evidence to predict impact. A typical example is the "logical framework/model", which is based on a logical sequence of steps from inputs to impacts. Theory-based approaches share common features such as considering the broader context and external factors that can affect success and defining "impact pathways". The impact pathway approach was further developed in the RI-PATHS project, which explores more details than the logical framework and provides a descriptive vision with more information on causes and effects.

6. Case studies: This approach involves an in-depth analysis of a specific case to understand the effectiveness of a policy or project. The analysis focuses on the specific context, identifying factors contributing to success or failure and deriving lessons that can be applied to future policies and projects. When used in impact evaluations, case studies aim to better reflect the uniqueness and complexity of RIs.

It is evident that some approaches are more suitable for assessing economic rather than social or scientific impact, and vice versa. In general, these approaches can complement each other—some are more quantitative, such as macroeconomic modelling or cost-benefit analysis (CBA), while others are more qualitative, like case study descriptions.

The RI-PATHS project systematically evaluated each of the mentioned approaches using criteria such as reliability, validity, precision, cost and time efficiency, and relevance to both policymakers and research infrastructure managers. It is evident that no single methodological approach can comprehensively address all the questions intended for impact evaluation. However, combining different approaches can offer greater value and effectiveness compared to relying on existing methods alone.

4 IMPACT PATHWAYS AND INDICATORS

While there is not a universally accepted approach to impact assessments in RIs, the work of the RI PATHS project has, as mentioned, become well established in Europe. Indeed, results from the survey conducted by ESFRI among RIs [7] show that impact pathways have become a common method for impact assessments among European RIs. Several RIs have conducted their impact assessments with the help of impact pathways as part of the RI-PATHS pilot exercises (for example, ALBA, ELIXIR, EATRIS) [9]. Identifying impact pathways was also an integral component of the impact assessment of ICOS [10].

The mechanism of impact pathways is recommended as a way to demonstrate causal links between inputs, various activities and outputs of RIs, and their identifiable impacts [3] [11]. These can be both intended or unintended – while impact pathways always have a clear origin in one or few related activities, which are under control of RIs, these activities branch out into different directions and trigger effects in different areas, which can be outside the sphere of influence of RIs. An example of exploring impact pathways according to spheres of control, influence, and interest can be seen in AnaEE's position paper [12], which sought to build a framework that would specify AnaEE's position in the chain of actors generating impact in its scientific field.

In order to map the path from activities of RIs to outcomes and impacts, it is crucial to systematically collect data. This is recommended for both performance monitoring and impact assessment. Several lists of indicators have been proposed in recent years (OECD, RI PATHS, ESFRI WG). The indicators can vary – from those that primarily measure performance, also known as key performance indicators (KPIs) [5], and those which are focused on impact (e.g. OECD prepared a list of impact indicators) [13]. The purpose of impact indicators is to create a link to strategic objectives of RI, as well as to different areas of impact that RIs create. In addition to the connection of indicators with strategic goals, the OECD recommends that the

indicators provide information related to operational issues and that the data is measured in a specific time frame.

Impact indicators can be quantitative or qualitative, e.g. in form of "narratives". This information is usually collected via tailored methods, such as interviews, surveys, or case studies. These indicators are more difficult to be standardised and must be tailored for specific RIs and depend on the context. These methods can help RIs to report on intangible impacts.

5 INTERNAL AND EXTERNAL IMPACT EVALUATION

Both external and internal evaluations are relevant for assessing the impact of RIs, each with its advantages and disadvantages. External evaluations are conducted by independent evaluators who assess the institution's impact. This approach ensures an objective and impartial assessment, as external evaluators are not affiliated with the evaluated institution and are, therefore, less likely to be influenced by internal biases or personal interests. Additionally, external evaluations can provide new perspectives and insights that are not available to internal evaluators. However, external evaluations are often costly and time-consuming and may sometimes fail to account for the contextual nuances and priorities of the evaluated institution.

In contrast, internal impact evaluations rely on an evaluation process conducted by the institution's staff or stakeholders. This approach is more cost-effective and efficient, as internal evaluators are already familiar with the institution and its operations. Internal evaluations may also better consider the institution's contexts and priorities and be more adaptable to changes in RI goals. However, internal evaluations may be biased due to internal motivations and conflicts of interest and may lack the objectivity and independence of external evaluations. Moreover, internal evaluators may be limited by their knowledge and expertise, reducing their ability to bring new insights and perspectives.

The choice between external and internal evaluation often depends on internal capabilities, available resources, evaluation objectives, and so on. To ensure a comprehensive and balanced assessment, it is beneficial to combine both approaches. It is also increasingly common for institutions (including RIs) to periodically self-evaluate, thereby preparing for external evaluation.

6 CHALLENGES AND OBSTACLES

There are several challenges that RIs encounter while conducting impact assessments. Some of them were outlined by respondents to an ESFRI survey among RIs (2023). According to the survey, a recurring challenge was to identify an appropriate method or framework or finding appropriate indicators. Other respondents mentioned the amount of resources required and the time frame needed to properly evaluate the impacts of their infrastructure. In general, some RIs are concerned that impacts may not be properly detected. This is a similar issue to what was described in the ERIC forum's "Report on Socio-economic impact framework" [14] as a "traceability" problem – there is uncertainty about how to link RI activities or data generated within an RI to their subsequent use. One of the RIs responded that measuring innovation or social impacts could take several decades.

It is important to note that some challenges may be specific (or more common) to a certain type of RI or to certain thematic areas they cover. To address this challenge, the recommendation is to avoid directly comparing impacts of RIs, and to consider the diversity of RIs. When deciding on a methodology, it is advisable to tailor the selected methodology to each RI, and first establish a consensus between RIs, funders, governments and other relevant stakeholders. This agreement should establish clear expectations regarding the objectives of the RI and the assessment itself. However, all RIs should strive to demonstrate impact in the field of scientific progress, while considering various other socio-economic impacts.
Providing adequate resources for the implementation of an impact assessment is indeed challenging, in particular as it is necessary to adopt a long-term plan for evaluation in order to capture impacts that take years to reveal. At the same time the data collection needs to be done systematically and begin early enough, which can be more resource intensive although also helps to lower the amount of "ad-hoc" data collection when conducting impact assessments.

In spite of these challenges, impact assessments provide important information for all RI stakeholders, as well as the general public, as they allow RIs to demonstrate their contributions to science, society and the economy, and help improve their performance. As such, they can be used as means to communicate about RI activities. Promoting and disseminating the results of these evaluations can subsequently help promote positive RI development and funding.

7 CONCLUSIONS

Despite the growing focus on this area, there remain significant challenges in developing a unified and comprehensive framework for evaluating such impacts, particularly when accounting for both economic and non-economic factors. There is a reason for that – the unified methodology cannot adequately address all aspects of variety of RIs and the diversity of fields where they operate. There is a number of methods which can be applied, and future work could explore how combinations of different methods (e.g. quantitative, such as macroeconomic modeling and cost-benefit analyses and qualitative such as case studies or theory-based assessments) can be effectively balanced. This could provide more holistic view on RI impacts, especially in understanding intangible impacts like societal and environmental changes.

There are already lists of indicators suggested to be used for impact assessment, nevertheless the selection of indicators should be done with a great deal of prudence and not to be used to compare RIs, given the diversity in their structure and objectives.

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Intellectual Property Valuation in the Cyber Security Sector

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ABSTRACT / POVZETEK

This paper explores the applicability of intellectual property rights (IPR) valuation methods in cyber security by using the criteria of the Artificial Intelligence development phase model. After analysis of the interconnections and interdependency in cyber security products, an approach to data quality is proposed. It is worth emphasizing that the process of valuating IPRs is highly contextual and requires professional judgment based on the experience of the appraiser, now also in terms of data management. This issue has not been discussed in the literature, an article is a contribution to the discussion on the importance of valuation in the cyber sector, given the specific characteristics of cyber start-ups using AI and machine learning solutions. Despite all these difficulties, IPR valuation will become increasingly necessary and induce further questions regarding the valuation of a given intellectual property (IP). Firstly, how to value a patent with Artificial Intelligence (AI), secondly how to assess the level of sophistication of model training, and thirdly how to rate and value data quality, or more broadly data sets. The findings can help practitioners, especially from Technology Transfer Offices, to develop roadmaps for IP valuation in the cyber security industry.

KEYWORDS / KLJUČNE BESEDE

IPR valuation, IP in cyber security, data quality in AI model

1. CYBER SECURITY SPECIFICITY VERSUS IPR VALUATION

1.1 Introduction

The growth in importance of IPR is unquestionable, in every sector of the economy, and in those key to the digital transformation an undisputed. The IPR valuation is gaining in importance and reliable valuation is relevant in the cyber security sector. The valuation approach dedicated to the cyber market is not described in the literature and represents an unexplored research question. In IPR valuation, whatever the method, the essential characteristics of an intellectual asset should be taken into account. There is a fundamental complication arising from the difficulty of determining the essential characteristics of IP, the scope of protection, and the need to consider source data related to potential cyber exploitation on an unprecedented scale. IP assets can be independently identified, are transferrable, protected and that protection can be enforced. In the case of cyber, they have an economic lifespan, defined by their characteristics. Depending on the nature of intangible assets, there are different legal instruments by which protection is possible and ultimately benefit from using them. It is important to understand the economic value of cyber IP assets by carrying out an IP valuation. The article addresses a topic specific and relevant to the digital economy, the literature abounds with methodologies for different approaches to valuing IPR [9], [1], but there is no guidance on how to consider the importance of data, learning models, and all aspects of AI in new inventions. The challenges faced by the cyber security sector are defensive AI and machine learning technology, sophisticated cyber attacks, reinforcement learning-based cyber attacks, AI-enabled malware, the vulnerability of IoT technology, cloud security issues, and the involvement of cryptography. However, future directions, in cyber security, such as quantum-secure encryption, biometric authentication, advanced artificial intelligence, and machine learning, may be able to address these issues.

1.2 Cyber security products

According to the American Authorities, precisely Cyber Security and Infrastructure Security Agency, cyber security is “the art of protecting networks, devices, and data from unauthorized access or criminal use and the practice of ensuring confidentiality, integrity, and availability of information” [2]. The current cyber security situation is characterized by the regular emergence of new cyber threats. The most common types of cyber threats include malware, phishing attacks, ransomware, threats against data or availability, disinformation, supply chain targeting, and distributed denial of service (DDoS) attacks. The level of digital resilience varies from different industries and countries, however, effective cyber security remedies use security technologies and techniques such as intrusion detection and prevention systems, firewalls, antivirus software, and encryption [8]. Cyber attackers are constantly evolving their approach to penetrate the computer systems of enterprises which means that organizations must continuously monitor their networks against potential attack vectors, using a broad array of cybersecurity solutions to protect the entire ecosystem, including clouds and several applications [8].

Typical products are software for stopping the biggest, bandwidth-busting DDoS attacks, software that proactively reduces attack surfaces, Edge DNS, authentication services, clouds for protecting customers and providing data security, which reduce friction during registration, authentication, and sign-ins while making it easy for customers to control their accounts from any device. Products are, on the one hand, closely related to IT or ICT. On the other hand, they use the latest developments in biometrics, behaviorism, psychology, and the sociology of human behavior. They use, as in criminology, knowledge about human behavior, but the implementation of knowledge is strictly technical, in a digital world.

2. MULTIDIMENSIONAL IP PROTECTION

2.1 Impact of cyber product features on IP protection

The development of new solutions to combat or prevent cybercrime requires the proactive action and the creation of new inventions combating the criminal incidents. Since AI is widely used in cyberspace, AI-based products are also tools for mitigating attacks. Ransomware and phishing attacks encrypt critical data, demand high ransoms, and disrupt a wide range of operations. The growing use of Internet of Things devices is introducing new security vulnerabilities, while cyber attacks targeting the software supply chain are exploiting third-party vulnerabilities to gain access to sensitive information. Artificial intelligence technologies enable cybercriminals to launch sophisticated attacks. These AI-based threats are often not subject to traditional security measures, making them difficult to detect and mitigate. The World Intellectual Property Organization (WIPO), the United Nations agency that serves the world's innovators, is following the trend of consumer interest in AI in various economic, social, and cultural sectors, having published some very interesting and important reports on AI over the past few years. [6], [10]. WIPO Technology Trends 2019 – Artificial Intelligence reveals trends in patenting of artificial intelligence innovations [10]. AI-related patents disclose AI techniques and applications and refer to an application field or industry. WIPO analysis shows that many sectors and industries are exploring the commercial exploitation of AI, telecommunications (mentioned in 15 % of all identified patent documents), transportation (15 %), life and medical sciences (12 %), and personal devices, computing and human-computer interaction (11 %), the rest - other sectors including banking and security. In the WIPO patent landscape report on Generative AI, there are the latest patent trends for GenAI with a comprehensive and up-to-date understanding of the GenAI patent landscape, alongside insights into its future applications and potential impact. The report explores patents relating to the different modes, models, and industrial application areas of GenAI. Deep neural networks can be adapted to be either discriminative or generative tasks, which has led to the development of various types of GenAI models, which can support different types of input and output data. This opens up a new perspective on the protection of inventions and products.

There is a need to answer the threshold question of whether such AI-related inventions qualify for patent protection. The United States Patent and Trademark Office (USPTO) has issued guidelines to clarify the requirements for patenting AI-assisted inventions. For an invention to be patentable, there must be significant human input into its conception. Human inventors must make a significant contribution to the invention that goes beyond the mere use of AI tools. Otherwise, the invention is not eligible for patent protection. In addition, the USPTO has created five principles for evaluating AI-assisted inventions, the fifth is worth mentioning here - namely, merely owning or supervising an AI system does not qualify a person as an inventor without a significant contribution to the concept of the invention [7]. This principle ensures that human ingenuity remains at the heart of patentable inventions while recognizing the supporting role of AI in the inventive process. In the cyber industry, solutions can be protected by patents and then there is a need to value IPR in the form of a patent on an AI-related property. The number of cyber security patent applications per year shows that the amount of investment going into finding new ways to help prevent cyber attacks is huge. However, it is usually a bundle of different IPs that is valued. Apart from the fact that AI-related IP problems appear numerous, including AI inventorship, patent eligibility, and AI-related copyright issues, particularly important are data issues.

2.2. FLDX system – an example of IPR protection

An example of a cyber security product is the FLDX system, patent protected by NASK, a Polish National Research Institute, whose mission is to develop and implement solutions that facilitate the development of information and communication networks in Poland, in addition to improving their effectiveness and security. Patent – PL241005-*Method and system for adaptive creation of network traffic filtering rules on a network device spontaneously detecting anomalies and automatically suppressing volumetric attacks (DDoS)* protects digital services and network devices from DDoS attacks and a sudden and unpredictable increase in user activity. Sudden and unexpected bursts of Internet traffic can saturate network links or overloading application servers. Therefore, protecting networks and digital services from intentional attacks must go along with fair distribution of network resources. The FLDX system is a fast and extremely effective way to protect the availability of services on the network - whether the source of the threat is a volumetric DDoS attack or a sudden increase in user activity. Maintaining a fair distribution of network bandwidth is the primary goal of the FLDX system, achieved in a time of up to 10 seconds. Unlike the solutions currently offered in the anti-DDoS market, the FLDX system is not based on a database of signatures and static rules. It dynamically self-adjusts filters to the current situation. This approach allows us to react extremely quickly to the observed changes in network load, as well as forecast them. The FLDX system is therefore not only a protection tool - it is also a network knowledge discovery tool. The object of the invention is a method for adaptively creating network traffic filtering rules on a network device spontaneously detecting anomalies and automatically suppressing volumetric attacks (DDoS).

That FLDX example may illustrate the challenges of protecting IPR in this area. The speed and precision of the FLDX system are the result of years of scientific research in the fields of control theory and adaptive signal processing, the IP behind the solution is not only a patent, but also a copyright protecting the software and the user's system, trade secret, the implicit knowledge of the implementation as well as the knowledge contained in the technical documentation. Solutions are sporadically planned to be patent-protected, due to non-compliance with requirements for implementations of mathematical theorems or new applications of functional analysis. However, even an obtained exclusive right is not sufficient protection in the market. It is necessary, as with other software-based products, to supplement protection not only with copyright protection due to the nature of the solution but also to keep in secret any know-how resulting from the implementation and to circumvent technical problems arising from software development and installation in the cloud or at the customer's site.

3. IPR VALUATION ISSUES

3.1 Valuation approach selection

Valuation of IPR regardless of the subject of valuation strictly depends on the potential area of application of the protected technology. In the cyber sector, the issue of the valuation of IP goods is becoming increasingly challenging, for several reasons. First, this is due to the obvious development of the cyber market and the growing demand for all kinds of services and products protecting digital assets. Secondly, AI technologies are finding applications in this sector, which makes the valuation problem more complicated, and thirdly, a complex

method of product IPR protection is common. The issue of IPR valuation in high-growth sectors, for new technologies, and cutting-edge technologies, has been addressed in the literature for years. Major researchers (such as Damodaran) describe the challenges of estimating value for technology [1], [9]. However, the growing cyber market introduces a significant level of complexity to the subject, due to the dynamics of development, key development trends, market estimation, and the scalability and adaptability of solutions in this market.

Depending on the nature of intangible assets, various legal instruments are offered to protect and ultimately profit from them. IP management is a key element of the business strategy of entities developing cyber services. The linkage of copyright protection, patent, trade secret, and confidential know-how protection makes IP valuation difficult. Trade secrets may be preferable to patents in several circumstances, such as when the patentability requirements may not be satisfied; the cost of pursuing patent protection outweighs the benefits; and/or the need for IPR protection extends beyond the available patent term [9].

Regardless of the method used, the valuation process requires gathering a lot of information about intellectual property assets, as well as an in-depth understanding of the economy, industry, and specific businesses that directly affect their value. It is well known that there are three basic categories of valuation methods for evaluating intellectual property and intellectual property rights: income-based, market-based, and cost-based. The choice of the appropriate method for valuing intellectual property depends on the type of intellectual property, the stage of development, the purpose of the valuation, and the available data. The cost method establishes the value of an IP asset by calculating the cost of a similar (or exact) IP asset. The cost method is particularly useful when the IP asset can be easily reproduced and when the economic benefits of the asset cannot be accurately quantified. This method does not account for wasted costs, nor does it consider any unique or novel characteristics of the asset. Although a cost-based method is used for software value estimation, the combination of various elements of protection makes one think about the wisdom of choosing a revenue-based method [9]. The income method values the IP asset based on the amount of economic income that it is expected to generate, adjusted to its present-day value. This method is easiest to use for IP assets with positive cash flows, for those whose cash flows can be estimated with some degree of reliability for future periods, and where a proxy for risk can be used to obtain discount rates. The market method is based on a comparison with the actual price paid for the transfer of rights to a similar IP asset under comparable circumstances. This method has the advantage of being simple and based on market information, so it is often used to establish approximate values for use in determining royalty rates and inputs for the income method. For cyber industry this type of approach can be highly problematic, since products in the cyber crime market are evolving very quickly and there is considerable difficulty in comparing them. Often, it is only possible to make inferences on the level of effects offered, i.e. expected rather than concrete results, due to the widespread confidentiality of information. Companies do not necessarily boast about the ineffectiveness of protecting their computers, resources, or access to the cloud.

While one approach may seem particularly well-suited, the final value estimation should merge the value indications obtained under different approaches [1], [9]. Irrespective of the choice of valuation approach, in the situation of innovation, patent, or AI-related know-how, there is an issue directly related to the understanding of the operation and use of AI models [4].

3.2. Data in Artificial Intelligence model

During training, the artificial intelligence model is exposed to a prepared dataset and tries to learn the patterns and relationships present in the data. This process involves adjusting the internal parameters of the model based on the input data and the desired outcome. In a situation where AI is used, another problem arises. When is the product in question completed? AI models need to be taught. What does AI model training include?

AI model training includes three main aspects:

a) data collection

There are ready-to-use open-source data sets. Data collection and other resources are also collected and used. Internal data collection provides access to proprietary information and control over data quality. Web scraping is the process of extracting data from websites using various tools. Automation eliminates the need for manual data collection, which in itself is impractical when it comes to training AI models. Regardless of the data collection technique, the data should be relevant, accurate, consistent, presentable, and complete. Such data increases the accuracy of the AI model, reduces bias, and increases user confidence and trust in the AI model.

b) data processing

Having a rich data set, it is necessary to validate the data. Data validation involves preparing the data to match the requirements of the specific learning mechanism used by the artificial intelligence model. Each learning technique requires the data to be presented in a specific way. An artificial intelligence model incorporating algorithms that learn through supervised learning aims to predict or classify new data points. So, to select data for an artificial intelligence model equipped with supervised learning algorithms, label your data. Then divide the selected data into training, validation, and test sets. Using the training set is needed to teach the artificial intelligence model, the validation set to evaluate performance, and the test set to evaluate the final model. For unsupervised learning, the artificial intelligence model aims to reveal underlying structures, group similar data, and discover patterns without the help of labels. The model needs to understand the data by finding commonalities and understanding the features that define a particular dataset. In this case, feature-based clustering of the data is required. This makes it easier for the AI model to navigate and learn from unlabelled data. The situation becomes a little more complicated taking into account reinforcement learning (learning through interaction) [5]. Artificial intelligence models involving reinforcement learning learn by exploring the specifics of a task in a particular environment and performing functions by trial and error. In reinforcement learning, an environment must be simulated for the AI model to interact with. However, another level of complication relates to deep learning (neural networks and beyond) , it is an advanced learning mechanism that drives the AI model and enables it to handle complex actions. AI models with deep learning algorithms require large-scale data collection based on what the model is supposed to do. As deep learning algorithms use multiple layers of learning, the goal is to have different versions of large data sets.

c) providing selected data to the AI model and iterative refinement

Once the data has been structured based on the AI model's learning technique, the data is fed into the AI model. The model learns from the algorithms on which it is built. During the

learning stage, the capabilities of the model should be explored for refinement. Without iteration, the model cannot adapt to changing data and cannot improve its performance when exposed to other data sets.

This raises further questions regarding the valuation of a given IP. Firstly, how to value a patent with AI, secondly how to assess the level of sophistication of model training, and thirdly how to assess and value the quality of training and validation data, or more broadly data sets. In addition, in the cyber area, matters are further complicated by the use of sensitive or confidential data, such as tools for detecting illegal, offensive or harmful content based on data from law enforcement agencies. An additional legal complication arises.

4. RECOMMENDATIONS AND CHALLENGES OF VALUATION IN CYBER SECURITY SECTOR

4.1 Exploring difficulties

Nowadays, cyber security plays a crucial role in the global economy. The risk of cyber threats becomes more prevalent and cyber attacks can have devastating consequences leading to financial losses, reputational damage, and national security breaches. Therefore, it is imperative that governments prioritize cyber security measures to safeguard their interests. In addition to economic implications, cyber attacks also pose significant risks to national security. Governments around the world are increasingly concerned about hacking activities that aim to steal sensitive information or disrupt critical infrastructure systems.
Cyber attacks usually modify, access, or destroy sensitive information, extort users' money, or disrupt normal business processes. In 2024, the cyber security industry is expecting a paradigm shift in a more coherent and business-involved approach that reflects a better understanding and management of cyber threats [8]. This shift concerns the latest technology adoption and revolution, associated liability, maturity, integration, regulatory, quantification, communication, and behavioral shifts. As the market grows, there will undoubtedly be an increased demand for intellectual solutions to support the fight against cyber crime. Hence, the growth in importance of IPR will be indisputable, which in turn will result in a significant increase in the valuation of IP and its need in the market [3]. Therefore, IP valuation is an important issue, and reliable valuation is important for multinational corporations involved in IP transactions. IP valuation guidelines and regulations are also changing around the world due to different statutory provisions in each country. Valuing intellectual property involves assigning a monetary value to the intangible assets of a business entity. However, the intangible nature of intellectual property means that it is often difficult to value and define, making it challenging to set a fair price.

4.2 Recommendations

The most challenging tasks are determining the scale of the valuation portfolio, determining the role of AI in an invention, patent, or confidential know-how, determining the strength of a patent using AI and comparing it to other similar solutions, and determining the extent of model validation and database quality. Of course, issues related to the market, comparison of coverage, the scale of adaptation, etc. are also in force. However, completely new problems are gaining importance, the valuation of IPR in the cyber sector will be a further stage of complication and will require knowledge of a great level of AI invention protection and data management. A large part of everyday life is based on technology; personal, sensitive, and business data are stored on computers, smartphones, and tablets, so an extensive range of concepts are covered by cyber security - from communication to transport, and shopping to healthcare. It is crucial to consider the interrelationships and relationships between the different types of IP. Depending on the business needs, an appropriate valuation method should be chosen, taking into account whether the IP relates to AI. When analyzing an AI-related patent, the relationship to the data, the individual datasets, and the way the models are taught should be explored. Particular care should be taken to analyze the quality of the data and to understand the principles of data management (from collection, description, sharing, archiving, etc., including the FAIR principle – it is an acronym for Findable, Accessible, Interoperable, and Reusable). In addition, the origin of the data in the cyber sector should be taken into consideration. Moreover, in the cyber area, further complications are caused by using sensitive or confidential data, such as tools for detecting illegal, offensive, or harmful content based on data from law enforcement agencies.
Without high data quality, even the most advanced artificial intelligence models will fail. Data quality in the new era of AI highlights the key role of data quality in shaping effective data strategies. The task of the IPR evaluator in cyber products or solutions is to evaluate the AI model, and assess how each dataset is used, how the evaluation process works, which IPRs use it, and to what extent, and what parameters influence the business aspect of the entire evaluation process. The process of valuing IPRs is highly contextual and requires professional judgment based on the experience of the appraiser, now also in terms of data management and understanding of AI development and application phase.

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The Challenge of Licensing Artificial Intelligence Technology for Cybersecurity Applications

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ABSTRACT

The central question of this article is whether the transfer of cyber security technology based on neural networks into a production environment poses significant challenges due to the complexity and time variation of the technical environment, constantly evolving threats, and regulatory requirements.

The article uses observational research techniques for cybercrime activities, and experimental research for product management since 2011.

The article presents an application case study of behavioural biometrics and artificial intelligence (AI) techniques to detect remote desktop attacks, and technology transfer adaptations to changing conditions.

The added value of the paper is to draw conclusions from a real business case observed in internal business activities.

KEYWORDS

Cybersecurity, Artificial Intelligence, software licensing, software development, low compliance, behavioral biometric, AI licensing.

1 INTRODUCTION

NASK activities are focused on issues of security in cyberspace.

One of the areas of influence on cyberspace [6] is the provision of new technologies for counteract cybercrime and transfer them to commercial IT products. The goal is to increase resilience of the banking services and key services supplier [1].

The banking sector is particularly vulnerable to the activities of commercially motivated criminals [7], who are believed to be personally motivated in their criminal activities. These are criminals who directly seek to make a profit by seizing the funds of electronic banking users.

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It's difficult to quantify the impact of cybercrime on the banking sector, but public data from the US[17] and the EU [16] suggest it is around €4 billion each. The criminals are highly effective in the search for the optimal strategy of action in order to steal money from Internet users, while at the same time minimizing the legal risk and the resources (effort) involved **Error! Reference source not found.**

The criminal'ss resources involved are the use of a technical method, a socio-technical method, or both, leading to a successful theft [5].

2 METHODOLOGY

Since 2007, cybercrime data has been based on natural observations. NASK provides Computer Emergency Response Team (CERT) services at the national level and commercial threat intelligence services to the main financial institutions in Poland.

The case study is an original commercialisation case provided as part of the BotSense product offered by NASK.

3 THE BANKS, THE THIEVES AND EVEN THE SCIENTISTS

Poland has a population of about 38 million and in the first quarter of 2024, the Polish banking sector operates approximately 43,5 million accounts retail accounts with contracts allowing access to internet banking. About 23 million accounts are actively accessed via internet banking and about 22 million users access via mobile applications [15]. Since 2007, NASK has been working with the Polish banking sector to identify and counteract theft from Internet banking users. Over the years, with the improvement of technical methods of protecting electronic banking, both on the side of the banks and on the side of the end user, attacks based on vulnerabilities of IT systems, have been significantly reduced [2] [3]. They required sophisticated technical knowledge, considerable technical resources and centralised malware management, making such criminal infrastructure vulnerable to law enforcement.

Socio-technical attacks , on the other hand, have experienced a renaissance, using voice communication techniques to persuade the victim to provide the criminal with login and authentication credentials for banking transactions and, crucially,

to give the criminal access to their device's desktop via a legal remote access application.

As a result, the attack scenario does not require any specialist IT knowledge [9], which has made this method of criminal activity accessible to a wider group of criminals, resulting in a sharp increase in the number of remote desktop attacks.

At the same time, in a social engineering and remote desktop attack scenario, there is virtually no event that can be classified as technically incorrect. The user voluntarily provides his or her credentials to the criminal, voluntarily agrees to open a remote desktop connection, and is often persuaded by the criminal to deliver the final blow by turning off the monitor. This means that no cybersecurity incident occurs in the data transmission channel between the endpoint and the bank's server.

Analyzing the above, it can be said that a dynamic market model is emerging in which criminals are effectively and efficiently adapting to the limitation of increasing the resistance of information systems to cyber-attacks. Criminals are creatively and rationally searching for new effective techniques and crime scenarios to carry out successful theft. The specific type of attacks mentioned above are those carried out with the unwitting participation of the victim.

However, banking institutions in particular, burdened by legislation [11], are forced to search for ever new technical solutions to identify electronic banking sessions compromised by criminals.

From a technology transfer perspective, this raises the non-obvious problem of how to organize the process of technology transfer to combat criminals.

4 Case Study - Behavioral biometrics and artificial intelligence techniques to detect a access via Remote Desktop

NASK set up an internal research project to work on an AI model capable of analysing how an end user uses a keyboard to identify themselves. In a laboratory environment, this is a task that requires a certain number of experiments, the construction of relevant data sets and the application of technical expertise, but in principle the level of scientific risk is limited. However, when it comes to transferring the developed technology to a production application that is expected to operate at a certain minimum level of effectiveness for the entire population using e-banking, the issue becomes much more complicated.

Even if the expected level of efficacy is auxiliary, e.g. 70%, and unrepresentative individuals are discarded from the user population.

4.1 The cybersecurity technology ecosystem

Cybersecurity technologies require deep and precise technical integration with the environment to be protected. For example, tracking the use of a keyboard via a web browser, as a function of the time can be disrupted by the security mechanism embedded in that web browser. One of the security mechanism implemented by vendors is randomization of selected user behavior data and disrupt the time line data.

If we take the oversimplification of identifying the main layers of the environment in which cybersecurity technology must operate, we can distinguish between technical layers: device category, hardware, operating system, components of operating system, web browser.

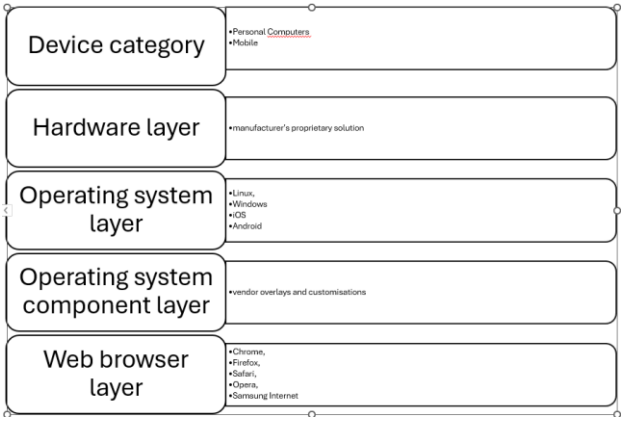

Figure 1: Technical layers

However, overcoming the additional complications posed by the diversity of devices, operating systems and web browsers does not guarantee the achievement of a stable, transferable technology. The whole technical environment described above is evolving. For example, the major web browsers, Chrome [13] and Firefox [14], are released on a monthly basis. This means that, the technical conditions under which cybersecurity technology should operate are constantly changing.

It should also be noted that changes affecting the security of the operating system and web browser may be made between the scheduled release dates of new versions and may involve unpredictable technical changes.

In addition, there are other elements in the formal-legal field [11] that we should consider, such as: international and national legislation, technical legislation, standards, norms, recommendations and internal company regulations.

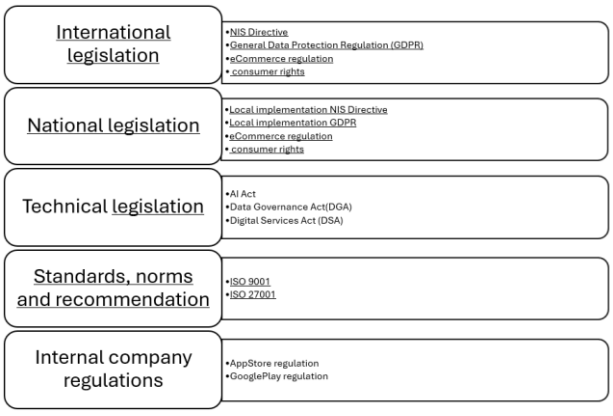

Figure 2: Formal layers

We are also seeing dynamic changes in the way criminals operate: variability of attack scenario and variability of tools.

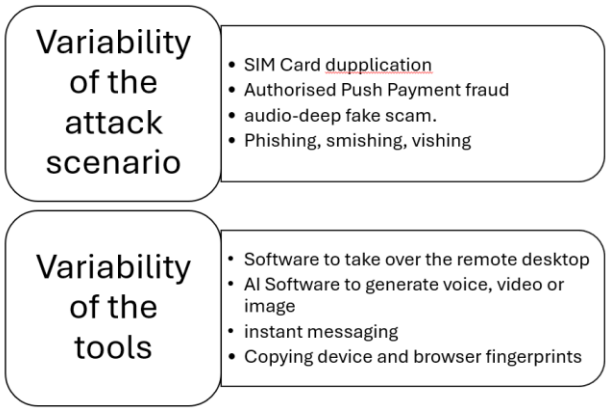

Figure 3: Criminal activity

And, of course, criminals are constantly identifying banking security techniques and bypassing or neutralising them [10].

We can think of cyber technology as a black box influenced by the forces of many independent parameters.

As in physics, the degrees of freedom (DOF) of a mechanical system is the number of independent parameters that define its configuration or state.

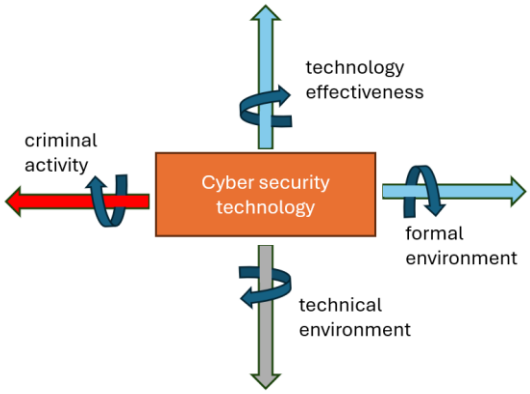

Figure 4: Forces affecting cyber security technology

A useful technology should be in balance between these parameters. If one vector increases, it means there's a need for action.

A multi-layered dynamic model of the variability of the environment is thus created, which seeks an equilibrium that includes the success rate of attacks. The stimulating (agonistic) factor is the activity of criminals and the antagonistic (inhibitory) factor is the development of security technologies. Another two parameters, which can be both agonistic and inhibitory, are changes in the technical or formal domain. Both can improve or reduce the effectiveness of cybersecurity technology. What is certain, however, is that all of these parameters create a need for constant review and adaptation of the technology.

4.2 The challenge of licensing

As a result, a solution developed in the laboratory will either start to fail immediately when deployed on the entire population, or it will start to fail over a finite period of time (as a function of time). This phenomenon has no risk characteristics, but is an inherent feature of the cybersecurity technology ecosystem.

The question is how to structure the process of technology transfer and licensing in this dynamic ecosystem?

In the process of technology transfer, we can distinguish:

1. Stage I - licensing the results of the R&D team and transferring them to the product development team (in this case software),
2. Stage II - advising the product development team on how to incorporate the innovation into the manufacturing environment.

Such an approach is not rational and will fail if we apply it to the transfer of cybersecurity technology.

This is because there is a high probability that the transferred technology will need to be modified before it is fully implemented in the product.

This will make the whole process infeasible and banks will start looking for non-IT methods to fight crime.

4.3 Practices applied

For technology transfer in the cyber domain, the NASK has adopted its own specific operating procedures.

First, the cybersecurity technologies developed in the NASK R&D teams are transferred to internal development teams.

By technology, we mean the form of a method, algorithm or learned AI model. The development team then builds a finished software component on top of it.

After that, the R&D team still, support and develop technology. The R&D teams are prepared for long-term development of the technology for detection of specific types of attacks, including its modification in the event of a change in the conditions of the technical environment in which the technology is to operate (e.g. loss of access to data relevant for detection).

Such organisation of technology production and preparation for transfer enables the temporary licensing of the finished software component, which allows the use of the cybersecurity technology for implementation in software. The license contains a number of specific conditions tailored to the cybersecurity ecosystem, the main ones are:

1. an assurance that the licensee will adapt the technology to changes in the technological environment,
2. an obligation on the licensee to improve the technology in the event of a decline in the effectiveness of attack detection,
3. an limitation of the licensor's liability for failure to adapt the technology to changes in the technological environment or to changes in the activity patterns of the perpetrators.

These points are almost impossible to define precisely. They are declarative in nature, with no strict guarantees from either party. The technology provider cannot reliably guarantee the effectiveness, cost or time it will take to modify its technology, and the recipient cannot guarantee the conditions under which it expects the technology to be effective.

In other words, the factor that determines the balance between the technology provider and the technology recipient is a common rational economic interest. And the basis for deciding on such a cooperation model should not be so much an assessment of the effectiveness of the technology at the time of its production, but rather the ability of the technology provider to modify and develop the technology to keep pace with changes in the application environment within a reasonable period of time.

5 Conclusion

The transfer of ICT technologies for cybersecurity may force a different way of thinking about building a collaborative model with business [12]. Thinking of collaboration with business as a one-off design phenomenon may prove to be a dead end. To ensure a steady flow of solutions for business in a rapidly changing environment, it is worth considering a process model of collaboration [4].

The example case study analyses the behavioral biometrics project and the AI technology used. However, the issue seems relevant to any application of technology or methodology in an unstable cyberspace environment.

The fundamental value of collaboration is to ensure the ability to solve a class of research problems within a reasonable time and cost. The process for sharing further technologies developed on the basis of the first project should be proposed in advance. The initial project or technology licensing is therefore only a starting point for long-term collaboration. It's also necessary to rethink the organisation of technology transfer agreements. Towards a collaborative framework and the definition of a dynamic research process.

For future work, it is possible to approach techniques to assist in predicting the effects of the changing environment.

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Technology Transfer: Revenues Estimation in the Cyber Security Sector

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ABSTRACT

This study investigates the complexities of technology transfer within the cyber security sector, focusing on the financial and operational challenges posed by its dynamic nature. The primary research problem is understanding how to define final cyber product and estimate associated costs, particularly in the context of both traditional and new economy revenue models. Preliminary findings reveal significant discrepancies in cost estimation and revenue forecasting, particularly due to the non-linear contributions of scientists, which complicate the creation of effective license agreements. The paper offers a framework to better align technology transfer processes with the unique characteristics of cyber security innovations, thus improving the accuracy of cost projections and licensing strategies.

KEYWORDS

Technology transfer, cyber security sector, revenue estimation, AI models, new economy, science contribution, license agreements

1 UNCERTAINTIES IN CYBER SECURITY TOOLS SPECIFICATION

Cyber security is a term with widely varying definitions that are frequently subjective and, in some cases, lack precision. According to the America's Cyber Defense Agency (CISA), it is defined as *the art of protecting networks, devices, and data from unauthorized access or criminal use and the practice of ensuring confidentiality, integrity, and availability of information* [11]. The absence of a clear, universally accepted definition that encapsulates the multidimensional nature of cyber security hinders progress in technology and science [6]. This is because it reinforces a technical perspective on cyber security, while simultaneously isolating disciplines that should be collaborating to address complex cyber security challenges effectively. The complexities involved significantly affect the determination of what constitutes a cyber security product, the criteria for deeming it complete, and the estimation of production costs within defined timeframes and budgetary constraints.

1.1 Defining cyber security product

Given the multidisciplinary nature of cyber security and its widespread impact on society, it is essential to establish, utilize, and elaborate a standardized terminology and develop a comprehensive, shared understanding of what constitutes cyber security product and economic risks associated with it [7].

In defining a cyber security product, it is crucial to recognize the role of interdisciplinary contributions, ranging from computer science and engineering to law, economics, and human factors. For instance, a cyber security product may include not only technical components, such as encryption algorithms or intrusion detection systems, but also legal frameworks and organizational practices that enhance security. The integration of these diverse elements requires a standardized terminology that can be universally understood across disciplines, enabling effective communication and collaboration.

Moreover, the definition of a cyber security product must account for its intended purpose and scope. Products may vary significantly in their focus - some are designed to prevent unauthorized access, others to detect intrusions, and yet others to respond to or recover from cyber incidents. This diversity necessitates a clear classification system that categorizes products based on their functionality, target environment, and the specific threats they address. For example, network security tools, endpoint protection software, and identity management systems each serve different purposes but collectively contribute to a comprehensive cyber security strategy.

Economic considerations also play a critical role in defining cyber security products. The value of a cyber security product is often measured by its effectiveness in mitigating risks, which are themselves subject to economic assessment. The economic impact of cyber threats, the cost of deploying and maintaining cyber security products, and the return on investment are all factors that influence how a cyber security product is defined and evaluated. This underscores the importance of aligning technical definitions with economic realities to ensure that cyber security investments are both effective and sustainable.

Furthermore, the lifecycle of a cyber security product must be clearly delineated, from initial development through deployment, operation, and eventual decommissioning. A comprehensive understanding of this lifecycle is necessary to establish criteria for when a product can be considered complete and to identify potential risks and vulnerabilities that may arise at various stages. This lifecycle approach also highlights the importance of adaptability in cyber security products, as they must evolve to address emerging threats and changing environments.

†Author Footnote to be captured as Author Note

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In summary, defining a cyber security product requires a multidisciplinary approach that integrates technical, legal, economic, and operational perspectives. Standardized terminology and clear classification systems are essential to fostering a shared understanding across disciplines, while economic considerations and lifecycle management provide the framework for evaluating the effectiveness and sustainability of cyber security products.

1.2 Estimating cyber product costs

A standardized method for measuring and managing the costs associated with implementing cyber security programs has yet to be established. To advance research and practice in this field, various cost estimation frameworks related to the development and deployment of cyber security products have emerged in recent years [9]. Estimating the costs associated with cyber security products is a critical aspect of cyber security planning and management. However, this task is fraught with uncertainties due to the dynamic and evolving nature of cyber threats, the complexity of cyber security products, and the diverse environments in which they are deployed [8]. Unlike traditional products, cyber security products must continuously adapt to an evolving threat landscape, where new vulnerabilities and attack vectors emerge regularly. This requires ongoing updates, patches, and upgrades, leading to unpredictable and often escalating operational costs over time.

Cost estimation for cyber security products involves several key components: development costs, deployment costs, operational costs, and decommissioning costs. Each of these components must be carefully assessed to provide an accurate estimate of the total cost of ownership (TCO) for a cyber security product.

1. **Development Costs:** These include the expenses incurred during the design and creation of the cyber security product. Development costs can vary widely depending on the complexity of the product, the technologies involved, and the level of expertise required. For example, developing an advanced threat detection system may involve significant investment in research and development, including the use of machine learning algorithms, data analysis tools, and security protocols. Additionally, the need for compliance with industry standards and regulations can add to development costs, as products must be designed to meet specific security requirements.
2. **Deployment Costs:** Once a cyber security product is developed, it must be deployed within the target environment. Deployment costs include the expenses related to integrating the product with existing systems, configuring it to meet organizational needs, and training personnel to use it effectively. In some cases, deployment may also involve significant infrastructure upgrades, such as installing new hardware or enhancing network capabilities. These costs can be substantial, particularly in large or complex organizations with extensive IT environments.
3. **Operational Costs:** The ongoing operation of a cyber security product generates costs related to maintenance, monitoring, and updates. Cyber security products must be continuously updated to address new threats and vulnerabilities, which can involve both software patches and hardware upgrades. Additionally, operational costs include the resources required to monitor the product's performance, respond to security incidents, and conduct regular security assessments. The need for highly skilled personnel to manage these tasks further contributes to operational costs, as cyber security expertise is often in high demand and short supply.
4. **Decommissioning Costs:** At the end of its lifecycle, a cyber security product must be decommissioned, which involves safely removing it from the environment and ensuring that no residual vulnerabilities remain. Decommissioning costs may include data migration, system reconfiguration, and the disposal of outdated hardware. Additionally, organizations may need to invest in new cyber security products to replace those being decommissioned, adding to the overall cost.

Estimating these costs is complicated by several factors, including the unpredictability of cyber threats, the rapid pace of technological change, and the variability in organizational needs and environments [10]. It means that a cyber security product may require extensive customization and integration efforts, which further complicates cost estimation. For example, the introduction of disruptive technologies, such as quantum computing, can render existing cyber security products obsolete, necessitating additional investments.

The need for specialized personnel to manage and maintain cyber security products, combined with the scarcity of cyber security expertise, adds another layer of complexity to cost forecasting. Furthermore, the consequences of underestimating the costs must be carefully considered, as they are often significant and far-reaching, potentially resulting in insufficient protection and increased risk exposure. This contrasts with other products, where cost overruns might primarily affect financial performance without posing immediate security risks. Therefore, the cost estimation of cyber security products must account for not only the tangible costs of development, deployment, and maintenance but also the intangible costs associated with risk management and the potential impact of cyber incidents.

To address these uncertainties, organizations must adopt a flexible and adaptive approach to cost estimation. This may involve using scenario analysis, which considers different potential future states and their impact on costs, as well as incorporating risk assessments to identify and quantify potential cost drivers. Additionally, organizations should consider the total cost of ownership over the entire lifecycle of the cyber security product, rather than focusing solely on upfront costs. This approach ensures that all relevant costs are accounted for and provides a more accurate estimate of the long-term financial commitment required to maintain cyber security.

2 METHODOLOGY

To address issues, this study employs a mixed-method approach. An extensive literature review is conducted. Relevant academic journals, industry reports, and government publications are examined. Additionally, qualitative data is collected through semi-structured interviews with key specialists and experts.

3 REVENUE ESTIMATION AND COMPANIES VALUATION

Cyber security is the practice of protecting individuals' and organizations' systems, networks, applications, computing devices, sensitive data, and financial assets against any digital attacks [3]. It refers to any technology, measure, or practice for preventing cyberattacks or mitigating their impact. We could categorize the main components of cyber security into the following areas: cyber security Governance, Policies, and Procedures, User Identity and Access Management, Network Security, Application Security, Data Protection, Business Continuity and Disaster Recovery Plan, Education. The number of fields results in miscellaneous cyber security business models, reflecting various comprehensive solutions in the evolving landscape of cyber threats and swift pace of technological advancement. The differences are both in revenue streams, cost structures and scalability.

3.1 Cyber security business models

We can distinguish three basic revenue streams: subscriptions, professional services, and licensing [5]. In first case cyber security firms offer their services on a subscription basis, providing continuous protection with regular updates and support in exchange for a recurring fee. This model ensures a steady and predictable revenue flow, development of customer relationships, mutually beneficial vendor relationships with major focus on customer procurement. Cyber security companies focused on professional services as business model often offer consulting, threat assessment, and response services. These include penetration testing, incident response teams and security audits. Finally, many companies operate under licensing model - selling licenses for proprietary security software or technology solution could be significant revenue stream, creates an easier entry into foreign markets, does not require capital investment or presence of the licensor in new geographical regions.

3.2 Classic technology valuation

Tech spending as a percentage of revenue has increased from 3.28% in 2016 to 5.49% in 2023 [4]. With bigger budgets often comes increased oversight and expectations from the business-tech leaders are becoming thoughtful about allocating capital for tech investments. 2023 Deloitte research shows that 6 in 10 executives struggle with measuring the value of these investments. The choice of an appropriate valuation method depends on the circumstances, scope, and purpose of the valuation – the three main approaches concentrate on the cost, market, and income.

Cost methods determine the value of intellectual property based on the historical cost of production or the estimated cost of replacement with assets of comparable utility. These methods involve considering any expenses that need to be incurred to remanufacture the asset or replace it with an asset comparable to the one being valued. Cost methods are applied mostly to unfinished or easily manufactured technologies. It is possible to imagine situations in which a relatively considerable sum of money has been spent on a technology that does not produce the anticipated benefits. In such a case, the valuation of technology by the cost method may significantly overestimate its value, and income methods will come to the rescue.

The income method of technology valuation is grounded in the belief that for a potential investor, a particular asset is worth as much as he can get income from that asset. The risk of the business and the time value of money should be considered. Valuation of technology using the income approach requires determination of the period of economic usefulness of the valued technology. It is done based on projected cash flows discounted at an appropriate discount rate. The income method is most often indicated as the most appropriate for valuing technology for which there is a high degree of confidence in the forecasts of operating income.

Market (comparative) methods of valuing intellectual property, on the other hand, involve estimating the value of technology based on a comparison to market transactions for similar assets. However, information on transactions for the purchase or sale of intellectual property is rarely publicly available. Therefore, the method often uses an analogy with the valuation of technology companies, whose value depends largely or entirely on the technology they own. The main shortcoming of this method is the inability to identify comparable technology. As a rule, each innovative technology is unique and has specific parameters, which leads to limited possibilities of comparison to existing solutions known to date.

3.3 Companies' valuation in cyber security sector

The Market Multiples method is a key tool for valuing companies in the cyber security industry. This approach involves valuing a firm by comparing it to similar private or recently acquired companies in the sector. Specifically, it focuses on two primary types of multiples: Revenue Multiple and EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization) Multiple. For startups (especially those that are pre-profit) the Revenue Multiple is often more relevant. It compares the company's value to its revenue, offering a perspective on how the market values the revenue generated. For more mature companies (with significant earnings), the EBITDA Multiple provides a view of the company's value relative to its profitability before accounting for financial and accounting factors.

Applying the Market Multiples method effectively requires a deep understanding of market trends and financial metrics specific to the cyber security sector. The rapidly evolving nature of cyber security, with frequent technological innovations and varying threat landscapes combined with investor confidence in the sector's growth can significantly influence these multiples.
The most common purpose of technology valuation is the needs for commercialization of completed development work in R&D Units. It is determined as part of the commercialization of technology, the value of the sale to an external investor or in-kind contribution to a special purpose vehicle (SPV or Spin-off). Prior to the commercialization of intellectual property, there is often a need to determine the value of these intangible assets and whole company. Another reason, also encountered, for the valuation of technology is the need to recognize the fair value in the accounting books. Less common are cases of estimating the value of technology for litigation, where it is required to determine the value of the subject matter of the dispute or under collateral for financial instruments. In the case of cyber security technology and company valuations, it is useful to define the circumstances valuation determines purpose: accounting, market

(for the current owners or new investors) or liquidation. It would be desirable to strike a balance between qualitative and quantitative measures.

4 IMPLICATIONS FOR TECHNOLOGY TRANSFER OFFICES

From the point of view of technology transfer and commercialization of scientific results, managing the process of new solution building using AI models is particularly difficult. The problematic question of revenue estimation implies further issues related to the creation of licensing or distribution agreements; additional complications also arise from the very characteristics of AI models. First, there are several problems associated with the application and obtaining Intellectual Property Rights (IPR) protection for such solutions. Secondly, cooperation with scientists is done in close cooperation with software developers, and scientific input is expected not in the entire process. Third, the solutions for specific markets generate several difficulties in shaping models for licensing agreements for the cyber security industry.

4.1 Intellectual Property Rights protection

When considering patenting AI-related inventions, there is a need to answer the fundamental questions of whether inventions qualify for patent protection. In European system, while a computer program or software may not be patentable, artificial intelligence and machine learning that serve or achieve a technical purpose may be a desirable alternative. The newest EPO guidelines [2], require the mathematical methods and training data used by an AI-related invention to be disclosed in sufficient detail to reproduce the technical effect of the invention over the whole scope of the claims. To address these issues and prepare a commercialization plan for the cyber security market, Technology Transfer Offices should identify the territories for patent protection for their AI inventions and assess whether such inventions meet the relevant subject matter eligibility criteria. If AI-related patent protection seems unfeasible and ineligible, TTO should consider protection using trade secrets or other alternatives. Protecting rights to training data, AI output, and other crucial training data requires attention, awareness, and careful action.

4.2 Relations with scientists

AI is forcing a change in the attitude of scientists, from that of a strict researcher to one that is far more oriented toward creating a working IT system. In terms of describing the types of scientists according to the Science Council, one can explain the change in attitude of the Explorer Scientist to the Developer Scientist [1]. This reflects a commitment to the area of creating AI solutions for specific and demanding markets. *"The Explorer Scientists rarely focus on a particular outcome or impact, rather they want to know the next piece of the jigsaw of scientific understanding and knowledge. […] The Investigator Scientist digs into the unknown observing, mapping, understanding, and piecing together in-depth knowledge and data, setting out the landscape for others to translate and develop"* [1]. The scientist is needed at specific moments, the innovation forces seasonal involvement, the product is created more as a result of collaboration with programmers and software developers, and there is no space for discovering independent universal truths in the sense of breakthrough ideas or inventions. We observe the non-linear contribution of the researcher to the development of the cyber security product. For TTOs, this is an additional complication, the connection of the author to his work is strong, and the cyber security market forces not only close teamwork but also IT and data professionals themselves are gaining in importance. Data stewards have a significant impact on the development of AI models and thus cyber products. For TTO is a difficulty related to the progress and commercialization plans for a specific solution.

4.3 Risks in license agreement

Forming a license agreement for a product or solution using an AI model requires considering the strict characteristics of training AI models, the difficulty of determining milestones for model development, and the system of subscription or license fees depending on the stage of learning or re-learning the model. The fundamental difficulty in estimating and establishing profit or revenue models depending on the development of machine learning lies in the indefiniteness of the solution itself. Models need successive iterations, the cost of software development changes, and the demand for certain solutions also changes, which makes it exceedingly difficult to forecast profits and build a model of fees and payments in a license agreement. The described problem of revenue estimation forces the adaptation of cyber security solutions using AI models of licensing agreements and billing systems, a thorough reflection is needed in the society of technology transfer professionals on this subject.

5 CONCLUSION

Developing a more precise and universally accepted definition of cyber security products is essential for standardizing cost and revenue estimation processes. Authors will focus on robust methodologies to account for the non-linear contributions of R&D teams in cyber security, as current models are inadequate. These areas will dictate the trajectory of future research, reducing uncertainties in product finalization and financial forecasting.

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Prospects for the Use of AI Tools in the Republican Centre for Technology Transfer Network

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ABSTRACT

The paper informs about services and information resources provided by the Republican Centre for Technology Transfer (RCTT) to innovation activity agents and prospects for the use of AI tools in the RCTT Network in order to improve the quality and speed of preparing profiles (technology offers/requests, business offers/requests and R&D requests), creating promotion and marketing content to find potential partners, drafting contracts, etc.

KEYWORDS

Technology transfer (TT), AI, generative AI, technology transfer offices (TTOs)

1 INTRODUCTION

"Will AI be replacing people in the near future?" "It looks to me like, and for a while, AI is much better at doing tasks than doing jobs. It can do these little pieces super well, but sometimes it goes off the rails. It can't keep very long coherence. So, people are instead just able to do their existing jobs way more productively, but you really still need the human there today." Sam Altman, CEO of Open AI.

As noted in the UNECE White Paper on the use of Artificial Intelligence in Trade Facilitation [1], artificial intelligence (AI) is an enabling technology impacting the global economy and international trade. Combined with business-process-oriented automation and more efficient data flow exchanges, AI further promises to lift barriers to international trade, stimulate growth in global electronic commerce and allow for better predictions and associations to inform policy decisions.

The benefits of AI-based systems include:

– reducing the time spent on working with one document by more than 80%;

– reducing the number of errors in procedures;

– creating centralized repositories of information and documentation associated with files that will remain accessible even several years after the file is closed (the data is the property of the client);

– automation of interaction between all participants in international cooperation;

– direct access to file information from anywhere where there is an Internet connection, even from mobile devices and smartphones.

United Nations System White Paper on AI Governance [2] suggests an increasing recognition of AI's role in amplifying the work of governments and international bodies. Additionally, Gartner predicts a staggering 80% of project management tasks will use AI by 2030 [3], a testament to the growing reliability and trust in AI technologies within structured operational frameworks.

Since 2023 the use of AI in the work of technology transfer offices (TTOs) has been regularly discussed at webinars of the Association of University Technology Managers (AUTM).

On May 5, 2023, a webinar "Generative AI has Arrived: Essential Knowledge for TTOs" was held, which explained: What is generative AI? Why should you care? The current state of AI and applications, such as ChatGPT, that are already at your disposal. How you can implement these tools in your office, some of the most pressing risks and concerns your office might face, and a look into what's coming next.

On March 3, 2024, a webinar "The AI Enabled TTO" was held, where the use of AI by TTOs to improve the efficiency of their work was discussed, in particular to: automate routine tasks, analyze market trends, assess competitors, assess intangible assets, speed up decision-making and optimize resources.

On May 2, 2024, a webinar "Tailoring Your AI Tools for Tech Transfer Transformation" was held. This webinar explores customizing AI tools to better support unique tech transfer processes and goals.

Video recordings and presentations of these webinars can be found on the Internet portal of AUTM [4].

Participation in the above webinars, as well as the analysis of publications [1–6] shows that, AI can be used in the work of the TTOs to:

– improve the quality of profiles (technology offers/requests, business offers/requests and R&D requests) published in the TT networks;

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– analyze big data to identify potential technologies for TT, as well as to predict market trends and demand;

– monitor patents and publications – AI can monitor publications and patents related to a particular technology to assess interest from the scientific community and industry;

– search for technologies – use machine learning algorithms to search for and compare technologies, patents and research results that can be commercialized or licensed;

– automate processes – AI can help automate routine tasks such as technology and intangible asset assessment, document management and licensing processes;

– predict risks – analyze risks and possible obstacles in technology transfer using machine learning methods to predict the likelihood of project success;

– improving communication – using chatbots or neural networks to interact with potential partners and clients.

2 SERVICES AND INFORMATION RESOURCES PROVIDED BY THE REPUBLICAN CENTER FOR TECHNOLOGY TRANSFER TO INNOVATION ACTIVITY AGENTS

Tasks set for RCTT:

– create and maintain information databases meant for serving clients in the technology transfer sector;

– provide RCTT clients with access to foreign technology transfer networks;

– assist innovation activity agents in development and promotion of their innovation and investment projects;

– train specialists in research- and innovation-related entrepreneurship;

– establish RCTT offices across the country, to create a unified national network of technology transfer centers;

– promote international technical and scientific cooperation and exchange of experts.

RCTT is a consortium with the headquarters in Minsk that comprises [7, 8]:

– 5 regional offices and 30 branch offices at research organizations, institutes, universities, enterprises in Brest, Vitsebsk, Homel, Hrodna, Lida, Minsk, Mahileu, Novapolatsk and other cities and towns across Belarus;

– 98 foreign partners in 23 countries: Armenia (3), Azerbaijan (2), China (25), the Czech Republic (2), Denmark (1), Germany (4), Georgia (1), India (1), Iran (1), Italy (1), Kazakhstan (6), Lithuania (1), Moldova (1), Poland (3), Russia (25), South Africa (1), South Korea (4), Sweden (1), UK (2), the USA (3), Ukraine (7), Uzbekistan (1), Vietnam (2);

– 2 overseas field offices in China.

RCTT has implemented over 400 projects, including over 100 international projects funded by UNDP, UNIDO, CEI, EU, the Swedish Institute, etc.

RCTT experts are certified members of 14 foreign technology transfer networks.

RCTT offers its services to innovation activity agents in Belarus as well as foreign companies and investors.

RCTT has a web-portal [9], with several subject sections and databases such as: "Virtual exhibition of the NAS of Belarus"; "Catalogue of innovation offers by organizations of the NAS of Belarus"; "New partnership opportunities", to present in real-time offers and requests from RCTT, NATT, AUTM and EEN networks; "Catalogs"; "Manuals"; "Media"; "Commercialization", with subsections "IP auctions", "Investment and venture funds", "Crowdfunding" and "Technoparks of Belarus"; "IP insurance"; "Legislation", covering the laws and regulations applicable to innovation activity in Belarus and foreign countries, and others.

RCTT provide services to more than 250 Belarusian state organizations, private enterprises and individuals. The National Academy of Sciences, Belarusian State University, Belarusian National Technical University are among its clients. In 2003–2024 with the support from RCTT more than 8500+ persons improved their skills in the filed of technology transfer at 650+ national and international events (workshops, conferences, exhibitions).

RCTT is the coordinator of the Republican Center for Technology Transfer Network which contains more than 3000 technology offers, technology requests, business offers, business requests, and offers for cross-border R&D collaboration of Belarusian enterprises and organizations.

As of August 2024 the Internet portal of RCTT contains:

– 1120+ cooperation offers from NASB organizations in Russian language and 1010+ in English language,

– 45+ catalogs, presenting services and products of organizations of the National Academy of Sciences of Belarus in Russian, English and Chinese,

– information about 250+ exhibitions, 50+ brokerage events, 210+ webinars and events in the field of intellectual property management, transfer and commercialization of technologies where organizations of the NAS of Belarus took part (will take part) in 2019–2024,

– 50+ educational materials in the field of IP management, technology transfer and commercialization.

3 PROSPECTS FOR THE USE OF AI TOOLS IN THE RCTT NETWORK

RCTT plans to use AI tools to solve the following problems:

– automation and improvement of the quality of profile preparation (technology offers/requests, business offers/requests and R&D requests);

– creation of promotion and marketing content to find partners;

– automatic scanning and analysis of Internet resources, scientific publications, patents, catalogs and other data sources to identify competitors and potentially valuable technologies;

– identification of technologies that can be successfully commercialized by matching the proposed technologies and services with market needs;

– determination of optimal product promotion channels and optimization of marketing strategies;

– support of the negotiation process by providing information on market prices, transaction terms, etc.;

– monitoring and management of the commercialization process. After a contract is concluded, AI can be used to track progress in commercializing the technology and identify possible problems or opportunities;

– improvement of communication – use of chatbots or neural networks to interact with potential partners and clients. A

chatbot is created to build a dialogue with the user. It simulates a conversation between real people and can respond briefly to a simple request or construct a complex conversation with a high level of personalization. Neural networks are a type of machine learning in which a computer program works on the principle of the human brain, using various neural connections. A neural network can be either a learning or self-learning system.

As part of the modernization and development of the automated system of information support for innovation activities and technology transfer in the NAS of Belarus (ASIS IATT), commissioned in December 2021 [10], on the basis of which the RCTT network operates, the following work is planned:

1. Analysis, selection and adaptation of AI models for carrying out work aimed at integrating the selected AI models into the ASIS IATT subsystems;

2. Integration of AI tools into the subsystems of the ASIS IATT.

Here are some examples of generative AI tools that can be used when preparing profiles, creating promotion and marketing content, scanning and analyzing Internet resources, and solving other problems:

a) AI tools for profile descriptions and other texts could be:

– OpenAI GPT-3 or Generative Pre-trained Transformer 3 is a powerful neural network model capable of generating text based on provided contextual data. It can be used to automatically generate technology descriptions, technical concepts, and other text materials;

– IBM Watson Natural Language Generator is a tool that allows you to automatically generate text based on specified templates and parameters. It can be used to create descriptions of technology features, product specifications, and other technical materials;

– Copy.ai is a platform that provides a wide range of tools for generating text content, including descriptions, headlines, articles, and more. It can be used to create excellent descriptions of technologies and products;

– Jasper (Adobe's AI Copywriting Assistant) is a tool that uses AI to generate text that can be used to create technology descriptions, blogs, and advertising materials;

– ChatGPT by OpenAI is a generative neural network model that can hold a conversation and generate text content based on user input. It can be used to chat with the user, provide information about technology, and answer questions;

– Writesonic is another AI-powered writing assistant that enables users to generate a variety of content types quickly and efficiently;

– ShortlyAI is an AI writing assistant focused on helping users generate long-form content efficiently.

b) There are a number of AI and machine learning tools available to automatically scan, analyze, and identify competitors and potentially valuable technologies. Here are some of them:

– Scite.ai is a platform for analyzing research articles and academic publications using AI. It allows you to identify connections between studies, evaluate their reliability, and find new technological directions;

– PatSnap is an AI-powered patent and intellectual property scanning tool that helps you research competitors, identify new technologies, and assess their business potential;

– Dataminr is a platform for monitoring news and social media using machine learning. It allows you to discover events, trends and competitors that may be important for a specific business or research;

– Crayon is an online competitor and technology monitoring platform. It uses machine learning to automatically scan websites, social media, and other data sources to provide insights into the competitive landscape and emerging technologies;

– Cortico is a data analysis tool that uses artificial intelligence to process and classify information from various sources, such as the Internet, news articles, and social media. It can help identify trends, competitors, and new technologies.

Integration of AI tools into the ASIS IATT subsystems will reduce time, labor, and technological costs and improve the quality and speed of preparing profiles, creating promotion and marketing content to find potential partners, and preparing contracts in the RCTT Network.

4 CONCLUSIONS

The paper informs about prospects for the use of AI tools in the RCTT Network for reduce time, labor, and technological costs, improve the quality and speed of services provided.

Examples of generative AI tools, that planned to be used in the RCTT Network for preparing profiles, creating promotion and marketing content, scanning and analyzing Internet resources, preparing contracts, and solving other problems are given.

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PREDGOVOR

Demografska vprašanja postajajo čedalje pomembnejša za Slovenijo, Evropo, svet. Poleg prenaseljenosti se pogosto pojavljajo teze kot pretirana migracija in depopulacija, vse pa se demonstrirajo kot resen politični in gospodarski izziv.

Slovenija, podobno kot mnoge evropske države, se sooča s posledicami nizke rodnosti in staranja prebivalstva, kar močno vpliva na delovno silo, socialno varnost in produktivnost. Poleg tega obsežne migracije ustvarjajo dodatne pritiske na politične in socialne strukture v Sloveniji, Evropi in ZDA. Naraščanje svetovne populacije je bilo zadnjih sto let eksponentno, a ta rast se upočasnjuje, zato depopulacija morda ni več tako nujna kot pred desetletji.

Kljub splošnemu prepričanju, da na demografske trende ni mogoče bistveno vplivati, izjemne demografske spremembe niso prišle same od sebe. Z ustreznimi politikami in inovativnimi pristopi lahko vplivamo na demografske razmere ter jih prilagodimo, da bodo najboljše za ljudi in celotno človeško civilizacijo. Zavedanje o nujnosti iskanja primernih rešitev je ključno, saj tako prenaseljenost kot depopulacija s sabo prinašata številne negativne posledice, kot so problemi delovne sile, izzivi pri vzdrževanju socialnih sistemov in upad gospodarske rasti.

Migracijski pritiski poudarjajo potrebo po uravnoteženih in trajnostnih politikah, ki hkrati naslavljajo migracijske tokove ter ohranjajo socialno in kulturno kohezijo. Slovenija, ki je obdana z dinamičnimi migracijskimi tokovi, se sooča z izzivom integracije priseljencev, hkrati pa želi ohraniti jezik, nacionalno identiteto in družbeno stabilnost. To zahteva učinkovite politike, ki bodo omogočale uspešno prilagoditev spremenjenim demografskim razmeram.

V tem kontekstu je razumevanje in obvladovanje demografskih trendov nujno. Prilagodljive politike, inovativne rešitve ter sodelovanje med strokovnjaki, politiki in družbo so ključni elementi, ki nam lahko pomagajo soočiti se s spreminjajočim se demografskim okoljem. Po mnenju nekaterih strokovnjakov bo že v nekaj desetletjih v številnih evropskih državah prišlo do dramatičnega demografskega obrata, kjer bo avtohtono prebivalstvo postalo manjšina. V nekaj stoletjih bi lahko prišlo celo do izumrtja malih evropskih narodov, kar predstavlja resen izziv za ohranjanje kulturne in jezikovne raznolikosti ter identitete evropskih držav.

Prispevki na konferenci ponujajo osnovo za poglobljeno razpravo o teh ključnih vprašanjih s poudarkom na Sloveniji, Evropi in globalnem kontekstu. Naš cilj je združiti strokovnjake in odločevalce, da skupaj raziskujejo strategije za učinkovito soočanje s kompleksnimi demografskimi izzivi in tako prispevajo k boljši prihodnosti za vse.

S skupnimi prizadevanji in izmenjavo znanja lahko oblikujemo trajnostne in učinkovite rešitve, ki bodo prispevale k dolgoročnemu demografskemu razvoju.

Janez Malačič, Mari Osredkar, Jože Sambt in Matjaž Gams

FOREWORD

Demographic issues are becoming increasingly important for Slovenia, Europe, and the world. In addition to overpopulation, topics such as excessive migration and depopulation frequently arise, manifesting as serious political and economic challenges.

Like many European countries, Slovenia faces the consequences of low birth rates and an aging population, which significantly impact the labor force, social security, and productivity. Furthermore, large-scale migrations create additional pressures on political and social structures in Slovenia, Europe, and the United States. While the global population has grown exponentially over the last hundred years, this growth is slowing, suggesting that depopulation may no longer be as urgent as it was decades ago.

Despite the common belief that demographic trends cannot be significantly influenced, major demographic changes did not occur on their own. With appropriate policies and innovative approaches, we can influence demographic conditions and adapt them to be the most beneficial for people and human civilization. Recognizing the urgency of finding suitable solutions is essential, as overpopulation and depopulation bring numerous negative consequences, such as labor force issues, challenges in maintaining social systems, and declining economic growth.

Migration pressures emphasize the need for balanced and sustainable policies that address migration flows while maintaining social and cultural cohesion. Slovenia, surrounded by dynamic migration flows, faces the challenge of integrating immigrants while striving to preserve its language, national identity, and social stability. This requires effective policies that will enable successful adaptation to changing demographic conditions.

In this context, understanding and managing demographic trends is crucial. Flexible policies, innovative solutions, and cooperation between experts, policymakers, and society are key elements that can help us face the changing demographic environment. According to some experts, within just a few decades, many European countries will experience a dramatic demographic shift where the indigenous population may become a minority. In a few centuries, this could even lead to the extinction of small European nations, presenting a serious challenge to preserving cultural and linguistic diversity and the identity of European states.

The contributions at this conference provide a foundation for in-depth discussions on these critical issues, with a focus on Slovenia, Europe, and the global context. Our goal is to bring together experts and policymakers to jointly explore strategies for effectively addressing complex demographic challenges and thus contribute to a better future for all.

Through collective efforts and the exchange of knowledge, we can shape sustainable and effective solutions that will contribute to long-term demographic development.

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Razvoj empatije, vloga spola in socialne vrednote pri mladostnikih

The Development of Empathy, the Role of Gender, and Social Values in Adolescents

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Povzetek

V obdobju mladostništva se mladi srečujejo z vrsto izzivov in sprememb, ki oblikujejo njihovo osebnost, vrednote in socialne spretnosti. Empatija, kot sposobnost razumevanja in deljenja čustev drugih, ima v tem obdobju ključno vlogo. Razvoj empatije pri mladostnikih ne vpliva samo na njihove medosebne odnose, temveč tudi na oblikovanje njihovih socialnih vrednot, ki so bistvene za zdravo in povezano družbo. Socialne vrednote so temeljni principi, ki usmerjajo vedenje posameznikov in skupin ter so ključnega pomena za oblikovanje družbenega reda. Vrednote, kot so solidarnost, spoštovanje in pravičnost, so pomembne pri iskanju rešitev za demografske izzive, kot so npr. staranje prebivalstva in migracije. V prispevku s pomočjo rezultatov raziskave, ki je vključevala 231 mladostnikov iz Grčije, Slovenije in Portugalske, prikazujemo razlike v kognitivni in čustveni empatiji pri mladostnikih. Razvidno je, da mladostniki dosegajo višjo stopnjo kognitivne empatije v primerjavi z emocionalno. Dekleta dosegajo višje rezultate pri obeh vrstah empatije. Te ugotovitve poudarjajo potrebo po prilagojenih pristopih pri vzgoji za socialne vrednote in spodbujanju empatije glede na spol, kar je ključno za učinkovito soočanje z demografskimi spremembami, za spodbujanje socialne vključenosti in za razumevanje drugih med mladostniki.

Ključne besede

Adolescenca, družbene spremembe, kognitivna empatija, emocionalna empatija

Abstract

Adolescence is a period of significant transition and change, during which young people encounter a range of challenges and experiences that influence the development of their personality, values and social skills. The capacity for empathy, defined as the ability to comprehend and vicariously experience the emotional states of others, is of paramount importance during this developmental period. The development of empathy in adolescents has a significant impact on not only their interpersonal relationships but also the formation of their social values, which are essential for the maintenance of a healthy and cohesive society. Social values represent the fundamental principles that inform the behaviour of individuals and groups and are instrumental in the formation of social order. The values of solidarity, respect and justice are of significant importance in the formulation of solutions to demographic challenges, life the ageing of populations and migration. This paper presents a comparative analysis of cognitive and emotional empathy among adolescents, based on the findings of a survey conducted among 231 adolescents in Greece, Slovenia and Portugal. It is evident that adolescents achieve higher levels of cognitive empathy compared to emotional empathy. Girls score higher on both types of empathy. These findings highlight the necessity for tailored approaches to social values education and the promotion of empathy according to gender, which is crucial to effectively address demographic change and promote social inclusion and understanding of others among adolescents.

Keywords

Adolescence, social change, cognitive empathy, emotional empathy

1 Socialne vrednote in soočanje z demografskimi spremembami

Socialne vrednote so temeljni principi in prepričanja, ki usmerjajo vedenje posameznikov in skupin v družbi. Opredeljene so kot standardi, ki jih posamezniki in družbene skupine uporabljajo za opredelitev osebnih ciljev ter bistveno oblikujejo naravo in obliko družbenega reda v kolektivu, tj. kaj je sprejemljivo in kaj ne, kaj mora biti in kaj ne, kaj je zaželeno in kaj ne [1]. Te vrednote vključujejo spoštovanje, enakost, svobodo, pravičnost, solidarnost, odgovornost in empatijo [2].

Vrednote so vir konkretnih smernic za ravnanje v praktičnih situacijah vsakdanjega življenja. Tesno so povezane s sorodnimi pojmi, kot so stališča, prepričanja in norme, saj vplivajo nanje. Na vrednotah temeljijo temeljna prepričanja, na tem stališča in norme, od tod izvirajo vedenjske namere in na koncu samo

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vedenje [3]. Socialne vrednote so ključnega pomena za oblikovanje vedenja in odločitev, tudi ob soočanju z demografskimi spremembami, ki prinašajo veliko izzivov. Vrednote, kot so solidarnost, spoštovanje in pravičnost, usmerjajo pri iskanju rešitev za staranje prebivalstva, migracije in spreminjajočo se družbeno strukturo. Z močnimi socialnimi vrednotami lahko spodbujamo medgeneracijsko sodelovanje, vključevanje marginaliziranih skupin in pravično porazdelitev virov. Te vrednote pomagajo graditi kohezivne skupnosti, kjer so posamezniki pripravljeni prispevati k skupnemu dobremu, sicer se krepi nelagodje in tesnoba ob soočanju z različnostjo [4]. Zato je krepitev socialnih vrednot nujna za trajnostno in pravično prilagajanje demografskim spremembam.

2 Empatija in njen družbeni pomen

Empatija, kot socialna vrednota, igra ključno vlogo v medsebojnem razumevanju in podpori v sodobni družbi ter se vse bolj uveljavlja kot temelj medosebnih odnosov in skupnostnega sobivanja. Po definiciji gre pri empatiji za sposobnost, da razumemo in občutimo čustva ter izkušnje drugih ljudi [5]. Pri tem zasledimo dve različni, a med seboj povezani komponenti empatije: kognitivno in emocionalno. Kognitivna empatija se nanaša na sposobnost razumevanja perspektive, misli ali čustev druge osebe na intelektualni ravni. Vključuje razumevanje mentalnega ali čustvenega stanja druge osebe, ne da bi nujno delili ali doživljali to stanje. Emocionalna empatija je sposobnost deljenja in doživljanja čustev druge osebe na način, kot da bi bila ta čustva lastna, pri tem pa sega onkraj zgolj golega razumevanja [6].

Empatija, zlasti kognitivna, omogoča posameznikom, da bolje razumejo perspektive drugih, kar je ključno za vzpostavljanje medsebojnega zaupanja in sodelovanja. Empatija pomaga tudi pri zmanjševanju konfliktov in povečanju socialne kohezije v družbi [7]. Največja tegoba sodobnega sveta je morda pomanjkanje empatije, kar vodi v individualizem in egoizem. Ljudje pogosto pričakujejo, da bodo drugi čustvovali in razmišljali tako kot oni, kar vodi v nestrpnost in razočaranje. Empatija nas uči, da je vsak posameznik drugačen in ga je treba spoštovati ter jemati resno. Zahodna večkulturna družba pogosto pojmuje empatijo kot most za demokratični dialog, saj omogoča preseči egocentrični pogled na svet in zavzeti sociocentrični pogled, ki vključuje tudi druge [8].

Empatija torej ni le individualna lastnost, ampak ključen gradnik, ki oblikuje našo kolektivno identiteto in družbeno strukturo. Dejavna empatija je ključna za socialni in moralni razvoj posameznika. Kot socialna bitja potrebujemo socialne vezi za fizično in čustveno preživetje. Empatija pomaga usklajevati dejanja posameznikov, razumeti misli in namene drugih ter spodbuja solidarnost [9]. Pomaga pri oblikovanju trajnih socialnih vezi, spodbuja altruistično vedenje in preprečuje medosebno nasilje [8]. Pomembno je tudi zavedanje, da empatija omogoča prepoznati, kdaj so naša dejanja do drugih škodljiva, kar nam omogoča, da ta dejanja popravimo [10].

Raziskave kažejo na močno povezavo med empatijo, socialnimi vrednotami in prosocialnim vedenjem. Empatija, zlasti čustvena empatija, je pozitivno povezana z altruističnimi vrednotami, negativno pa z vrednotami, ki so usmerjene samo na posameznika [11]. Ta povezava se ujema s hipotezo o empatiji in altruizmu. Empatija in relacijske vrednote so tesno prepletene [12]. Koncept družbene empatije, ki združuje individualno empatijo, razumevanje konteksta in družbeno odgovornost, zagotavlja okvir za obravnavanje strukturnih neenakosti in spodbujanje družbene pravičnosti [13]. Te ugotovitve poudarjajo pomen empatije in vrednot pri spodbujanju prosocialnega vedenja in trajnostnih odnosov med ljudmi in naravo, tudi v kontekstu soočanja z izzivi in različnostjo, ki jih prinašajo demografske spremembe.

3 Mladostnik, socialne vrednote in empatija

Mladostništvo je kritično obdobje za razvoj identitete in tudi oblikovanje in ponotranjenje vrednot, kjer sta značilni vse večja notranja skladnost in stabilnost [14]. Na vrednote, ki usmerjajo mladostnikovo vedenje in oblikujejo družbene interakcije, vplivajo kulturni, družbeni in verski dejavniki [15, 16]. Razvoj vrednot v mladostništvu vključuje neprekinjen cikel notranjega potrjevanja z izbiro in udejanjanjem ciljev ter zunanjega potrjevanja s socialno primerjavo med vrstniki [17].

Raziskave kažejo, da so vrednote mladostnikov tesno povezane z njihovo socialno kompetentnostjo in prilagoditvijo. Socialne vrednote igrajo pomembno vlogo pri tem, saj vplivajo na njihovo vedenje, odnose in odločanje. Vrednote, kot so spoštovanje, empatija, pravičnost in odgovornost, pomagajo mladostnikom razumeti njihov položaj v družbi in pomembnost prispevanja k skupnemu dobremu. Mladostniki, ki internalizirajo pozitivne socialne vrednote, kažejo višjo stopnjo empatije in sodelovanja [18]. Ti mladostniki so bolj verjetno vpleteni v prostovoljne dejavnosti in imajo manj konfliktov z vrstniki, kar kaže na pomembnost socialnih vrednot pri spodbujanju zdravega socialnega vedenja [19]. Poleg tega socialne vrednote pomagajo mladostnikom krmariti skozi zapletene družbene izzive, kot so pritiski vrstnikov in moralne dileme [20].

Empatija ima v mladostništvu več pomembnih vidikov. Pomembna je za povezovanje z drugimi, vzpostavljanje in krmarjenje v odnosih: empatija služi kot most, ki spodbuja razumevanje in povezovanje z vrstniškimi skupinami in družinskimi člani mladostnikov [21, 22]. Empatija je pomembna za reševanje konfliktov, saj posameznikom omogoča razumevanje perspektiv in čustev drugih. To posledično olajša učinkovito komunikacijo in pogajalske veščine [23]. Empatija je tesno povezana s prosocialnim vedenjem, vključno z dejanji prijaznosti in altruizma. Mladostniki z dobro razvitim občutkom empatije se pogosteje vključujejo v dejavnosti, ki koristijo drugim, ter tako prispevajo k pozitivni in podporni skupnosti [24]. Za najstniška leta so značilne povečane čustvene izkušnje in razvijanje spretnosti čustvenega uravnavanja. Empatija mladostnikom pomaga prepoznati in razumeti lastna čustva in čustva drugih, kar vodi k boljšemu čustvenemu uravnavanju in mehanizmom spoprijemanja [25, 26]. Učinkovita komunikacija je temelj uspešnih odnosov. Empatija mladostnikom omogoča, da se uglasijo s čustvi, ki so v ozadju verbalnih in neverbalnih znakov, kar omogoča natančnejšo in sočutnejšo komunikacijo [27].

Raziskave dosledno kažejo pozitivno povezavo med empatijo, prosocialnim vedenjem in socialnim razumevanjem pri mladostnikih. Empatija, zlasti empatična skrb, je močan napovedni dejavnik prosocialnega vedenja [28]. Razlike med spoloma so očitne, saj dekleta na splošno izkazujejo višjo stopnjo empatije in prosocialnega vedenja kot fantje [28, 29]. Te

ugotovitve opozarjajo na zapleteno prepletanje med empatijo, socialnim razumevanjem in prosocialnim vedenjem v razvoju mladostnikov.

4 Razvoj empatije v mladostništvu

Razvoj empatije v mladostništvu je zapleten in večplasten proces, ki vključuje čustvene, kognitivne in vedenjske komponente. V obdobju mladostništva se razvoj empatije bistveno spremeni in ima ključno vlogo pri oblikovanju socialnih interakcij in prosocialnega vedenja. Raziskave kažejo, da se empatija običajno povečuje od otroštva do mladostništva [27] in naprej v odraslost [30]. V zorenju nevronskih mrež in čustvenih odzivov se že zgodaj pojavijo razlike med spoloma in vplivajo na razvoj empatije [31].

Pot razvoja empatije od zgodnjega mladostništva do odraslosti ostaja nepopolno opisana, saj obstajajo notranji (biološki, kognitivni) in zunanji (socialni in okoljski) dejavniki, ki oblikujejo empatijo v mladostništvu. Kar raziskave konsistentno omenjajo, je značilna razlika v stopnji empatije (tako čustvene kot kognitivne) glede na spol, kar je tudi pomemben dejavnik pri na empatiji oblikovanem odnosu do družbe in okolja.

Raziskave [32, 33] kažejo na razlike med spoloma pri razvoju kognitivne (in čustvene) empatije. Čeprav tako fantje kot dekleta na splošno doživljajo rast empatičnih spretnosti, dekleta pogosto kažejo nekoliko zgodnejši in naprednejši razvoj kognitivne empatije v mladostništvu. Pri dekletih se kognitivna empatija začne povečevati pri 13 letih. Čustvena empatija ostaja razmeroma visoka in stabilna v celotnem obdobju odraščanja. Pri fantih se kognitivna empatija začne povečevati pri 15 letih. Med 13. in 16. letom pride do začasnega upada čustvene empatije, ki pa se v poznih najstniških letih ponovno vzpostavi. Upad čustvene empatije pri mladostnikih je lahko delno povezan s hkratnim povečanjem ravni testosterona. Povečanje ravni testosterona je povezano z željo po prevladi in moči nad drugimi in ni težko razumeti, da so ti interesi pogosto v nasprotju s sposobnostjo sočutja in razumevanja drugih. Čeprav torej fantje začenjajo razvijati kognitivne sposobnosti empatije in se teoretično lahko postavijo v čevlje nekoga drugega, bodo morda težje ravnali v skladu s tem, zlasti v skupinskih situacijah. Te ugotovitve poudarjajo dinamično in spolno pogojeno naravo razvoja empatije v mladostništvu [28].

5 Raziskava: Razlike v čustveni in kognitivni empatiji pri mladostnikih

Razlike med spoloma v razvoju empatije v mladostništvu so lahko pomembne za razvoj prosocialnega vedenja, saj empatija igra ključno vlogo pri motivaciji posameznikov za pomoč drugim in pri oblikovanju moralnih stališč. Razumevanje, kako se empatija razvija različno pri dečkih in deklicah, lahko osvetli mehanizme, ki spodbujajo ali zavirajo prosocialno in socialno odgovorno vedenje pri mladostnikih. Zato je smiselno zavedanje teh razlik, da bi razvili učinkovite strategije za spodbujanje prosocialnega vedenja pri obeh spolih in tako prispevali k bolj sodelujoči in sočutni družbi. Za osvetlitev teh razlik predstavljamo rezultate raziskave, ki, tako kot številne druge raziskave, prikazuje in potrjuje razlike med spoloma v čustveni in kognitivni empatiji pri mladostnikih in utemeljuje smiselnost upoštevanja različnih izhodišč pri vključevanju empatije v odzivanju mladostnika na zaznane družbene probleme in potrebe.

5.1 Metoda

5.1.1 Udeleženci. V raziskavi je sodelovalo 231 mladostnikov, od tega 43,7% fantov in 56,3% deklet. Njihova povprečna starost je bila 16,11 let (Min. 14; Max. 20; SD = 1,185).

5.1.2 Pripomočki in postopek. Za merjenje stopnje kognitivne in čustvene empatije je bil uporabljen Vprašalnik z za merjenje mladostnikove empatije in sočutja - AMES (ang. Adolescent Measure of Empathy and Sympathy) [34]. Instrument je zasnovan za merjenje in razlikovanje kognitivne, emocionalne empatije in sočutja/simpatije (te dimenzije v našo raziskavo nismo vključili). Udeleženci so posamezne trditve ocenjevali na lestvici od 1 (nikoli) do 5 (vedno). Višji rezultati na posamezni lestvici pomenijo višjo stopnjo kognitivne oz. čustvene empatije. Koeficient zanesljivosti (Cronbachov alfa) za dimenzijo kognitivne empatije je znašal $\alpha = 0{,}748$, za dimenzijo emocionalne empatije pa $\alpha = 0{,}767$.

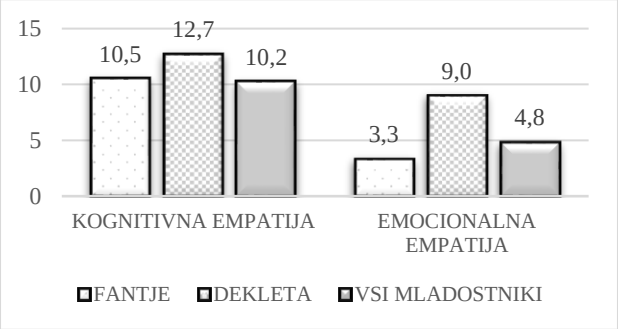
Raziskava je bila izvedena v okviru ene izmed faz projekta »Using virtual reality for inclusive and action-oriented empathy in schools« (VR4Empathy) [35], katerega namen je oblikovati, preizkusiti in razširiti ozaveščeno uporabo virtualne resničnosti za razvoj kognitivne empatije v šolah ter tako povečal kakovost in vključenost digitalnega izobraževanja na ravni EU. Projekt temelji na stičišču najsodobnejših raziskav VR, psihologije in izobraževanja ter predlaga v prihodnost usmerjen pristop na ravni EU, ki bo zagotovil znanja in vire za uporabo VR kot izobraževalne podpore pri poučevanju tem v več učnih načrtih, ki zajemajo teme, povezane z evropskimi zgodovinskimi dejstvi, skupnimi evropskimi socialnimi vrednotami ter evropskim državljanstvom in različnostjo, razvijajo kognitivno empatijo in izboljšujejo učinkovitost učnih izkušenj. Udeleženci so v tej fazi poleg stopnje empatije ocenjevali še svoje digitalne kompetence ter motivacijo za uporabo virtualne tehnologije v učnem procesu. Udeleženci iz treh sodelujočih držav (Grčija, Slovenija, Portugalska) so izpolnili vprašalnik v spletni obliki. Anketiranje je potekalo aprila 2024. Rezultate smo izračunali z uporabo programskega paketa SPSS 20.

5.2 Rezultati in razprava

Mladostniki so na vprašalniku AMES, ki razlikuje med emocionalno in kognitivno empatijo, dosegli višjo stopnjo kognitivne empatije (M = 10,2) v primerjavi z emocionalno empatijo (M = 4,8). Na vsaki lestvici je bilo mogoče doseči največ 20 točk.

Razlike v stopnji kognitivne in emocionalne empatije so vidne tudi glede na spol. Fantje (N = 101) so v povprečju pri kognitivni empatiji (M = 10,5) dosegli manj točk kot dekleta (N = 130; M = 12,7). Prav tako so pri emocionalni empatiji fantje (M = 3,3) dosegli manj točk kot dekleta (M = 9,0) (Slika 1). Preverili smo tudi, ali so te razlike statistično pomembne, za kar smo uporabili Mann-Whitneyev U-test, saj se podatki niso distribuirali normalno. Rezultati so pokazali, da so pri mladostnikih glede na spol razlike v kognitivni (p =,000) in emocionalni empatiji (p =,000) statistično pomembne. Dekleta dosegajo statistično pomembno višjo stopnjo kognitivne

empatije v primerjavi s fanti. Prav tako dekleta dosegajo statistično pomembno višjo stopnjo emocionalne empatije v primerjavi s fanti.



Slika 1. Povprečne vrednosti kognitivne in emocionalne empatije po spolu pri mladostnikih

Rezultati kažejo, da so v splošnem sposobnosti kognitivne empatije pri mladostnikih boljše v primerjavi z emocionalno empatijo, kjer so vrednosti precej nizke. To pomeni, da so mladostniki razmeroma sposobni pri razumevanju perspektive ali čustvenega stanja druge osebe na intelektualni ravni, medtem ko so njihove sposobnosti dejanskega deljenja in doživljanja čustev druge osebe razmeroma nizke. Pri kognitivni empatiji dekleta dosegajo višje povprečne vrednosti v primerjavi s fanti, vendar je stopnja kognitivne empatije še razmeroma enaka oz. primerljiva. Večje razlike so pri emocionalni empatiji, kjer fantje dosegajo bistveno nižje rezultate v primerjavi z dekleti. Ti vidiki predstavljajo relevantna izhodišča pri ukrepih za spodbujanje empatije pri mladostnikih ter pomenijo tudi različna izhodišča, ki jih je potrebno upoštevati pri nagovarjanju empatije mladostnika (npr. dekleta bodo lažje pri osvajanju neke vsebine in situacije izhajala iz emocionalne empatije kot fantje, medtem ko bo kapaciteta kognitivne empatije pri obeh spolih relativno podobna).

Soočanje z demografskimi spremembami, kot so večja kulturna raznolikost in različni družbeni izzivi, zahteva, da vzgojitelji in oblikovalci politik upoštevajo te razlike v empatiji med spoloma. Dekleta, ki so bolj nagnjena k emocionalni empatiji, bodo morda lažje sprejemala in se vključevala v medkulturne in medosebne dinamike, ki zahtevajo čustveno povezanost in razumevanje. Pri fantih pa bo potrebno dati več poudarka na spodbujanje razvoja emocionalne empatije, da bi dosegli enako stopnjo socialne vključenosti in razumevanja.

Pri spodbujanju kognitivne empatije, kjer so razlike med spoloma manj izrazite, je smiselno uporabljati enake strategije za oba spola, saj imajo mladostniki relativno podobne kapacitete za razumevanje perspektive drugih na intelektualni ravni. Prav tako je kognitivna empatija pri mladostnikih višja v primerjavi z emocionalno, kar kaže na to, da je ta vidik empatije bolj smiselno nagovarjati in povezovati s socialnimi vrednotami in vključevati v soočanje s socialnimi izzivi. To je mogoče doseči z vključevanjem aktivnosti, ki spodbujajo razmišljanje o čustvenih stanjih drugih in reševanje problemov skozi razumevanje perspektiv drugih.

6 Sklep

Raziskave o empatiji in socialnih vrednotah pri mladostnikih poudarjajo njen ključen pomen za razvoj socialnih kompetenc in pozitivnih družbenih odzivov. Empatija se v mladostništvu običajno povečuje, pri čemer je pri dekletih praviloma višja kot pri fantih. Tako kognitivna kot čustvena empatija prispevata k razvoju socialne kognicije in vplivata na interakcije mladostnikov z različnimi perspektivami v družbi [36]. Razvoj empatije v adolescenci napoveduje socialne kompetence v odrasli dobi, vključno s komunikacijskimi spretnostmi in zadovoljstvom v odnosih [27]. Spodbujanje in krepitev empatije lahko predstavlja pomembno izhodišče za programe opolnomočenja mladostnikov, kar lahko prinese dolgoročne družbene koristi. Razumevanje razlik v empatiji med spoloma v obdobju najstništva omogoča bolj ciljno usmerjene pristope v vzgoji za socialne vrednote in učinkovitejše soočanje z demografskimi spremembami, saj lahko prilagodimo strategije in programe, ki spodbujajo enakopravnost, povezanost in medsebojno razumevanje med mladostniki.

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Prednosti IKT tehnologije pri pouku športne vzgoje

Advantages of ICT technology in physical education lessons

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Abstract / Povzetek

V prispevku je predstavljeno, kako se lahko s pomočjo IKT tehnologije lotimo izziva prekomerne telesne teže dijakov in dijakinj ter spregovorimo o pomenu zdrave prehrane in presnove, ki je v času odraščanja za mladostnike ključnega pomena. Mladostniki se v našem učnem sistemu pogosto srečajo s pomenom zdrave prehrane, prav tako pa je zdrava prehrana pogosto tema v medijih. Kljub pogostemu omenjanju pomena zdrave prehrane, je raziskava pokazala, da mladostniki velikokrat posežejo po nezdravi hrani. Več kot polovica anketiranih mladostnikov je mnenja, da se prehranjujejo zdravo, vendar so rezultati pokazali, da je v resnici takšnih zgolj 28%. Potrošniki pogosto v trgovini kupujemo hrano glede na izgled embalaže, mladostniki pa so glede na vizualni izgled in oglaševanje določenega izdelka še bolj dovzetni. Posledično nezdravo hrano pogosto zamenjajo za zdravo in jo v prepričanju, da je zanje ustrezna, jedo. Da bi mladostnikom na drugačen način približali pomen zdrave prehrane, je bila opravljena raziskava, v kateri so dijaki najprej preverili svoje znanje o zdravi prehrani, izpolnili anketo o njihovih prehranjevalnih navadah in bili nato vključeni v delavnice o pomenu zdrave prehrane in presnove. Na delavnicah so dijaki s pomočjo aplikacije Energy for life na interaktivni način spoznali pomen zdrave prehrane in kako se hranila presnovijo v našem telesu. Svoje znanje so nato preverili z vprašalnikom. Na koncu delavnice so dijaki s pomočjo aplikacije Veš kaj ješ? naredili primere zdravih jedilnikov.

Ključne besede

IKT tehnologija, zdrava prehrana, prekomerna telesna teža, delavnice, presnova, aplikacija.

Abstract

The article presents how we can tackle the challenge of excessive body weight in male and female students and address the importance of healthy diet and metabolism using ICT technology, which is crucial for adolescents during their growth. Adolescents are often confronted with the importance of healthy eating in our learning system, and healthy eating is often a topic in the media. Despite the frequent mention of the importance of a healthy diet, research has shown that adolescents often resort to unhealthy foods. More than half of the adolescents surveyed said they were eating healthy, but the results showed that only 28% actually did. Consumers often buy food at the store based on the appearance of the packaging, and adolescents are even more receptive to the visual appearance and advertising of a particular product. As a result, unhealthy foods are often mistaken for healthy foods and eaten in good faith. In order to approach adolescents in a different way the importance of a healthy diet for their development and metabolism, a study was conducted in which students first tested their knowledge of healthy eating, completed a survey of their eating habits, and then participated in workshops on the importance of healthy eating and metabolism. Through the Energy for life application, students learned the importance of a healthy diet and how nutrients are metabolised in our bodies, and then tested their knowledge with a questionnaire. At the end of the workshop, students used the application Veš kaj ješ? and made examples of healthy menus. If writing in Slovene, add English abstract below the Slovene one.

Keywords

ICT technology, healthy nutrition, overweight, workshop, metabolism, aplication.

1 Uvod

Zdrava prehrana je nekaj o čemer se zadnje čase zelo pogosto govori. Pomen zdrave prehrane je ključen za zdrav razvoj, saj telo za izgradnjo notranjih ogranov, mišic, kostnine in živčevja nujno potrebuje hranila, ki jih vsebuje hrana. V zgodnjem otroštvu se običajno prehranjujemo bolj zdravo in uživamo raznoliko prehrano, ki nam omogoča zdrav razvoj. Otrokov jedilnik določajo starši oz. skrbniki in posledično ne moremo kot posamezniki vplivati na izbor hrane in uživati zgolj hrane, ki nam je všeč. V času pubertete, pa mladostniki počasi začnejo sami določati svoj jedilnik in pri tem večkrat ne upoštevajo smernic zdravega prehranjevanja. Nepravilen izbor živil in njihovo uživanje pa lahko pusti posledice, ki se pokažejo kot nepravilna, neenakomerna rast za vse življenje, prav tako pa lahko vpliva na oblikovanje prehranjevalnih navad v kasnejšem življenju. [6] Zaradi upada upoštevanja smernic zdrave prehrane skozi obdobje pubertete je bila posledično opravljena raziskava katere

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namen je ugotoviti prehranske navade mladostnikov, v kateri so sodelovali dijaki tretjih letnikov III. gimnazije Maribor. Dijaki so sprva izpolnili vprašalnik, ki je preveril njihove prehranske navade, nato pa so preko didaktične delavnice, pri katerih so uporabljali interaktivni aplikaciji, ki mladostnike spodbudita k boljšem razumevanju pomena zdrave prehrane in njene presnove, spoznavali načela zdravega prehranjevanja. Z vidika varovanja zdravja je namreč zdrava prehrana za mladostnike izredno pomembna, saj imajo ravno v tem obdobju veliko večje potrebe po beljakovinah, vitaminih in mineralih ter energiji. [1]

2 Pomen zdrave prehrane

Mladostniki se že v času osnovne šole pri pouku gospodinjstva srečajo s pomenom zdrave prehrane, kjer se učijo o prehranski piramidi in različni pripravi hrane. Nato se o prehrani in presnovi učijo pri pouku biologije, kjer največ poudarka namenijo presnovi ter vgradnji hranil v človeško telo in posledicah nepravilne prehrane in prehranskih navad. Njihove prehranske navade so v času osnovne šole običajno dobre, vsaj v prvi in drugi triadi. V tretji triadi pa mladostniki med glavnimi obroki pogosto uživajo prigrizke za katere je značilno, da vsebujejo veliko energije, zaradi prisotnosti sladkorjev in maščob, ne vsebujejo pa hranilnih snovi, ki jih telo potrebuje za krepitev odpornosti. Ena izmed praks mladostnikov v tretji triadi je opuščanje zajtrka in neustrezen ritem prehranjevanja ter premajhne količine zaužite zelenjave. Vendar se prehranske navade osnovnošolskih otrok v tretji triadi v veliki meri razlikujejo od navad srednješolskih otrok, saj le ti velikokrat nimajo primerne šolske malice. [5]

Zdravo prehrano bi lahko opredelili z naslednjimi smernicami:

- redna prehrana (vsaj 5 obrokov dnevno),
- uživanje hrane glede na prehransko piramido,
- raznolikost hrane,
- počasno uživanje hrane, ki jo dobro prežvečimo,
- izogibanje sladkim in mastnim jedem,
- izogibanje prigrizkom [2].

Iskanje krivca slabih prehranskih navad mladostnikov ni enostavno, saj na njihove navade vpliva mnogo različnih dejavnikov. Živimo v okolju, ki spodbuja debelost, saj smo kot družba izredno potrošnikov naravnani in nam mediji dnevno posredujejo vedno nove in nove proizvode. Poleg tega, pa nas okolje spodbuja k temu, da smo vedno manj aktivni (električna kolesa, električni skiroji, uporaba osebnega vozila...). Podatki za Slovenijo kažejo naraščajoče gibanje prekomerno hranjenih in debelih mladostnikov in odraslih pri nas, kar kaže, da se navade pogosto prenašajo s starejše na mlajšo generacijo [7]. Debelost pri mladostnikih je namreč eden izmed največjih problemov današnjega časa, saj prekomerna telesna teža v mladostniškem obdobju zelo pogosto nakaže na prekomerno telesno težo tudi v odraslem obdobju. Pri mladostniku neuravnotežena prehrana povzroča manjšo delovno storilnost, utrujenost, manjšo sposobnost pomnenja in kronične bolezni. Strokovnjaki so ugotovili, da so številne bolezni neposredno povezane s hrano, kar pomeni da je od prehrane odvisno naše zdravje. Nepravilna prehrana pa je večkrat povezana z različnimi slabimi navadami kot je telesna neaktivnost in kajenje. Bolezni katere lahko neposredno povežemo s prehrano so:

- beri-beri (posledica, dolgoročnega pomankanja vitamina B1),
- skorbut (nastane zaradi pomanjkanja vitamina C v daljšem časovnem obdobju),
- hipertenzija (povišan krvni tlak zaradi hrane, ki vsebuje visoke vrednosti nitratov),
- zobna gniloba (posledica prekomernega uživanja sladke hrane in slabe ustne nege).

Obstaja še množica drugi bolezni, vendar njihovega nastanka ne morejo povezati izključno z slabimi prehranskimi navadami [8].
Ker so bolezni, ki jih povzroča nezdrava prehrana velik javnozdravstveni problem, se veliko pozornosti namenja k omilitvami posledic le teh.

3 Interaktivno poučevanje

Ustaljena praksa poučevanja mladostnikov o pomenu zdrave prehrane, očitno ne prinaša dobrih rezultatov, saj se delež

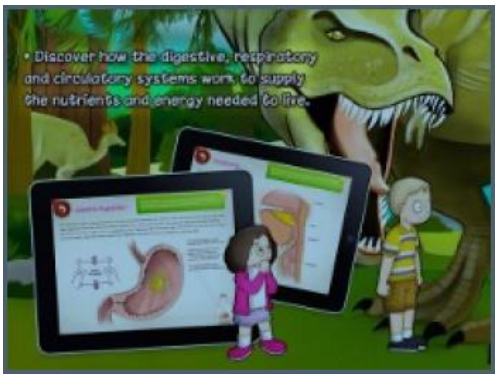
mladostnikov, ki imajo slabe prehranske navade in posledično zdravstvene težave, iz leta v leto povečuje. Razlog za slabe navade mladostnikov, bi lahko bili tudi zastareli načini poučevanja v šoli, saj so učenci zaradi uporabe interneta, mobitelov in televizije navajeni na interaktivno pridobivanje informacij. Frontalen način poučevanja, katerega uporablja večina učiteljev, v večini primerov ne doprinese k trajnostnem znanju, saj so učenci do takšnega pridobivanja informacij vedno manj motivirani pri učnem procesu [4]. Učitelj mora dan danes učence spodbujati, da sami pridejo do določenih spoznanj, ne da jim zgolj posreduje znanje. Z uporabo in upoštevanjem konstruktivističnega pristopa pri izkustvenem učenju lahko učitelj učencem pomaga povezati ugotovitve s praktičnimi zakonitostmi. Uporaba IKT (informacijsko komunikacijske tehnologije) lahko omogoči posredovanje učne snovi na bolj atraktiven način. Pri pouku lahko uporabimo tako računalnike, kot tudi mobilne telefone, sploh v primeru, ko imamo v vzgojno

izobraževalnem zavodu težave zagotoviti primerno število računalnikov za večjo skupino učencev. Uporaba mobilnih telefonov pri pouku ima tudi svoje omejitve in predstavlja določene izzive, sploh od učiteljev. Prednost mobilnih telefonov je v tem, da jih ima večina učencev in da so običajno zmogljivejši od šolskih računalnikov [3].

4 Aplikacije za poučevanje o zdravi prehrani in presnovi

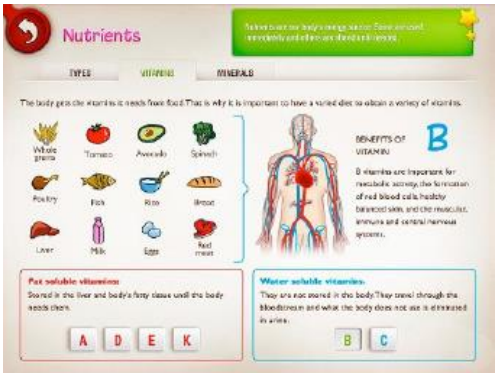
Na spletu je množica različnih aplikacij in spletnih strani, ki opisujejo zdravo prehranjevanje vendar je zgolj peščica didaktično primernih za uporabo v učnem procesu. Večina aplikacij je namenjena ali izobraževanju ali zabavi, vendar le malo je takšnih, ki bi združevale oba spektra. Ena izmed aplikacij, ki je tako poučna, da uporabnik pridobi in utrdi svoje znanje, kot tudi zabavna, da se ne naveliča in je pripravljen dlje

časa ostati motiviran, se imenuje Energy for life. Aplikacija sicer ne ponuja uporabe v slovenskem jeziku, temveč je zgolj v angleškem in španskem jeziku. Posledično se lahko aplikacijo uporabi kot primer medpredmetnega povezovanja biologije in angleščine. Prednost aplikacije je tudi v tem, da je popolnoma brezplačna in omogoča več različnih učnih modulov. Aplikacija s pomočjo igrifikacije – uporaba dinozavra, ki pritegne pozornost uporabnika, uči novih konceptov in ga motivira za interakcijo, kar izboljša učni proces. Zaradi enostavnega umesnika je ta aplikacija dostopna vsem učencem različnih starosti, tako v osnovni, kot tudi v srednji šoli. Vizualen prikaz in strokovna natančnost izrazov, se določi s pismenimi sposobnostmi uporabnika. Velik poudarek je na znanstveni pismenosti, povezan z vizualnimi dražljaji, ki uporabnika spodbujajo k aktivni uporabi aplikacije. Aplikacija je zasnovana tako, da se jo lahko uporablja ob spremstvu vodje učnega procesa ali pa se jo uporablja samostojno. Slika 1 prikazuje dinozavra, ki mladostnika nagovarja, kaj vse lahko s pomočjo aplikacije izve. Uporabnik lahko izbira med različnimi področji, ki jih lahko s pomočjo aplikacije osvoji in utrdi svoje znanje. Slika 2 prikazuje modul prebavil, katerega uporabnik lahko izbere v aplikaciji in s pomočjo njega pregleda kaj vse njegovo telo potrebuje za delovanje. Nato uporabnik preveri kaj se zgodi, če tega hranila ne dobi (nastanek različnih obolenj). Prav tako, ga aplikacija spodbuja k nadaljnjem razmišljanju in preizkušanju naučenega znanja.



Slika 1: Prikaz različnih modulov apliakcije

Aplikacija Veš kaj ješ? omogoča uporabniku preveriti energijsko vrednost hrane. Prav tako uporabniku omogoča, da s pomočjo prehranskega semaforja ugotovi, katerih živil naj se zaradi prekoračenih vrednosti določenih hranil izogiba. Namen aplikacije je pomoč pri sestavi jedilnika, katerega lahko vsak posameznik sestavi glede na svoje prehranske navade. Slika 3 prikazuje primer uporabe aplikacije na pametnem telefonu med opravljanjem nakupov. Aplikacija nam omogoča uporabo kamere pri pametnem telefonu in s tem skeniranje črtne kode izdelka, katerega prehransko vrednost želi uporabnik preveriti. Aplikacija nam nato s pomočjo barvnega semaforja prikaže katerih hranil je v izdelku v zadostnih, prekomernih ali premajhnih količinah. Pri sliki 4 lahko vidimo, kako je razčlenjen prehranski semafor, ki uporabniku sporoča še dopustno vrednost določenih hranil v izdelku. Aplikacija Veš kaj ješ? ni namenjana zabavi in je posledično manj atraktivna kot aplikacija Energy for life, zato je vsaj uvodna uporaba aplikacije priporočljiva pod vodstvom učitelja. Učitelj mora pred uporabo mobilnih telefonov kot učnega pripomočka med poukom oceniti smiselnost, pri kateri učni snovi ga bo uporabil in katere učne cilje bo s pomočjo njih usvojil. Prav tako ni namen vsakodnevne uporabe mobilnih telefonov pri učnem procesu, saj bi s tem njegova atraktivnost izzvenela, prav tako pa bi lahko postal moteči faktor v razredu zaradi morebitne nedovoljene uporabe iz strani učencev.



Slika 2: Prikaz modula hranila

Slika 3: Prikaz aplikacije Veš kaj ješ?

5 Raziskava

Da bi ugotovili odnos do zdrave prehrane mladostnikov in preverili znanje o pomenu zdravega prehranjevanja in presnove, je bila opravljena raziskava, v kateri so sodelovali dijaki tretjih letnikov III. gimnazije Maribor. Za namen raziskave je bilo izbranih 42 dijakov, ki so sprva izpolnili vprašalnik, ki je bil sestavljen iz 14 vprašanj, katerih namen je bil ovrednotiti znanje dijakov o zdravi prehrani in presnovi, prav tako pa je bil namen vprašalnika preveriti njihove prehranske navade. Nato so bile izvedene 3 učne ure, pri katerih so dijaki s pomočjo aplikacije Energy for life ugotovili pomen zdrave prehrane in presnove, nato pa so s pomočjo aplikacije tudi preverili svoje znanje. Pri učni uri je bila vloga učitelja zgolj kot usmerjevalec učnega procesa in ne posredovalca znanja. Po uporabi aplikacije so bili dijaki pozvani kakšne so njihove prehanske navade in opisu njihovega tedenskega jedilnika. Ker so imeli pri jedilniku večje težave, so nato s pomočjo aplikacije Veš kaj ješ? preverili kakšne jedi so primerne za določen del dneva in katerih jedi se morajo izogibati pri svoji prehrani. Po zaključku dela z aplikacijo so dijaki s pomočjo razgovora posredovali
kaj so se naučili in izročke oblikovane skupaj z učiteljem zapisali v zvezke. Nato so ponovno izpolnjevali vprašalnik, s katerim je bilo preverjeno, kaj so se naučili. Določeni rezultati vprašalnika

so bili pričakovani, saj se je tako znanje kot tudi odnos do zdrave prehrane izboljšal. Presenetljivo je bilo to, da je bilo 54% odstotkov dijakov mnenja, da se prehranjuje zdravo, vendar je bilo nato v nadaljnjem delu rezultatov vprašalnika prikazano, da so zmotno prepričani v svoj zdrav način prehranjevanja. Kar 48% dijakov navaja premalo časa kot glaven krivec za njihove slabe prehranske navade, 35% dijakov pa navaja, da stres močno pripomore k njihovim prehranskim navadam. Kot glaven razlog zakaj kupijo določen proizvod so dijaki podali izgled in njegovo oglaševanje. Večina dijakov ne pregleda hranilnih vrednosti pred nakupom produkta. Pri vprašanju katera pijača ima najvišjo vrednost sladkorja,
je sprva od 42 dijakov pravilno odgovorilo zgolj 5 dijakov, kar nakazuje na njihovo zmotno znanje o hranilih v sladkanih pijačah. Pri zapoznelen vprašalniku pa je pravilno odgovorilo 18 dijakov. Večina dijakov, kar 34 od 42 je odgovorila pri zapoznelen vprašalnikov, da bodo več pozornosti namenili svojim prehanskim navadam.

6 Zaključek

Ključno je, da se o zdravi prehrani začnemo pogovarjati čim prej v začetku izobraževalnega procesa. Vendar zgolj frontalno poučevanje ne prinaša željenih rezultatov, saj se delež prekomerno debelih otrok in mladostnikov v zadnjem času drastično povečuje. V raziskavi je predstavljen eden od načinov, kako lahko izobrazimo mlade o pomenu zdrave prehrane. Aplikacije, ki jih dan danes učenci uporabljajo pri pouku, so dostopne preko mobilnih telefonov, kar pomeni, da lahko tudi vzgojno izobraževalni zavodi z omejitvami pri omogočanju dovolj velikega števila računalnikov za vse učence, omogočijo svojim učencem izvedbo pouka na takšen način. Ali bo uporaba takšnih aplikacij drastično vplivala na prehranske navade učencev je neodgovorno trditi, vendar njihova uporaba lahko pripomore k boljšem ozaveščanju zdravega načina prehranjevanja in razumevanju presnove hranil ter zdravemu načinu življenja.

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E-branje in e-knjige: posebnosti in izzivi v šolski praksi

E-reading and e-books: specifics and challenges in school practice

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POVZETEK

V prispevku predstavljamo e-knjige in e-branje v šolski praksi. Osredotočamo se na posebnosti in izzive, ki se porajajo pri njihovem vključevanju v pouk slovenščine. Povzemamo nekatere raziskave e-branja, njegove specifike in možnosti, ki jih nudi za bralno motivacijo pri današnjih šolajočih se generacijah, ki so v digitalni svet vpete praktično na vseh korakih.

KLJUČNE BESEDE

E-knjiga, e-branje, pouk slovenščine, motivacija za branje, digitalna generacija

ABSTRACT

In this paper we present e-books and e-reading in school practice. We focus on the specifics and challenges that arise, when we include them in Slovenian language lessons. We summarize some research of e-reading, its specifics and the possibilities, that e-books offer for reading motivation among today's school-age generations, who are embedded in the digital world at practically every step.

KEYWORDS

E-book, e-reading, Slovene language lesson, reading motivation, digital generation

1 BRANJE IN E-BRANJE: PODOBNOSTI IN RAZLIKE

1.1 Opredelitev (e-)branja

Pri strokovnih (in znanstvenih) razpravah o (e-)branju je vedno potrebno vzeti v obzir čas in s tem družbene okoliščine, znotraj katerih se pogovarjamo o branju. Prav tako je potrebno jasno definirati, o katerem segmentu branja oz. stopnji razvoja bralne zmožnosti razpravljamo.

Če se dotaknemo opredelitve branja, gre za proces dekodiranja/prepoznavanja zapisanih črk in njihovega pretvarjanja v glas, tj. izgovorjave. Gre za človeku specifično dejavnost, ki nam ni dana, ampak se je (na)učimo. Da postane avtomatiziran proces, je potrebno (dovolj) vaje. Kot tako predstavlja najučinkovitejše sredstvo usvajanja znanja. Učenje branja poteka stopenjsko (več o tem v [18]).

Če se osredotočimo na namene prispevka, bomo v nadaljevanju s pojmom "branje" zajeli opredelitev, uveljavljeno v slovenistični stroke. Ta branje[1] razume kot temeljno dejavnost, ki vodi k bralni pismenosti [5].

1.2 Kratek pregled raziskav e-branja

V slovenskem prostoru je relativno malo raziskav, ki bi se osredotočale na raziskovanje razlik med "klasičnim" branjem, tj. branjem s papirja, in med "digitalnim" oz. e-branjem. Med raziskavami izstopa S. Pečjak [20], ki s sodelavko ugotavlja, da je generacija Y[2] pri e-branju nekoliko hitrejša od branja s papirja, kar pripisuje verjetnemu pogostemu pregledovanju družabnih omrežij, brskanju po spletu in branju informativnih vsebin, pri čemer zaradi same narave tovrstnih besedil redkeje uporabljajo metakognitivne strategije in torej manj preverjajo svoje razumevanje med samim branjem. Posledično lahko z računalnika berejo hitreje kot s papirja, vendar manj natančno in imajo zato več težav s ponovnim iskanjem informacij, porabijo več časa za naloge bralnega razumevanja in odgovarjanjem na vprašanja. Glede razumevanja prebranega pa med tistimi, ki so brali s papirja, in tistimi, ki so brali na zaslonu, ni pomembnih razlik [20].

Za primerjavo z rezultati slovenske raziskave naj navedemo še primer raziskave na Norveškem, ki jo je s sodelavci izvedla E. Mangen [4]. Ugotovili so, da so učenci, ki so brali besedila s papirja, dosegli boljše rezultate pri nalogah bralnega razumevanja od tistih, ki so brali besedila na zaslonih. V tem segmentu se raziskavi med seboj razlikujeta.

A. Kepic Mohar [1] pa ugotavlja, da je proces pridobivanja znanja in s tem celotnega razvoja posameznika, za katerega je v preteklosti veljalo, da potekalo (s knjigami in) z branjem, dandanes le še pot do pragmatičnega cilja, torej orodje za lažji vstop na trg delovne sile. Novi digitalni mediji, ki praktično vsakodnevno vstopajo v vse sfere našega življenja, vplivajo in

[1] V prispevku se bomo osredotočili na branje digitalnega bralnega gradiva in ga mestoma primerjali s (klasičnim) tiskanim. Stroka pa poleg teh dveh med vrste bralnih gradiv uvršča še zvočne in interaktivne (za več glej razvojni projekt Bralna pismenost in razvoj slovenščine – OBJEM (Ozaveščanje, Branje, Jezik, Evalvacije, Modeli), ki je potekal pod okriljem Zavoda Republike Slovenije za šolstvo).

[2] Tudi t. i. digitalna generacija, ki je odraščala v drugačnih okoliščinah in je bolj vajena branja z računalniškega zaslona, zato ima tudi najbrž temu primerno razvite bralne strategije [20].

spreminjajo oblike sporazumevanja/komunikacije, jezik, ki ga pri tem uporabljamo, značilnosti pisanja in podobno, nenazadnje pa tudi naše zmožnosti sprejemanja besedil različnih vrst, kamor spada branje.

1.3 Posebnosti branja elektronskih besedil

Digitalizacija je spremenila naš vsakdan in močno posegla tudi v šolstvo. Ne le da je omogočila hiter dostop do velike količine informacij, spremenila je tudi naš način razmišljanja ter branja in posledično učenja, če ostajamo na predpostavki, da je branje (še vedno) najučinkovitejši način usvajanja znanja, čeprav se učenci več ne učijo samo s papirja, ampak tudi z zaslona.[3]

Da bi lahko razumeli posebnosti branja elektronskih besedil in jih upoštevali v svoji praksi, je potrebno poznati značilnosti digitalnih virov. Ti imajo dve temeljni značilnosti:

(1) nematerialnost oz. neoprijemljivost in
(2) večzaznavno naravo interakcij.

Učenec torej pri uporabi digitalnih virov nima konkretnih oz. oprijemljivih predmetov za manipulacijo (prijemanje, premikanje …), poleg tega pa je v digitalnem okolju prekinjena prostorsko-časovna povezanost med aktivnostjo učenca in njegovim zaznavanjem. Digitalna/elektronska besedila zmanjšujejo eno ključnih navigacijskih sposobnosti bralca, tj. nadzor nad branjem, ki je ena od osrednjih regulacijskih sposobnosti [19].

A. Kepic Mohar [1] (po Kovač in van der Well 2018) povzema tri načine branja, ki so posledica digitalizacije in ki so povezani z dolžino besedil ter medijem, na katerem beremo:

(1) branje s preletom (angl. *skimming*);
(2) vživeto branje (angl. *immersive/absorbed reading*), ki poteka pri branju žanrskega leposlovja;
(3) poglobljeno/globoko branje (angl. *in-depth/deep reading*), ki pa je kognitivno zahtevnejše oz. študijsko branje in vključuje predznanje.[4]

Da je e-branje drugačno od branja s papirja, je pokazala tudi mednarodna raziskava *Spretnosti odraslih* (PIAAC), kakor povzema njene rezultate P. Javrh [15]. Že sama narava elektronskih besedil narekuje "drugačno" branje, je potrdila raziskava. Poleg tega pa je za učinkovito obdelavo informacij v digitalnem okolju predpogoj dobro usvojena bralna tehnika/veščina. Ta je namreč potrebna, da lahko pri e-branju in obdelavi e-gradiv stečejo zahtevnejši kognitivni procesi.

2 E-KNJIGA IN ZVOČNA KNJIGA: ISTA STVAR, RAZLIČNO POIMENOVANJE?

V šolski praksi se pogosto dogaja, da se uporabljata dva različna izraza za isto stvar, kar vnaša marsikatero zmedo in nejasnost. Tudi kar zadeva e-branje (ali elektronsko branje), ki se odvija v e-knjigah (ali elektronskih izdajah knjig), se dogajajo (napačne) interference z drugim pojmom. Gre za t. i. zvočne knjige, ki v zadnjih letih (zlasti po epidemiji covida) vedno bolj prodirajo v vsakdanje življenje in šolsko prakso, zato je prav, da nekaj mesta namenimo tudi razmejitvi teh dveh pojmovanj.

2.1 Opredelitev e-knjige

Slovar slovenskega knjižnega jezika (dostopen na fran.si v nadaljevanju *SSKJ*) opredeljuje e-knjigo oz. elektronsko knjigo kot knjigo v elektronski obliki, namenjeno zlasti za branje na e-bralniku ali drugih elektronskih napravah. Kot sopomenko e-knjigi najdemo tudi pojem digitalna knjiga (prim. [24]). Tukaj najdemo še nekoliko obširnejšo opredelitev, saj gre za enciklopedičen članek, in sicer da je to knjižna publikacija, izdana v digitalni obliki. Lahko je izdana samostojno ali kot različica tiskane knjige. Namesto v fizični obliki do nje dostopamo s pomočjo računalniške naprave in se izpisuje na zaslonu (za primerjavo glej [6]).

E-knjiga je torej prvenstveno namenjena branju (in posledično v šolski praksi bralnemu razumevanju).

2.2 Opredelitev zvočne knjige

V *SSKJ* ne najdemo zadetka pod iztočnico "zvočna", ko želimo najti definicijo zvočne knjige, prav tako ne pod iztočnico "knjiga". Ponujena nam je razlaga pod iztočnico "avdioknjiga" in je v *SSKJ* opredeljena kot "obsežnejše literarno besedilo, ki je posneto na nosilec zvoka, navadno na CD-ploščo". Nadalje jo najdemo še pod iztočnico "zvočnica", ki jo *SSKJ* opredeljuje kot:

(1) "zvočni posnetek zlasti literarnega besedila, ki ga navadno berejo profesionalni bralci, igralci" oz. kot
(2) "knjig[o] za otroke, ki omogoča zaznavanje predstavljene vsebine (tudi) s sluhom".

Iz slovarskega sestavka izvemo še, da je pojem "zvočnica" nastal iz "zvočne knjige" po zgledu angleškega izraza "audio book" in da se zanj uporabljata še sinonimna pojma "avdioknjiga" in "zvočna knjiga".[5]

Zvočna knjiga/zvočnica je torej knjiga, namenjena poslušanju (posledično v šolski praksi imenovanemu slušnemu razumevanju).

2.3 Kaj pa (e-)bralnik?

E-bralnik (pogosto tudi elektronski papir ali e-papir) je naprava, zelo podobna tabličnemu računalniku, namenjena branju e-knjig. Zanj je značilen zaslon e-ink oz. zaslon s črnilom. "Zaslon s črnilom je vrsta zaslonske tehnologije, ki natančno posnema videz knjige. E-ink zaslon je tudi zelo varčen in manj obremenjuje oči." [10] (več o tem tudi [11])

3 APLIKACIJE, NAMENJENE BRANJU E-KNJIG

V nadaljevanju navajamo pregled aplikacij, namenjenih branju e-knjig. Pri tem se osredotočamo na e-knjige v

[3] Za lažje razumevanje posebnosti e-branja (tudi digitalnega branja, kakor se pogosto imenuje v slovenistični stroki, primer [2]), na kratko po S. Pečjak [19] povzemamo nekaj značilnosti generacij, ki so v času nastajanja prispevka vključene v sistem formalnega izobraževanja. Gre za dve generaciji, in sicer za (1) generacijo Z (rojeni v letih 1995–2010), imenovano tudi digitalni pionirji, in (2) generacijo alfa (rojeni po letu 2010), ki jo imenujejo tudi digitalni domorodci. »Za obe generaciji je značilno, da sta v svojem življenju doživeli največ družbenih sprememb od vseh generacij pred njima, najbolj pa ju je zaznamovala digitalizacija življenj, tj. povsod navzoča prisotnost tehnologije« (62) Nadalje avtorica povzema rezultate raziskav, ki so pokazale, da „digitalne" generacije nimajo odpora do branja z zaslona, a lažje razumejo slišano/prebrano in prikličejo bistvo prebranega, če poslušajo oz. preberejo na papirju kot v e-obliki.

[4] Na podlagi nove informacije si širimo besedni zaklad in s kognitivnimi procesi gradimo znanje [1] (po Kovač in van der Well 2018).

[5] Za več glej [12].

slovenskem jeziku, saj želimo osvetliti priložnosti in ovire pri njihovi uporabi pri pouku slovenščine [6] (kot prvega oz. maternega jezika):

(1) KOBI je aplikacija, namenjena začetnemu branju, tj. učenju in treningu branja (bralne tehnike). Uporaba aplikacije je brezplačna. Ker je namenjena učenju branja in je torej primerna za prvo triletje osnovne šole, je podrobneje ne bomo obravnavali.
(2) Biblos, spletna platforma, je prva slovenska e-knjižnica (in e-knjigarna), nastala leta 2013 pod okriljem Beletrine, zavoda za za založniško dejavnost, in s sodelovanjem mreže slovenskih knjižnic ter inštitutom IZUM, skrbnikom sistema COBISS [13]. Prvenstveno je bila namenjena izposoji e-knjig, kasneje tudi njihovemu nakupu. Za uporabnike, člane splošnih knjižnic, je bila izposoja brezplačna. S 1. 6. 2024 jo je za člane splošnih knjižnic nadomestila platforma COBISS Ela (več o njej v nadaljevanju). Beletrina ima od takrat naprej novo platformo, Beletrina Digital, ki ob plačilu naročnine nudi izposojo in nakup e-knjig, zvočnih knjig, filmov, podkastov in prispevkov.
(3) sBiblos je Beletrinina spletna platforma, namenjena izposoji knjig za učence zadnjega triletja osnovne šole in srednješolce. Uporaba je zanje brezplačna, prijava je mogoča z AAI računom.
(4) Mladinska knjiga PLUS je aplikacija založbe Mladinska knjiga, ki ob plačilu izbranega paketa nudi različne digitalne vsebine (e-knjige, zvočnice, animirane pravljice in podkaste ter drugo, glede na izbran paket).
(5) COBISS Ela je platforma, ki nudi članom splošnih knjižnic ob namestitvi ustrezne programske opreme izposojo e-knjig.

3.1 Za šolsko prakso uporabne aplikacije

Pregled aplikacij za e-branje, ki so uporabne v šolski praksi, bomo naredili na podlagi temeljnih ciljev pouka književnosti, ki jih opredeljuje učni načrt za osnovno šolo v zadnjem triletju (7.–9. razred) in učni načrt za gimnazijo.[7] Kot podlago smo vzeli še gradnike bralne pismenosti projekta OBJEM [8], ki se nanašajo na branje in bralno motivacijo.

3.1.1 Cilji pouka slovenščine (kot prvega oz. maternega jezika)

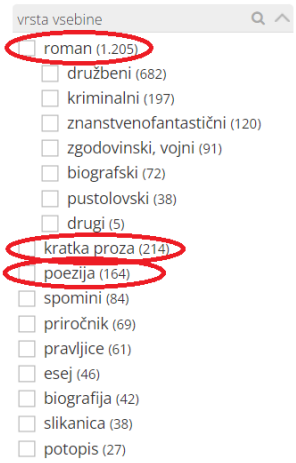
Naj na kratko zaradi lažjega razumevanja in za argumentacijo izbora povzamemo temeljne cilje pouka slovenščine, ki se nanašajo (tudi) na (motivacijo za) branje.

Učenci in dijaki pri pouku slovenščine razvijajo sporazumevalno zmožnost v slovenskem (knjižnem) jeziku, torej zmožnost kritičnega sprejemanja (in tvorjenja) besedil različnih vrst. Branje (zlasti v okviru pouka književnosti) prepoznavajo kot užitek, prijetno doživetje in intelektualni izziv. "Pri razvijanju sporazumevalne zmožnosti ob dejavnem stiku z neumetnostnimi in umetnostnimi besedili z uporabo digitalne tehnologije varno, ustvarjalno in kritično pridobivajo ter uporabljajo podatke/informacije." [21] (7) V gimnaziji razvijajo zmožnost literarnega branja kot specifično podvrsto sporazumevalne zmožnosti ter se usposabljajo za branje in interpretacijo literarnih besedil [22] (7).

Eden od gradnikov bralne pismenosti je motiviranost za branje, ki zajema interes za branje, pozitiven odnos do branja različnih vrst besedil (za različne namene, in sicer branje za znanje in branje leposlovja oz. razvojanje bralne kulture) ter izbiranje tiskanih in drugih informacijskih virov glede na namen branja v povezavi z uporabo različnih lokacij bralnih virov. Drug (za naš prispevek relevanten) gradnik je še tekoče branje, ki med drugim zajema tehniko branja (in njeno prilagajanje zahtevam besedila).

3.1.2 Zbirka e-knjig v slovenščini

Razpoložljiva baza e-knjig v slovenskem jeziku zajema zlasti literarna/umetnostna besedila, kot je razvidno s Slike 1[8] in ki jih obravnavamo pri pouku književnosti. Ker gre za branje literarnih besedil, to vrsto branja v slovenistični stroke imenujemo literarno branje[9] (prim. [5, 3]).



Slika 1: Tipologija e-knjig v COBISS Eli (zajem zaslona)

Tudi baza e-knjig, ki so brezplačno na voljo za učence in dijake v platformi sBiblos zajema literarna besedila, kot je razvidno s Slike 2.

Slika 2: Tipologija e-knjig v sBiblosu (zajem zaslona)

[6] Osredotočili se bomo na pouk slovenščine od 6. do 9. razreda osnovne šole in pouk slovenščine v srednješolskem izobraževanju.
[7] Na ostale programe srednješolskega izobraževanja se nismo posebej osredotočali, saj gre v večini za nadaljevanje in manjšo nadgradnjo osnovnošolskih ciljev.
[8] Podatke sicer navajamo za platformo COBISS Ela, vendar podobno velja tudi za Biblos v začetku leta 2017 [13]: razmerje gre v prid leposlovja, in sicer je predstavljajo 71 % vseh razpoložljivih e-knjig, strokovna literatura pa 29 %.
[9] V stroki pojmujemo literarno branje kot najbolj kompleksno branje, ki nudi največ možnosti oblikovanja vsestranskega bralca [5, 3].

E-knjige v slovenskem jeziku najdemo tudi na slovenskem Wikiviru [23] (in drugih spletnih mestih), kjer so digitalizirana dela slovenskih avtorjev različnih obdobij slovenske književnosti (prim. [14, 25]). Ker gre za postavitev literranih besedil na splet, do katerih ne dostopamo preko aplikacije, jih v našem prispevku ne bomo podrobneje obravnavali.

3.2 Možnost uporabe izbranih aplikacij pri pouku

Pri predstavitvi možnosti uporabe aplikacij za branje e-knjig smo se odločili za vključitev tistih, ki nudijo brezplačno uporabo za učence in dijake, saj na ta način omogočimo vsem učencem enake možnosti dostopa. To sta dve, in sicer COBISS Ela in sBiblos.

3.2.1 COBISS Ela

Platforma COBISS Ela na spletni strani [7] nudi pregledna navodila, katere naprave in aplikacije za branje podpirajo izposojo in branje e-knjig. Kot prednost platforme gre izpostaviti, da lahko e-knjige beremo na mobilnih napravah, ki temeljijo na Androidu in tudi na sistemu iOS. Zraven je navedeno tudi ime aplikacije, ki si jo je potrebno namestiti. Navodilom so dodani tudi e-vodiči za posamezne korake.

E-knjige lahko beremo tudi na osebnih računalnikih ter bralnikih e-knjig in bralnikih inkBOOK. Preprost je tudi način iskanja želene e-knjige, saj je brskalnik enak iskalniku tiskanih knjig v knjižnicah. To je zagotovo velika prednost, saj ni potrebnega "novega učenja" iskanja želene e-knjige.

V bazi e-knjig najdemo večino sodobnih slovenskih mladinskih romanov, ki najbolj motivirajo mlade bralce, saj jih nagovarjajo z njim aktualnimi vsebinami/temami. E-knjigo si lahko izposodimo na dveh različnih napravah, na voljo pa nam je 21 dni od dneva izposoje. Naenkrat si lahko uporabnik izposodi 5 e-knjig. To je lahko uporabno za učence, saj lahko e-knjige berejo na dveh različnih napravah, na eni npr. v šoli in na eni doma. Prav tako lahko hkrati berejo več različnih knjig, jih med seboj primerjajo (iščejo podobnosti in razlike, analizirajo posamezne motive ipd.).

3.2.2 sBiblos

Beletrinin sBiblos prav tako deluje na mobilnih napravah z operacijskima sistemoma Android in iOS. Na spletni strani [9] so podrobna navodila, kako po korakih namestiti potrebne aplikacije za dostop do e-knjig. Zelo uporabni so tudi e-vodiči in slikovno gradivo, ki pomaga pri nameščanju in uporabi bralnika. E-knjige lahko uporabniki berejo na osebnih računalnikih, mobilnih napravah in e-bralnikih.

Do storitev sBiblos lahko učenci dostopajo z AAI uporabniškimi podatki, v kolikor ima šola urejen dostop do storitve Moja Knjižnica in podpisano pogodbo o obdelavi osebnih podatkov z IZUM-om.

V zbirki e-knjig najdemo večino literarnih del, ki se obravnavajo v šoli in tudi novejša dela z učencem in dijakom privlačnimi temami. Tudi sBiblosovi zbirki pedstavljajo navečji del literarnega opusa romani in kratka proza. Učenci in dijaki si lahko naenkrat izposodijo 3 e-knjige, na mesec 10 e-knjig, vsaka knjiga pa jim je na voljo 30 dni od dneva izposoje. V primerjavi s COBISS Elo je čas izposoje e-knjig uporabnikom prijaznejši, je pa na voljo manj hkrati izposojenih knjig.

3.2.3 Čemu v šolsko prakso vključiti e-knjige?

Nanizali bomo zgolj nekaj argumentov, zakaj v šolsko prakso (občasno) vključiti e-knjige.

Prvič se nam zdi takšen način zelo pragmatičen, saj potrebujemo malo opreme, zadostuje že kakšen (pametni) telefon ali tablični računalnik in lahko manjša skupina (predlagamo do 4) učencev/dijakov bere skupaj eno e-knjigo. Na ta način pokrijemo tako sodelovalno učenje, razvijanje digitalnih kompetenc učencev in še hkrati jih motiviramo za branje ter pogovarjanje o prebranem (izmenjavo mnenj, različnih interpretacij prebranega, razjasnjevanje manj jasnih mest ipd.). Na ta način lahko pokrijemo tudi skupno daljše branje izbranih literarnih del po delih z učencem zanimivo/privlačno tematiko.

Podoben način dela lahko uporabimo tudi za (obvezno) domače branje, ki nemalokrat učencev ne pritegne in se ga izogibajo ali pa površno preberejo (pogosto zgolj obnove na spletu). Digitalno tehnologijo lahko v tem primeru uporabimo tudi za refleksijo o prebranem in analizo prebranega, in sicer v obliki e-dnevnika, lastne e-knjige, e-diagrama ali e-table. Ob tem je potrebno učencem le še dati nekaj usmeritev/navodil, kako se lotiti dela.

Vključevanje e-knjig v šolsko prakso pa se vidimo kot koristno tudi za možnost večjega poudarka na lastni izbiri literarnega dela v obliki e-knjige za branje, saj lahko učenec zlahka dostopa do druge e-knjige, če ga tematika ene ne pritegne. To zagotovo deluje zelo motivacijsko pri današnjih generacijah, ki so vešče dela z digitalnimi viri.

SKLEP

Digitalizacija v šolstvu je pogosto videna kot nekaj negativnega, vendar je potrebno pristopiti v smeri iskanja priložnosti in pozitivnih vidikov. Šole in učiteljev računalniki (in naraščajoča uporaba umetne ingteligence) ne bodo mogli nadomestiti, lahko pa učitelji tehnologijo izkoristimo sebi in namenom pouka v prid. Glede na to, da so naši učenci in dijaki "digitalin pionirji" in "digitalin domorodci", je potrebno didaktične pristope prilagajati njim in značilnostim njihovega učenja. S tem vsekakor ne mislimo na popolno opustitev "tradicionalnih" pristopov in načinov dela, ampak tehnologijo izkoristiti za motivacijo tistih področij/dejavnosti, ki jih zaznavamo kot šibkejše oz. manj učinkovite.

V prispevku smo v skladu s tem namenom želeli prikazati, kako en segment pri pouku slovenščine, tj. motivacija za branje (morda tudi domače ali vsaj skupno dolgo branje v razredu) skušati razvijati skladno z značilnostmi šolajočih generacij, da bo čim učinkoviteje in da bodo uspeli uresničiti (vsaj del) ciljev pouka.

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Zlorabe pri starejših osebah[1]

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Abstract / Povzetek

Zlorabe starejših predstavljajo resen in pogosto prikrit družbeni problem, ki ima lahko hude posledice za žrtve. Gre za vsakršno obliko fizične, psihične, finančne in spolne zlorabe ter zanemarjanja, ki se dogaja v različnih okoljih, vključno z domovi za ostarele, družinami in skupnostmi. Starejše osebe postajajo z leti in glede na zdravstvene težave vedno bolj odvisne od drugih, imajo manjšo možnost fizične obrambe in so zato bolj izpostavljene in ranljive. V teoretičnem prispevku želimo na podlagi pregleda raziskav predstaviti posamezne vrste zlorab in njihovo prevalenco, dejavnike tveganja, izzive pri zaznavanju, posledice in strategije za preprečevanje.

Keywords / Ključne besede

zlorabe starejših, prevalenca, dejavniki tveganja, posledice, preprečevanje.

Abstract

Elder abuse is a serious and often hidden social problem that can have serious consequences for victims. It includes any form of physical, psychological, financial, or sexual abuse and neglect that takes place in a variety of settings, including nursing homes, families, and communities. Older people become increasingly dependent on others because of their age and health problems, they are less able to physically protect themselves, and are therefore more exposed and vulnerable. In this theoretical paper, we aim to review the research done on the topic and present the different types of abuse as well astheir prevalence, risk factors, challenges in detection, consequences, and prevention strategies.

Keywords / Ključne besede

elder abuse, prevalence, risk factors, consequences, prevention.

UVOD

Staranje prebivalstva je globalni fenomen, ki postavlja nove izzive, zlasti v smislu varnosti in zaščite starejših oseb. Po podatkih Svetovne zdravstvene organizacije (WHO) [1] se predvideva, da se bo svetovno prebivalstvo, staro 60 let in več, več kot podvojilo, z 900 milijonov leta 2015 na približno 2 milijardi leta 2050, saj se v številnih državah prebivalstvo hitro stara. Število „najstarejših“ odraslih, starih 80 let ali več, narašča hitreje kot število starejših odraslih. Do leta 2050 se bo na primer število „najstarejših“ več kot potrojilo, in sicer s 125 milijonov leta 2015 na 434 milijonov [2]. Poleg tega imajo ženske v povprečju daljšo pričakovano življenjsko dobo kot moški, zato predstavljajo 61,6 % oseb, starejših od 80 let. Ženske in „najstarejši“ starejši bodo verjetno tudi v prihodnosti ostali največja starostna skupina v ustanovah za dolgotrajno oskrbo [2]. Starejši trenutno predstavljajo tudi največji delež odraslega prebivalstva, ki živi v ustanovah za odrasle z motnjami v duševnem razvoju [3]. Prebivalci teh ustanov imajo pogosteje več oblik motenj, vključno z duševnimi, telesnimi ali vedenjskimi motnjami ter invalidnostjo. Zato so prebivalci v institucionalnih ustanovah zaradi svoje šibkosti običajno bolj odvisni od oskrbe drugih in so lahko bolj izpostavljeni nevarnosti zlorabe in zanemarjanja kot starejši v drugih oblikah skupnosti [4]. Razširjenost zlorab je lahko veliko večja, kot se poroča, saj je lahko poročanje povezano z nezmožnostjo poročanja pri žrtvah ali s strahom pred posledicami in povračilnimi ukrepi [5].

Približno 1 od 6 oseb, starih 60 let in več, je v zadnjem letu v skupnosti doživela eno od oblik zlorabe [1].

Raziskava, opravljena v Združenih državah Amerike na 897 starejših osebah, ki so se med pandemijo zadrževale doma, kaže, da se je med pandemijo COVID-19 stopnja zlorab starejših še povečala O njej je poročala ena od petih

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starejših oseb (21,3 %), kar je 83,6-odstotno povečanje v primerjavi z ocenami razširjenosti pred pandemijo. Pred pandemijo COVID-19 je zloraba starejših vsako leto prizadela enega od 10 ameriških starejših odraslih. Predpostavlja se, da je pandemija s seboj prinesla porast zlorabe starejših zaradi posameznikov, ki jim je bilo odrejeno, da ostanejo doma, skupaj s povečanimi medosebnimi stresorji.

1 OBLIKE ZLORAB PRI STAREJŠIH

Zloraba starejših je enkratno ali ponavljajoče se dejanje ali pomanjkanje ustreznega ukrepanja, ki se zgodi v katerem koli odnosu, v katerem se pričakuje zaupanje, in ki starejši osebi povzroči škodo ali stisko. Ta vrsta nasilja pomeni kršitev človekovih pravic in vključuje fizično, spolno, psihološko in čustveno zlorabo, finančno in materialno zlorabo, zapuščanje, zanemarjanje ter resno izgubo dostojanstva in spoštovanja [1]. Poleg delitve na vrsto ali obliko v splošnem, lahko zlorabe razvrstimo tudi na to, kdo zlorabo izvaja - družinski člani, neformalni in formalni skrbnik ali znanec; ali okolje, v katerem se zgodi - v skupnosti in instituciji [7]. V institucionalnem okolju pa lahko zlorabo na splošno razvrstimo na zlorabo med stanovalci ali zlorabo osebja med stanovalci [4].

Zloraba starejših je pomemben javnozdravstveni problem. V pregledu 52 študij iz 28 držav iz različnih regij iz leta 2017 je bilo ocenjeno, da je bila v zadnjem letu vsaka šesta oseba (15,7 %), stara 60 let in več, izpostavljena neki obliki zlorabe [8], kar pomeni približno 141 milijonov ljudi. Čeprav so natančni podatki omejeni, pregled vsebuje ocene razširjenosti deleža starejših ljudi, ki so bili deležni različnih vrst zlorabe. Meta analiza je pokazala, da je o psihološki zlorabi poročalo 11.6% starejših ljudi, o fizični zlorabi 2.6%, o finančni 6.8%, o spolni zlorabi 0.9% in o zanemarjanju 4.2% starejših oseb.

Podatki o obsegu problema v ustanovah, kot so bolnišnice, domovi za ostarele in druge ustanove za dolgotrajno oskrbo, so pomanjkljivi. Vendar pa pregled nedavnih študij o zlorabi starejših v institucionalnih ustanovah kaže, da je 64,2 % zaposlenih samoporočalo, da je v zadnjem letu storilo neko obliko zlorabe [9].

Raziskava osebja v domovih za starejše v Združenih državah Amerike je pokazala, da je 40 % osebja priznalo psihično in 10 % fizično zlorabo v zadnjem letu [10]. Sistematični pregled zlorab v institucijah je pokazal, da se fizična zloraba pogosto pojavlja kot oblika maščevanja osebja nad fizično agresivnimi stanovalci [11]. Prav tako je osebje poročalo, da je bolj verjetno, da bo agresivnim stanovalcem odreklo izbiro česarkoli [12]. V drugi nacionalni študiji v Združenih državah Amerike je 1,5 % osebja samo poročalo, da je zagrešilo krajo [13].

1.1 Fizična zloraba

Zloraba starejše osebe pogosto ni omejena le na eno obliko; fizično nasilje na primer pogosto spremlja psihična zloraba, finančno zlorabo pa lahko spremlja zanemarjanje ali fizična zloraba [14]. Fizična zloraba vključuje namerne telesne poškodbe starejših oseb, kot so udarci, potiski ali druga škodljiva dejanja. Pregled fizičnih poškodb pri zlorabi starejših je pokazal, da se dve tretjini poškodb pojavita na zgornjih okončinah in maksilofacialnem področju [15]. Nekatere raziskave kažejo, da je verjetnost reviktimizacije večja pri ženskah, ki so ovdovele, imajo diagnozo demence in so se vrnile na dom, kjer je storilec živel ali jih obiskoval [16]. Verjetnost prijave je v takih primerih zelo redka, saj je problem dokazovanje in odvisnost od tistega, ki skrbi za žrtev, ki naj bi bila istočasno hvaležna za skrb, saj sicer ne bi preživela, po drugi strani pa je deležna nasilja in zlorab in ujeta v brezizhodni situaciji.

1.2 Psihološka zloraba

Psihološka ali čustvena zloraba vključuje uporabo groženj, ponižanja, ustrahovanja, preklinjanja in drugega verbalnega vedenja in (ali) katere koli druge oblike duševne krutosti, ki povzroči duševno ali fizično stisko. Študija, ki je zajela pregled 49 raziskav, je ugotovila razširjenost psihične zlorabe med starejšimi v Evropi, ki znaša od 10,4 % do 29,7 %, pri čemer je višja v severnih državah (Nemčija, Litva, Švedska) v primerjavi z južnimi državami (Portugalska, Italija, Španija in Grčija) [22]. Ugotovitve so presenetljive, saj bi pričakovali, da bo na severu nižja tolerance do nasilja in boljši življenjski standard. Lako pa je prav to razlog, da je povečana senzitivnost za vsako vrsto zlorabe in je zato poročanje o pojavnosti višje v primerjavi z južnimi državami. Dejavniki, ki so bili povezani z visokim tveganjem za psihično zlorabo, so bili: nizka socialna podpora, življenje v najemniških stanovanjih, uživanje alkohola, pogosta uporaba zdravstvenih storitev ter pogosta anksioznost in somatske težave.

1.3 Finančna zloraba

Finančna zloraba vključuje izkoriščanje starejših oseb za finančno korist, kot so goljufije, kraje ali prisiljevanje v nepoštene finančne transakcije. Raziskave kažejo, da so starejši pogosto tarča finančne zlorabe, zlasti če so odvisni od drugih za upravljanje svojih financ. Čeprav se slabo ravnanje s finančnimi sredstvi pogosto ne obravnava v kontekstu čustvenih in zdravstvenih posledic, je povezano s precej večjo verjetnostjo depresije, posttravmatske stresne motnje in splošno anksioznostjo. Pri tem je pomembno poudariti, da se tveganje za negativne posledice še toliko bolj poveča, če so storilci finančne zlorabe družinski člani ali prijatelji [18].

1.4 Spolna zloraba

Spolna zloraba, opredeljena kot „kakršni koli spolni stiki brez privolitve“, naj bi bila najbolj skrita oblika zlorabe starejših ter najmanj priznana in prijavljena vrsta slabega ravnanja s starejšimi. Pregled je pokazal, da je bila večina žrtev spolne zlorabe v domovih za ostarele kognitivno oslabljenih (demenca, Alzheimerjeva bolezen, možganska kap in poškodbe možganov), s psihiatrično diagnozo in/ali

telesno šibkih (invalidski voziček, postelja, paraliziranost in omejena mobilnost) ter s somatskimi boleznimi. Najstarejši bolniki (stari 79-99 let) so bili pogosteje izpostavljeni spolni zlorabi. To bi lahko potrjevalo mnenje, da so v najstarejši starostni skupini poleg spola pomembnejši tudi drugi dejavniki. To je poudarjeno tudi v poročilu Svetovne zdravstvene organizacije, kjer je na podlagi študij razširjenosti v skupnosti ugotovljeno, da so starejši moški v približno enakem deležu kot ženske izpostavljeni zlorabi s strani zakoncev, odraslih otrok in drugih sorodnikov. Najpogostejši storilci so bili zaposleni v domu za ostarele in sostanovalci. Drugi najpogostejši storilec je bil družinski član. Obiskovalci, ki so bili žrtvi znani ali neznani, so bili manj pogosti. V številnih primerih je imel storilec kognitivne motnje, psihiatrično diagnozo, zlorabo snovi, kriminalno preteklost ali predhodno storjeno spolno zlorabo [14]. Študija Burgessa s sodelavci [19] je pokazala, da so vse storilce vodili različni motivi. Dva skupna imenovalca za vse storilce sta bila, da so imeli nizke ocene na področju socialnih kompetenc in da so iskali žrtve, ki so bile krhke in nezaščitene.

Spolna zloraba starejših oseb presega tradicionalne meje med spoloma, kulturami in vlogami žrtev in storilca. Obstaja tveganje, da se spolne zlorabe starejših oseb ne obravnavajo resno, saj se jih zaradi starosti lahko obravnava kot aseksualne. Zato mnogi menijo, da je malo verjetno, da bi prišlo do spolne zlorabe. Zdravstveni delavci se izogibajo spraševanju starejših oseb o spolnem zdravju in nočejo verjeti obtožbam o spolni zlorabi ali se nanje odzvati [20].

1.5 Zanemarjanje

Zanemarjanje starejših ljudi je globalno vprašanje javnega zdravja in človekovih pravic, ki ogroža zdravje in varnost starejših ljudi. Običajno se nanaša na zavračanje ali nezmožnost zagotavljanja nege in zaščite na področjih hrane, vode, oblačil, higiene, zdravil, življenjskega okolja in varnostnih ukrepov. Lahko se kaže s strani drugih oseb, ki naj bi skrbele za starejšo osebo ali kot samozanemarjanje [21]. Nenamerno zanemarjanje se večinoma pojavi zaradi malomarnosti, na primer, ko negovalec nima potrebnih veščin ali znanja, se ne zaveda razpoložljivih vrst podpore ali ne more zagotoviti oskrbe, ker je sam bolan. Običajne spremembe staranja in simptomi, povezani z boleznijo, se lahko prekrivajo z znaki zanemarjanja in vodijo do premajhnega odkrivanja. Zanemarjanje je lahko neposreden vzrok smrti ali prispeva k smrtnemu izidu s poslabšanjem obstoječih stanj [22].

2 Posledice zlorab

Burgers s sodelavci [19] piše v svoji študiji na temo spolnih zlorab, da je bilo nekaj storilcev zlorab kaznovanih in napadi niso imeli pravnih posledic, čeprav so bile v več primerih zlorabe prisotne priče. V primerih, ko so bili bolniki storilci, so bili premeščeni na druge oddelke ali v druge domove za starejše. Kadar so bili storilci člani osebja, so jim odpovedali delovno razmerje, jim dali dopust ali jih premestili na drugo delovno mesto. Nekateri so se znašli v kazenskih evidencah, nekaj pa jih je bilo obsojenih.

Ko gre za žrtve zlorab, so bile premeščene na drug oddelek znotraj doma za ostarele, spremljale so jih ali pa sploh niso dobile pomoči. Zelo malo jih je bilo po napadu deležnih zdravstvene in psihološke obravnave. Mnoge žrtve so bile še naprej izpostavljene tveganju za nove zlorabe [19].

Pogoste posledice spolnega nasilja za žrtve so težave z duševnim zdravjem, vključno s samomorilnim vedenjem. Znane so smrtne žrtve, povezane s posilstvom. Podatki kažejo, da je 11 od 20 pacientov v domovih za starejše umrlo v enem letu po spolnem napadu. Ni mogoče reči, ali so bile te smrti posledica napada ali ne, saj je bilo veliko žrtev starih in slabotnih. Kar zadeva prijavo zlorabe organom, sta bila najpogostejša razloga, zakaj primeri niso bili prijavljeni, pomanjkanje dokazov in zdravstveno stanje žrtve [19].

Zlorabe starejših, ne glede na vrsto, imajo lahko resne posledice za telesno in duševno zdravje, finančno in družbeno stanje, telesne ali psihične poškodbe, prezgodnjo umrljivost, izgubo ali kršitev človekovih pravic, depresijo, upad kognitivnih sposobnosti, finančno opustošenje, namestitev v domove za ostarele in slabšo kakovost življenja starejše osebe. Pri starejših ljudeh so lahko posledice zlorabe še posebej hude, okrevanje pa lahko traja dlje [23, 24].

3 Dejavniki tveganja

Raziskava [18], ki je preučevala dejavnike tveganja, ki povečujejo možnost, da bo nekdo postal žrtev ali storilec v primeru zlorab med starejšimi, je pokazala:

- da so bile žrtve pogosteje ženske,

- da so bile starejše belke bolj ogrožene v primerjavi z drugimi etničnimi skupinami, čeprav so nekatere študije omejene na vzorce belcev,

- da so bile starejše ženske z nižjim izobrazbenim statusom in nižjimi dohodki bolj izpostavljene tveganju viktimizacije na vseh področjih,

- da so starejši ljudje s telesnimi in/ali duševnimi boleznimi ali odvisnostmi bolj izpostavljeni večjemu tveganju kot tisti brez bolezni, pri čemer se je pokazala največja viktimizacija v starostni skupini med 60 in 70 let.

Dejavniki tveganja in značilnosti storilcev pa so pokazali:
- da je večina storilcev moških,

- da je v večini primerov storilec pogosto veliko mlajših od žrtve (več kot 30 let),

- da so storilci žrtvam običajno znani in

- da so nekateri med njimi bili že v preteklosti obsojeni zaradi spolnih ali drugih kaznivih dejanj [18].

Na ravni odnosov sta vrsta odnosa (npr. zakonec/partner ali otrok/starš) in zakonski stan lahko povezana s

povečanim tveganjem za zlorabo, vendar se ti dejavniki razlikujejo glede na državo in regijo. Dejavniki na ravni skupnosti in družbe, povezani z zlorabo starejših, lahko vključujejo predsodke do starejših in nekatere kulturne norme (npr. normalizacija nasilja). Po drugi strani pa naj bi bila socialna podpora in samsko življenje povezano z zmanjšanim tveganjem za zlorabo starejših [25].

4 Strategije za preprečevanje ali preventiva

V nekaterih državah je zdravstveni sektor prevzel vodilno vlogo pri opozarjanju javnosti na zlorabe starejših, v drugih pa je vodilno vlogo prevzel sektor socialnega varstva. Na svetovni ravni je o zlorabi starejših in njenem preprečevanju premalo znanega, zlasti v državah v razvoju.

Za preprečevanje in odzivanje na zlorabe starejših so bile uporabljene številne strategije, vendar so dokazi o učinkovitosti večine teh ukrepov trenutno omejeni. Med najbolj obetavne strategije sodijo intervencije za oskrbovalce, ki nudijo storitve za razbremenitev bremena oskrbe, programi za upravljanje denarja za starejše odrasle, ki so izpostavljeni finančnemu izkoriščanju, telefonske linije za pomoč in zavetišča za nujne primere ter multidisciplinarne skupine, saj so potrebni odzivi pogosto povezani z več sistemi, vključno s kazenskim pravosodjem, zdravstvom, duševnim zdravjem, službami za zaščito odraslih in dolgotrajno oskrbo [25].

Poleg tega raziskave [22] poudarjajo pomen podrobne dokumentacije ter sodelovanja med kliničnimi zdravniki, sorodnimi zdravstvenimi delavci, organi pregona in medicinskimi forenzičnimi službami za izboljšanje rezultatov bolnikov in zmanjšanje tveganja za nadaljnje zlorab.

Zaključek

Zlorabe starejših so resen in kompleksen problem, ki zahteva večplastno obravnavo. Z naraščajočim številom starejših v svetovnem prebivalstvu je nujno povečati ozaveščenost o zlorabah ter izboljšati sisteme za odkrivanje in preprečevanje teh dejanj. Zlorabe se pojavljajo v različnih oblikah, od fizičnih in psihičnih do finančnih in spolnih, pri čemer so žrtve pogosto odvisne od svojih oskrbovalcev, kar povečuje njihovo ranljivost. Potrebna je večja vključenost zdravstvenega in socialnega sektorja, saj so prav ti sektorji ključni pri zaščiti starejših oseb. Prav tako je pomembno izboljšati usklajevanje med institucijami, da bi zagotovili celovitejši odziv na zlorabe. Razvoj programov za izobraževanje osebja v domovih za starejše ter skrbnikov na domu je ključen korak k zmanjšanju zlorab in izboljšanju obravnave starejših oseb. In nenazadnje, učenje mladih generacij z zgledom, kako lahko sodelujemo s starejšimi generacijami – mladost ima več moči, starost pa več modrosti. Tako eno kot drugo je potrebno, da lahko uspešno opravljamo svoje poslanstvo. Pomembno je tudi vzpostaviti mehanizme, ki omogočajo starejšim osebam, da varno prijavijo morebitne zlorabe brez strahu pred posledicami ali dodatnimi negativnimi vplivi na njihovo vsakodnevno življenje. V tem kontekstu je pomembno tudi spodbujanje medgeneracijskega sodelovanja in solidarnosti, saj to dodatno okrepi socialno povezanost ter pripomore k zmanjšanju diskriminacije na podlagi starosti. Na ta način lahko kot družba poskrbimo za boljše varstvo in spoštovanje pravic starejših, saj bomo nenazadnje prej ali slej vsi nekega dne stari.

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Matične knjige pravoslavne župnije sv. Cirila in Metoda v Ljubljani

Registry Books of the Serbian Orthodox Parish St. Cyril and Methodius in Ljubljana

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POVZETEK

Kljub nizki rodnosti in izseljevanju, Slovenija ohranja število prebivalcev zahvaljujoč priseljevanju iz južnih držav Balkana, kar se močno odraža v islamskih in pravoslavnih verskih skupnostih v Sloveniji. V Islamski verski skupnosti v Sloveniji, Makedonski pravoslavni Cerkvi in v Srbski pravoslavni Cerkvi v Sloveniji se zelo povečuje število vernikov. Namen članka ni predstavitev številk, temveč na vzorčnem – reprezentativnem primeru ljubljanske srbske pravoslavne župnije pokazati, kako se je v Srbski pravoslavni Cerkvi v zadnjih 30 letih povečala dejavnost pri podeljevanju zakramentov krsta in poroke ter pri opravljenih pogrebih. V prispevku so predstavljene matične knjige ljubljanske župnije sv. Cirila in Metoda Srbske pravoslavne Cerkve, iz katerih je to dejstvo razvidno.

Ključne besede: demografija, rodnost, Srbska pravoslavna župnija sv. Cirila in Metoda v Ljubljani, matične knjige.

ABSTRACT

Despite the low birth rate and emigration, Slovenia maintains its population thanks to immigration from the southern countries of the Balkans, which is strongly reflected in the Islamic and Orthodox religious communities in Slovenia. In the Islamic religious community in Slovenia, the Macedonian Orthodox Church and the Serbian Orthodox Church in Slovenia, the number of believers is increasing greatly. The purpose of the article is not to present these numbers, but rather to show, using exemplary - representative examples of the Serbian Orthodox parish in Ljubljana, how activity in the Serbian Orthodox Church has increased over the past 30 years in the granting of the sacraments of baptism and marriage, as well as funerals. The paper presents the registry books of the Ljubljana parish of St. Cyril and Methodius of the Serbian Orthodox Church, from which this fact is evident.

Keywords: demography, birth rate, Serbian Orthodox Church, Parish of St. Cyril and Methodius in Ljubljana, parish registers.

1 Uvod

1.1 Demografski položaj balkanskih držav

Balkanske države se soočajo z zmanjševanjem prebivalstva. Albanija je zaradi izseljevanja od leta 2011 izgubila več kot 400.000 oz. 14% prebivalcev (1); v istem obdobju se je tudi na Hrvaškem prebivalstvo zmanjšalo za isto številko, pri njih to pomeni 9,25% (2). Število prebivalcev Srbije se je v zadnjih desetih letih zmanjšalo za skoraj pol milijona ali za 6,7 % (3). Severna Makedonija ima 9,2% manj prebivalcev kot pred dvajsetimi leti (4), tako, da je Makedoncev v tej državi manj od dveh milijonov. Tudi na Kosovu je 200.000 prebivalcev manj kot pred petimi leti (5). Demografi v teh državah kot glavni razlog za zmanjševanje števila prebivalstva navajajo izseljevanje. Edino Črna Gora nima manjka (6).

1.2 Privilegij Slovenije

Medtem, ko se število prebivalcev vseh samostojnih držav, ki so nastale na ozemlju bivše Jugoslavije, drastično zmanjšuje, Slovenija ohranja število prebivalcev (trenutno jih ima nekoliko več od dveh milijonov in 124.000) (7) oz. jih kljub nizki nataliteti in izseljevanju celo nekoliko povečuje. Slovenija ima namreč veliko boljše gospodarstvo od južnih držav Balkana, veliko možnosti zaposlovanja in v primerjavi z njimi predvsem boljše plače. Vsekakor pa je v Sloveniji dobra kvaliteta življenja. Vsi ti razlogi privabljajo Hrvate, Bošnjake, Srbe, Makedonce in Albance v Slovenijo. Posledično se veča število pripadnikov v islamskih in pravoslavnih verskih skupnostih v »deželi pod Alpami«.

1.3 Rast islamskih in pravoslavnih skupnosti v Sloveniji

Medtem, ko je ob zadnjem uradnem štetju prebivalstva, ki je vsebovalo vprašanje verske pripadnosti, leta 2002, v Sloveniji živelo nekoliko več kot 48.000 muslimanov, jih je danes v naši državi, po oceni vodstva skupnosti, več kot 100.000. »Razloga za to sta predvsem dva: nadaljevanje priseljevanja muslimanskega prebivalstva v Slovenijo in nove generacije muslimanov, ki so že rojene v Sloveniji« (8). Pred petindvajsetimi leti je v Sloveniji deloval en imam, danes jih dvajset skrbi za pastoralno oskrbo vernikov. Poleg njih ima skupnost za pastoralne potrebe (verouk, administracija) zaposlenih še deset oseb. Makedonska pravoslavna Cerkev išče pastoralne prostore v Mariboru, ker se je tam povečalo vernikov močno povečalo. Ravno tako se v Sloveniji veča število

pripadnikov Srbske pravoslavne Cerkve. Nobena od teh treh verskih skupnosti ne ve točno, koliko članov ima. Mnogi verniki se sicer udeležujejo obredov v Sloveniji, ampak naša domovina je za njih le prehodna in ko se ponudi priložnost, nadaljujejo svojo pot na zahod Evrope; drugi verniki se udeležujejo obredov le občasno in svoje prispevke za versko skupnost raje oddajajo v matični domovini. Nihče torej sistematično ne vodi evidence članstva.

Namen tega prispevka ni ugotavljanje števila pripadnikov, temveč na vzorčnem primeru analize matičnih knjig pokazati na povečanje aktivnosti podeljevanja zakramentov in opravljenih pogrebov v Srbski pravoslavni župniji sv. Cirila in Metoda v Ljubljani, ki je največja in hkrati reprezentativna za Srbsko pravoslavno Cerkev v Sloveniji. Krst, poroka in pogreb so namreč trije pokazatelji, da so priseljenci »pognali korenine« v slovenskem okolju.

2 Zgodovina SPC v Sloveniji

Začetke Srbske pravoslavne Cerkve v Sloveniji najdemo v letih po prvi svetovni vojni, ko je bila ustanovljena kraljevina Srbov Hrvatov in Slovencev. Prva pravoslavna župnija je bila ustanovljena v Ljubljani leta 1919. V Mariboru dve leti kasneje. V Celju je v tistem času bivalo okoli 200 orožnikov pravoslavne vere s svojimi družinami. Duhovno oskrbo zanje je prevzel ljubljanski vojaški duhovnik protojerej Dimitrije Janković, ki je imel veliko zaslug, da je bila leta 1921 ustanovljena cerkvena občina, in nato leta 1928 tudi župnija v Celju(9). Na začetku druge svetovne vojne so okupatorji Nemci porušili cerkvi v Celju in v Mariboru in s tem onemogočili župnijsko versko življenje. Po koncu vojne je duhovnik iz Ljubljane oskrboval srbske pravoslavne vernike po vsej Sloveniji. Postopoma pa so se ponovno ustanavljale župnije: V Celju leta 1968, v Kopru leta 1976, dve leti kasneje v Kranju, v Novi gorici leta 1980, v Novem Mestu 1983; zadnji dve sta bili ustanovljeni 2005 (ponovno) v Mariboru in 2011 v Postojni. Leta 1968 je deloval v Sloveniji en duhovnik Srbske pravoslavne Cerkve, ob vsaki ustanovitvi župnije se je pridružil tudi nov duhovnik; na nekaterih župnijah deluje več duhovnikov, tako, da je danes v Sloveniji na osmih župnijah aktivnih 15 duhovnikov Srbske pravoslavne Cerkve. Skupnost se v zadnjih desetletji močno širi oz. se povečuje število njenih vernikov. Priseljujejo se iz Srbije in iz Republike srbske iz Bosne in Hercegovine. Točnega števila vernikov ne ve nihče povedati, po oceni duhovnika Aleksandra Obradovića je na vseh njihovih župnijah v Sloveniji aktivnih približno 100.000 vernikov. Omenjeni duhovnik in njegov kolega Rade Despotović ocenjujeta, da je v letu 2024 v ljubljanski župniji, ki poleg mesta Ljubljane vključuje tudi Domžale, Škofljico in Kamnik, aktivnih približno 2000 vernih družin, kar pomeni 8 do 10 tisoč vernikov.

3 Predstavitev matičnih knjig

Župnija sv. Cirila in Metoda, srbske pravoslavne Cerkve v Ljubljani, katere cerkev se nahaja na Prešernovi cesti 35, hrani tri vrste matičnih knjig: krstne (Knjiga krštenih), poročne (Knjiga venčanih) in pogrebne (Knjiga umrlih).

3.1 Krstne matične knjige

Za našo raziskavo nam je bil omogočen vpogled v Krstne matične knjige od številke VII do XII. Krstna matična knjiga št. VII ima na sprednji platnici napisane letnice 1994 do 2000 (10). Toda prvi vpisani krsti so iz januarja leta 1995; zaključi pa se s krstom, ki je bil podeljen 9. septembra 2000 in je zabeležen na strani 99. Skupno lahko torej na 99 straneh najdemo 931 oseb, ki so se z zakramentom krsta včlanile v Srbsko pravoslavno Cerkev (v veliki večini so bili krščeni otroci) in podrobne podatke o njihovih starših in botrih. Krstna matična knjiga št. VIII ima vpisane krste od septembra 2000 do decembra 2006 (97 strani) (11). Krstna knjiga št. IX ima vpisane krste od januarja 2007 novembra 2012 na 103 straneh (12). Krstna knjiga št. X ima vpisane krste od februarja 2013 do decembra 2018 (na 197 straneh) (13). Krstna knjiga št. XI ima vpisane krste od januarja 2018 do januarja 2023 na 99 straneh (14) in Krstna knjiga št. XII ima vpisane krste od februarja 2023 do danes (15). Šest knjig, ki smo jih dobili v vpogled, so v dobrem stanju, pisava v cirilici je čitljiva, so pa pogoste napaka pri zaporednih številkah oz. pri numeriranju knjižnih strani. Razen na platnicah, kjer so uporabljene rimske številke strani, so v knjigah za številčenje uporabljene »arabske številke«!

3.2. Poročne matične knjige

Pregledali smo tri poročne matične knjige. Poročna knjiga I je označena z letnicami 1952-2007. Na 99-tih straneh vsebuje podatke o vseh porokah na župniji od leta 1954 do 2007 (16). Navedena so imena ženinov in nevest, ki so sklenili cerkveno poroko v ljubljanski pravoslavni cerkvi in hkrati njihovi podrobni podatki. Poročna knjiga II ima na 49-tih straneh vpisane poroke od leta 2008 do 2015 (17). Poročna knjiga III pa od 2015 danes (18). Vse tri knjige so v dobrem stanju, pisava v cirilici je čitljiva in vse numeriranje je korektno. Razen na platnicah, kjer so uporabljene rimske številke strani, so v knjigah za številčenje uporabljene »arabske številke«!

3.3. Pogrebne knjige

Pogrebne matične knjige so tri. Pogrebi I, na straneh od 1 do 100 vsebuje seznam vseh pogrebov od leta 1952 do 2004 (19). V knjigi Pogrebi II pa so vpisane osebe in njihovi podatki, ki so jih duhovniki pospremili na pokopališče in opravili verski obred pri grobu od leta 2005 do 2021 (20). V zadnji, Pogrebi III so vpisani pogrebi od leta 2021 do danes (21).

V spodnji razpredelnici smo navedli število krstov, porok in pogrebov od leta 1952 do danes.

3.1 Tabela 1: Podatki iz matičnih knjig

Leto	Krsti	Poroke	Pogrebi
1952			6
1953			6
1954		4	5
1955		2	4
1956		0	5
1957		1	3
1958		0	6
1959		2	1
1960		1	7
1961		3	4
1962		2	7
1963		0	11
1964		1	11

1965		5	10
1966		1	11
1967		3	9
1968		2	11
1969		1	11
1970		2	7
1971		3	15
1972		5	18
1973		7	15
1974		5	15
1975		0	10
1976		2	15
1977		5	16
1978		3	6
1979		4	13
1980		6	10
1981		6	10
1982		2	13
1983		15	14
1984		21	2
1985		27	14
1986		29	16
1987		30	10
1988		15	5
1989		28	14
1990		16	15
1991		19	9
1992		19	19
1993		24	25
1994		31	17
1995	200	43	37
1996	142	24	26
1997	149	34	23
1998	140	27	30
1999	191	28	37
2000	165	35	34
2001	155	45	45
2002	100	41	52
2003	158	38	38
2004	177	30	44
2005	155	24	52
2006	164	39	49
2007	150	36	50
2008	145	36	46
2009	176	27	49
2010	172	24	46
2011	165	34	69
2012	160	29	69
2013	159	37	48
2014	184	30	36
2015	170	20	55
2016	181	22	54
2017	215	23	53
2018	195	35	77
2019	173	29	68
2020	106	14	78
2021	158	14	105
2022	188	32	92
2023	218	21	82

4 Krsti

Število krstov v ljubljanski srbski pravoslavni župniji nam v bistvo kaže na položaj rodnosti v tej verski skupnosti. Čeprav ni znan podatek o spreminjanju (rasti) števila članov v skupnosti, nam prav število krstov orientacijsko razodeva demografske spremembe v skupnosti. Ko želimo primerjati rodnost v župniji in v Sloveniji na splošno, nam koeficient 1,5, ki ga statistični urad objavlja za Republiko Slovenijo, nič ne koristi, ker koeficienta za župnijo Srbske pravoslavne Cerkve v Ljubljani ne moremo izračunati. Ne poznamo namreč števila žensk v rodni dobi. Da bomo lahko primerjali s slovensko rodnostjo, bomo primerjali povprečje prvih treh in zadnjih treh let obravnavanega obdobja v župniji in v Sloveniji.

Število krstov se od 1995 do 2023, torej v zadnjih tridesetih letih, na prvi pogled ni bistveno spremenilo, oz. opažamo zgolj majhno rast. Če pa upoštevamo »odcepitev« župnije Postojna v letu 2011, vidimo, da se je takrat krivulja na grafu št. 1 obrnila navzdol, potem pa se zopet povzpela. Od 1995 do 1997 lahko iz matičnih knjig razberemo, da je bilo na župniji v povprečju 163,66 krstov na leto. V triletju 2021 do 2023 pa se je to povprečje dvignilo na 188 krščenih otrok. S preprostim računom ugotovimo, da se je rodnost od zadnjega triletja v prejšnjem tisočletju do danes povečala za 14,87%. Ko pa to konstantno rodnost primerjamo rodnosti v Sloveniji, pa pridemo do zanimivih rezultatov. Da bo primerjava korektna, bomo tudi tu primerjali povprečji prvih in zadnjih treh let obravnavanega obdobja. V Sloveniji se je po podatkih Statističnega urada (22) leta 1995 rodilo 18.980 živorojenih otrok, leta 2023 pa 16.989. Od leta 1995 do 1997 se je v Sloveniji povprečno na leto rodilo 18.644 živorojenih otrok. Od 2021 do 2023 pa je to povprečje 17.866 rojstev. To pomeni zmanjšanje natalitete za 4,17%. V Sloveniji v prvem desetletju tretjega tisočletja do sredine drugega desetletja sicer beležimo povečano število rojstev, od 2017 pa do 2023 pa je drastičen padec, ki se zaključi z najnižjim številom rojstev v zgodovini vodenja statistike v Sloveniji. V ljubljanski župniji Srbske pravoslavne Cerkve se je rodnost torej povečala za nekaj manj od 15%, Slovenci pa beležimo zmanjšanje za nekaj več od 4%. Razlika je skoraj 20%.

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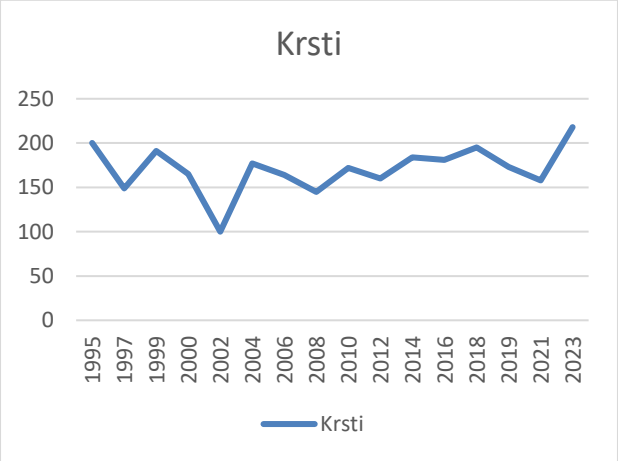
V spodnjem grafu nam krivulja kaže gibanje krstov na obravnavani župniji.

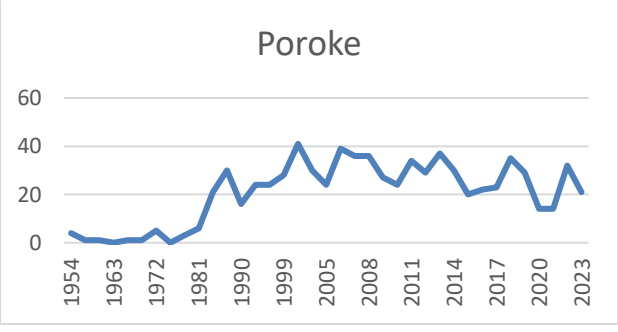
4.1 Graf 1: Število krstov



5 Poroke

Odgovorni na župniji so nam omogočili vpogled v poročne matične knjige od leta 1954 dalje. Do 1983 je število porok na leto zelo majhno. Prvih deset let se število giblje od 0 do 4, leta 1980 jih je bilo 6; leta 1985 najdemo vpisanih petnajst parov, ki so se poročili v cerkvi sv. Cirila in Metoda. V obdobju od 1983 do 1994 se število giblje od 15 pa vse do 31, od 1995 pa do 2002 pa je število med 30 in 45. Tudi tu je potrebno upoštevati, da je bila leta 2011 ustanovljena nova pravoslavna župnija v Postojni, ki je od ljubljanske župnije »odtrgala ozemlje od Vrhnike do Postojne. Zaradi manjšega števila vernikov, je v tem obdobju zabeležen padec porok v ljubljanski župniji. Od 34 poročenih parov v letu 2011 vidimo padec števila (z izjemo 2013) porok vse do leta 2018, ko se zviša. V zadnjih šestih letih pa se število zopet manjša, tako, da imajo v letu 2023 zabeleženih le 21 porok. Ta upad je po izjavi duhovnika Aleksandra Obradovića povezan s tendenco, ki je v Sloveniji »moderna«, da mladi pari ne sklepajo uradnih zakonskih zvez ampak zgolj živijo skupaj »brez obljub oz. obveznosti. V pogovoru z avtorjem tega prispevka je duhovnik, ki je odgovoren za vso Srbsko pravoslavno Cerkev v Sloveniji pojasnil, da v zadnjih letih polovica krstov otrok, ki jih na ljubljanski župniji opravijo, zaprosijo starši, ki niso (cerkveno) poročeni.

5.1 Graf 2: Število porok

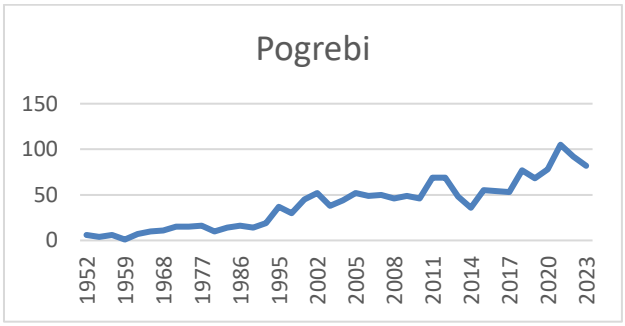


Število porok v dvajsetih letih 21. stoletja ostaja identično številu iz devetdesetih let. Vendar, kakor smo omenili zgoraj, je potrebno upoštevati nov način skupnega življenja. Vsekakor pa je ohranitev števila porok pokazatelj velikega števila parov oz. družin. Če namreč primerjamo s katoliškimi župnijami, kjer je število zelo upadlo, je je ohranitev števila na pravoslavni župniji znamenje velikega števila vernikov.

6 Pogrebi

Najboljši pokazatelj gibanja aktivnosti na župniji svetih bratov Cirila in Metoda je pogrebna matična knjiga. Pri izseljencih, ki imajo močne vezi s svojo matično domovino, torej s svojimi sorodniki in prijatelji, je značilno, da svoje pokojne pokopljejo na pokopališču v domačem kraju, v Srbiji ali Republiki srbski. Šele, ko »poženejo korenine« v novi domovini, torej v Sloveniji, se odločijo in kupijo grob na primer na ljubljanskih Žalah in tu pokopljejo svoje umrle. Dobili smo vpogled opravljenih pogrebov od leta 1952 do danes. Prvih deset let število ni preseglo deset pogrebov na leto. Nato se številka veča; od 1963 do 1993 se giblje med deset in dvajset. Upoštevati moramo, da se številka nekoliko zaustavi v letih, ko so nove župnije postopoma zmanjševale teritorij in število vernikov ljubljanske župnije: 1968, ko je bila (ponovno) ustanovljena župnija Celje, 1976, ko je bila ustanovljena župnija Koper, 1978 z ustanovitvijo župnije v Kranju, 1983 v Novem Mestu in 2011 v Postojni. Po letu 1995 je bilo nad trideset pogrebov v povprečju na leto. Z letom 2020 pa številka pogrebov strmo naraste. Upoštevati moramo večjo umrljivost, ki jo je povzročil virus Korone leta 2021. V letih 2022 in 2023 se namreč število pogrebov zmanjša.

6.1 Graf 3: Število pogrebov



Sklepamo na konstantno priseljevanje, le ob ustanovitvi novih župnij je padec opravljenih pogrebov. V zadnjih tridesetih letih se je število pogrebov povečalo za štiri do pet krat, to je od 20 na 90 pogrebov.

7 Analiza gibanja številk

Kljub temu, da je ljubljanska župnija v osemdesetih letih prejšnjega stoletja z ustanovitvijo novo meške župnije izgubila Grosuplje in Kočevje, leta 2011 pa ozemlje od Vrhnike do Postojne, ki se je pastoralno osamosvojila, se je število krstov na župniji v zadnjih tridesetih letih povečalo za slabih 15%, število

porok je sicer ostalo enako, število pogrebov pa se je povečalo za skoraj 5 krat. Pri analizi dejavnosti v Srbski pravoslavni župniji svetih bratov Cirila in Metoda v Ljubljani moramo omeniti še dve dejstvi. V začetku devetdesetih let je na župniji deloval en duhovnik, danes jih deluje 5, ki poučujejo tudi verski nauk 120 otrok[1]. Po izpovedi duhovnika Aleksandra je bilo leta 2013 v Ljubljani samo 40 vero učencev. Torej se je število duhovnikov v zadnjih tridesetih letih povečalo za 5 krat, število vero učencev pa v zadnjih desetih letih 3 krat.
Če te ugotovitve združimo, lahko napišemo, da so se verske aktivnosti v zadnjih tridesetih letih na predstavljeni župniji močno povečale. Iz tega lahko sklepamo, da se je tudi povečalo število vernikov oz. prišlekov iz Srbije in Republike srbske, ki izpovedujejo Srbsko pravoslavno vero.

8 Sklep

Pri migracijah smo ljudje najbolj občutljivi na vrednote, ki jih prinesejo migranti s seboj in se razlikujejo od naših vrednot. Najprej gre za kulturo, potem jezik in nenazadnje tudi versko prepričanje. Odnos med prišleki in lokalnim prebivalstvom se od države do države razlikuje. Evropska unija zagovarja in predlaga model integracije. Integrirani migranti se bodo lahko vključili v slovensko kulturo in se naučili slovenskega jezika. Vera pa je nekaj tako intimnega, da človek ohrani versko prepričanje in pripadnost svoji verski ustanovi tudi v okolju, kjer živijo prebivalci drugačnih veroizpovedi. Za skupno bivanje je torej nujno potreben medkulturni in medverstveni dialog. Ta pa vključuje sprejemanje in spoštovanje drugačnosti, kar je pogojeno s poznanjem veroizpovedi in verske prakse, v našem primeru, srbske pravoslavne skupnosti v Sloveniji. Bojan Cvelbar piše v svoji knjigi, da so v Celju v letih po prvi svetovni vojni katoličani raztrgali celo oglase, ki so Srbe vabili na ustanovni sestanek Srbske pravoslavne občine. Danes se kaj takega ne dogaja več. V Sloveniji imamo zgleden odnos med katoličani, pravoslavnimi in muslimani. Dokaz tega prijateljskega dialoga so srečanja in skupne izjave o družbeno pomembnih vprašanjih.

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(11) Knjiga krštenih VIII, Parohija ljubljanska u Ljubljani.

(12) Knjiga krštenih IX, Parohija ljubljanska u Ljubljani.

(13) Knjiga krštenih X, Parohija ljubljanska u Ljubljani.

(14) Knjiga krštenih XI, Parohija ljubljanska u Ljubljani.

(15) Knjiga krštenih XII, Parohija ljubljanska u Ljubljani.

(16) Knjiga venčanih I, Parohija ljubljanska u Ljubljani.

(17) Knjiga venčanih II, Parohija ljubljanska u Ljubljani.

(18) Knjiga venčanih III, Parohija ljubljanska u Ljubljani.

(19) Knjiga umrlih I, Parohija ljubljanska u Ljubljani.

(20) Knjiga umrlih II, Parohija ljubljanska u Ljubljani.

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EMIGRATIONS FROM KOSOVA IN THE FIRST TWO DECADES OF THE 21st CENTURY- TREND AND CHALLENGES

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Abstract:

In the first two decades of the 21st century, Kosova is characterized as a territory with a very high rate of emigration, a rapid decrease in births and natural increase, followed by changes in the structure of the population by age, which have consequently caused challenges in many segments of life in Kosova.
High rate of emigration is the main factor that today Kosova is facing radical changes in its demographic profile. The situation is so unfavorable that it can be defined as a demographic crisis.
The demographic problems that Kosova is facing can be prevented or mitigated through population policies that would enable the creation of conditions for sustainable demographic development, which is achieved by creating conditions for people, particualrly for the youth, to have confidence in building a future in their country.
If the population, particularly young people, have access to quality education and health care, if they are in stable employment and receive support for raising children, etc., they will be less likely to emigrate and more likely to decide to have children. Eliminating the causes that push young people to emigrate is the key to cease the deepening of the demographic crisis in Kosova.
The perspective of future development made it necessary to take measures to control demographic processes, especially emigration and births, after the forecasts of Kosova's population show that in the future Kosova will face many challenges as a result directly from the unfavorable demographic developments, which in the following years and decades will only deepen further.

Key words: emigration, population, demographic sustainability, challenges, Kosova etc.

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1. Introduction

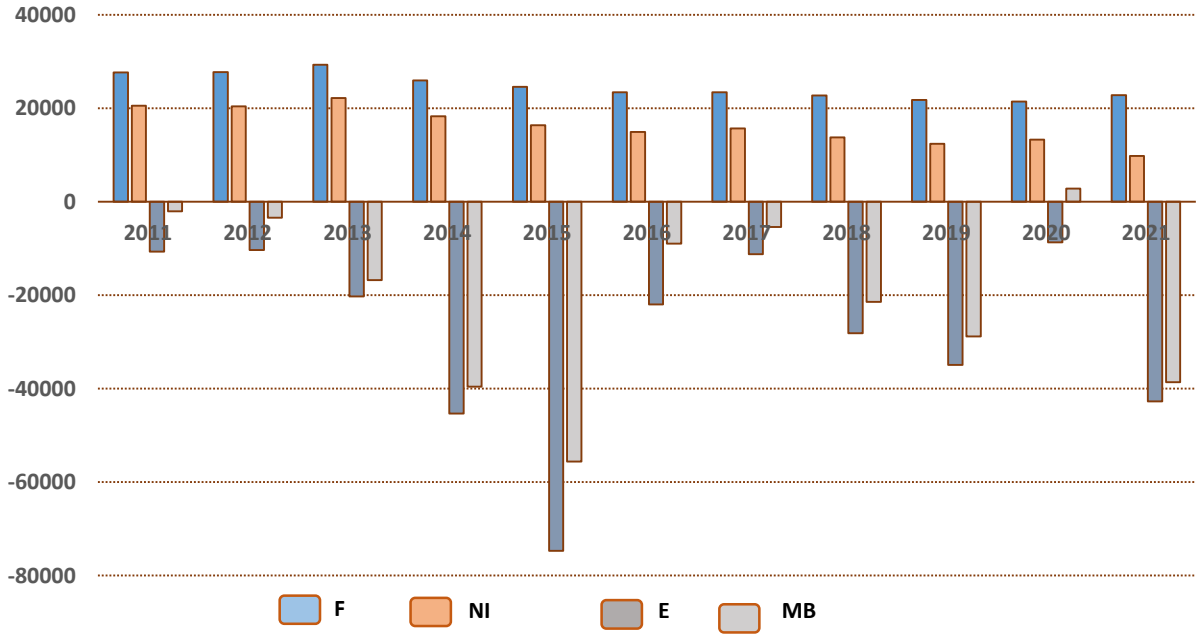
Population (people) are the greatest asset of a country

Population emigration from Kosova to European countries is not a new phenomenon. Throughout the 20th century and the beginning of the 21st century Kosova has remained a typical migratory territory. The main causes that forced the population to emigrate were and still remain: the low
level of economic development, the destruction caused by wars, the unfavorable political situation, the creation of the system based on political party criteria and nepotism, avoiding meritocracy and values in the creation of the system, the dissatisfaction of the citizens of Kosova with the perspective of the socio-economic future and with the general level of well-being, which is manifested by a high rate of unemployment (especially among young people) and a high percentage of people living in poverty, etc. Therefore, the economic issues related to unemployment and poverty are the main concerns of Kosova citizens. Recent opinion polls show that these two economic parameters are also national security threats that Kosova faces with. According to these data, about 70% of respondents believed that the high rate of unemployment is the biggest threat to Kosova **(1)**. Considering the high rate of unemployment and the large number of people living below the poverty level, emigration is seen as an opportunity by the citizens of Kosova to find a better social and economic perspective abroad, turning emigrations into a risk for demographic, socio-economic and security developments in the country.
As a result of the high migratory flux, Kosova nowadays is facing radical changes in its demographic profile: on the one hand, there is a drastic reduction in the number of births - natural increase, while on the other hand, as a result of selective emigration, the population is aging with accelerated trends.
Since emigrations are the most important factor in the decline or stagnation of the population of Kosova, it is necessary for the state to act in order to affect the reduction of the causes that encourage emigration. Creating the conditions for people, particularly for the youth to contribute to building a future in their country, is the key to stopping emigration and solving the demographic crisis in Kosova.

2. External (international) emigrations of the population

. For a period of over a century, Kosova has been characterized by a negative migration balance, which means that the number of emigrants has been greater than the number of returnees-immigrants.
In the period 2000-2021, over 420,000 inhabitants left Kosova (according to KAS statistics), with an average of over 21,000 inhabitants per year, although there was previously the conviction that upon the freedom and independence, Kosova would also recover from this century-old wound.
External emigration is one of the main reasons why Kosova nowadays is characterized by unfavorable demographic trends such as: stagnation of the total number of the population with a downward trend, rapid trends of decreasing the birth and natural increase, deterioration in the structures of the population by age - demographic age, as well as other population structures.
The situation is so unfavorable that it can be considered a demographic crisis.
Since the end of the 1999 war, strong waves of emigration from Kosova have been associated with the second decade of the 21st century, with a culmination during the years 2014 and 2015, which are also associated with the economic crisis and global uncertainty. *While the reasons for emigration, in the beginning, were of an economic nature, now the loss of hope and uncertainty about the future in Kosova has become the main reason for emigration.*
The emigrations of the two decades of the 21st century are the most unfavorable waves to date. This trend is developing in circumstances of reduced births, decline in natural increase, stagnation with decreasing trends in the total number of the population and the accelerated process of deformation of the population structures, particularly that by the age towards the aging of the population.

Graph 1**. Trends in births, natural increase, emigrations and external migration balance in Kosova 2011-2021**(2)

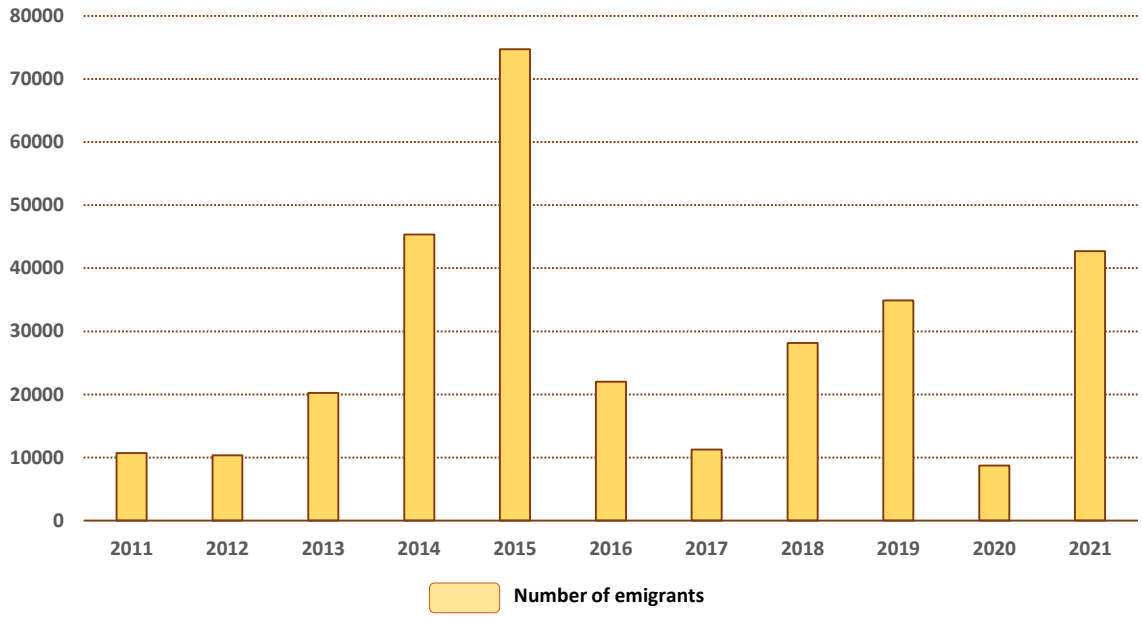


2.1. Trends of external emigrations of the population 2011-2021

Like in many countries of the world, also in Kosova, emigration statistics are incomplete because many residents do not deregister their residence in Kosova before they leave or they do so long after moving. However, even such incomplete data show that in the period 2011-2021 more than 309 thousand inhabitants moved abroad, this number is much higher (almost 190 thousand more) than in the period 2001-2010, when more than 119 thousand of them moved.
Although the emigration statistics are incomplete, they are the only official data on the number of emigrants presented in table 1. As it can be seen from the table and graph on population emigration in Kosova 2011-2021, from 2011 to 2015 there is a constant increase in the number of emmigrants. The year 2014 and particularly 2015, represent the years with an extreme increase in the number of emmigrants when the number of emmigrants compared to 2011 had increased by 323.9% or 4.2 times (2014) and 598.8% or close to 7 times (2015). Excluding the mass exodus and deportation of about 1 million Albanians by the Milosevic's regime in 1999, between the end of 2014 and the beginning of 2015, an unprecedented phenomenon of illegal emigration occurred in Kosova **(3).**
In the period 2017-2021, there was also a continuous

increase in emigration, with exception of the year 2020 when Kosova was characterized by a positive migration balance.
The main reason for this is the pandemic of the disease COVID-19, due to which many countries closed their borders, so the employment of foreign nationals in these countries became difficult or impossible. Thus, more than 150 countries had imposed such restrictive measures, making this period with the most movement restrictions in the history of international travel **(4).** However, in 2021, the number of emmigrants was much higher than in 2020 (4.8 times higher) and close to 2014, so it can be expected that after 2021 there will be no decrease in the number of emmigrants.

Graph 2. *Number of emigrants from Kosova 2011-2021****(5)***



That emigrations have reached alarming proportions is also proven by the fact that during 2021, 119 people left Kosova within a day, or 1 person every 12 minutes. Based on the preliminary data, during 2022 the situation only worsened even more.
Even more worrying is the fact that based on various surveys carried out in the country, about 60% of the respondents have expressed the desire to leave Kosova, mainly the new generations (20 to 40 years old) who make up the main demographic and birth contingent, the contingent of work, security, etc., causing a decline in "human capital", as the main carrier of socio-economic development.
Despite the fact that Kosova faces a very high emigration flux, more than half of Kosova's citizens (55.4%) agree that emigration will have a negative impact on future developments in the country, 15.3% agree that there will not be any impact, 16.9% do not know what impact they will have, while 11.6% agree that emigration will have a positive impact **(6).**
Taking into account the current progress but also what is expected in economic development, employment opportunities and other unfavorable circumstances, for some more time there should be expected migratory movements of the population with undiminished intensity. Unfortunately, Kosova's institutions have done very little in addressing the emigration driving factors such as: economic development, unemployment, prospects for a better and safer, more dignified life, etc.
The situation in terms of emigrations may even deteriorate in the case of visa liberalization and the union of Kosova with the EU, which may trigger an increasing wave of emigration, given the fact that Kosova lags behind the EU countries in the socio-economic sphere, since one of the main factors of migrations is the difference in incomes between the countries of origin and the hosting countries. Such a tendency is also based on the practices of various countries which, after liberalization and membership in the EU, have faced an increased migratory flux.

2.2. External emigrations from Kosova by municipalities

The analysis of emigration at the level of municipalities provides us with information about the spatial dimension of this phenomenon in Kosova, as well as the ascertainment whether there have been significant changes in certain periods of time.
In order to ascertain the spatial change and the fact that there have been changes in the intensity of external emigration, there will be used as the indicator - the rate of emigration, which represents the ratio between the number of emigrants and the number of the resident population in 2021 in the respective municipality (per 100 inhabitants). The number of emigrants in relation to the number of

resident population in Kosova differs greatly among municipalities. The data from the 2011 population census show that in municipalities with a small number of resident population, such as: Shtërpca, Graçanica, Ranillug and Mamusha, the emigration was lower, below 10%.

In this census, Kosova had 21.4% of the population living abroad, whereas between 1-9% of the population abroad was from 9 municipalities, 10-19% from 12 municipalities, 20-29% from 13 municipalities, 30-39% from 3 municipalities and over 40% from 1 municipality. In relation to the resident population, Suhareka had the largest number of emigrants in the 2011 census, nearly 47% of the population lived abroad, Klina 34.1%, Mitrovica 33.2%, Gjakova 31.4%, etc. **(7)**

The data and the difference (increase) in the data on emigration at the municipal level, between the 2011 population census and the emigration statistics of 2021 show that the phenomenon of emigrations in many municipalities has taken on worrying proportions.

Based on the statistics of the Kosova Agency of Statistics in 2021, the percentage of the overall Kosova population living abroad reached 36.6% from 21.4% in the 2011 population census, while there was a significant increase in this percentage in its municipalities. Thus, between 1-9% of the population abroad was from 6 municipalities, 10-19% - from 7 municipalities, 20-29% - from 6 municipalities, 30-39% - from 8 municipalities and over 40% - from 11 municipalities. In relation to the resident population, Suhareka, Obiliq, Gjilan, Mitrovica, Vushtrri, etc. had the largest number of population involved in emigration.

2.3. Emigration by Municipalities 2011-2021

Migration, Migration, especially external emigration, continued with considerable intensity during the period 2011-2021. During this period, almost all municipalities in Kosova were characterized by a negative migration balance, except for the year 2020 when, due to the pandemic (when movements, especially abroad, were restricted), only the municipalities of Prishtina and Kaçanik had a negative migration balance; all other municipalities in 2020 had a positive balance.

Data **(8)** published by the Kosova Agency of Statistics show that at the Kosova level, in the period 2011-2021, an average of 15.9 residents (16 residents per 100) were involved in migration compared to the total number of residents in 2021

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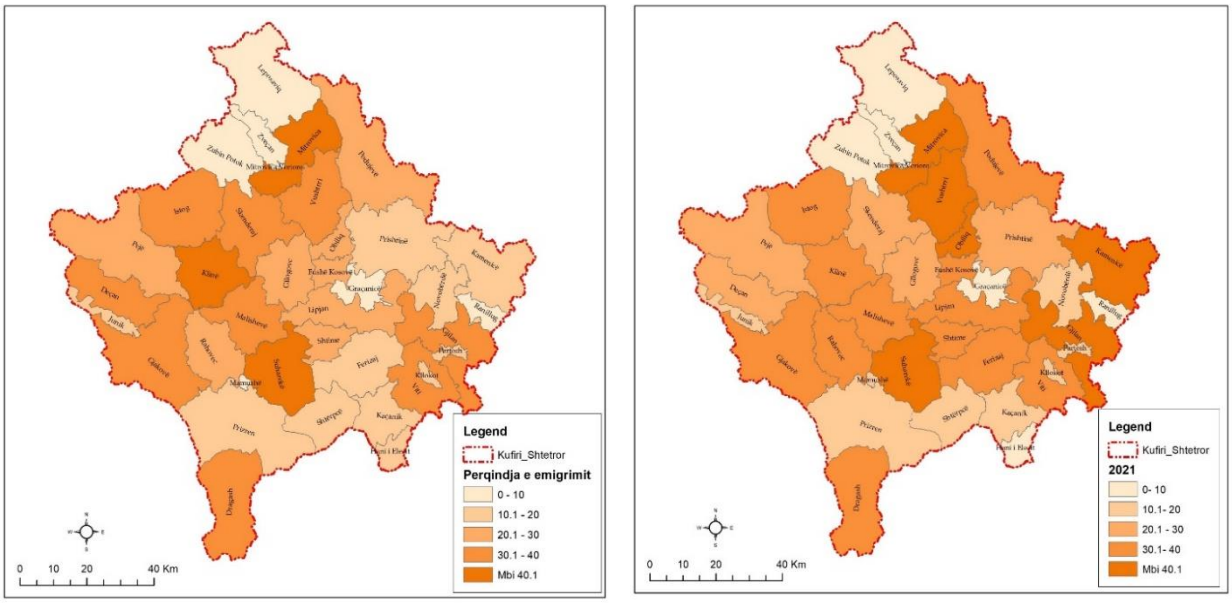
***Map 1 and 2**: The number of emigrant population compared to the resident population by municipalities in 2011 and 2021, expressed as a percentage.*



. As in the 2011 population census and during the 2011-2021 period, in municipalities with a small number of resident populations, migration was lower, such as in Partesh, Gračanica, Zvečan, Zubin Potok, Kllokot, Hani i Elezit, North Mitrovica, and Deçan, municipalities that had fewer than 5 emigrants per 100 residents. However, it should be noted that low migration in some municipalities (especially those with a majority Serb population) may also be due to incomplete statistics (non-inclusion) and the fact that these municipalities are already experiencing demographic aging (lack of migration potential).

During the 2011-2021 period, in relation to the resident population, the municipalities with the highest number of emigrants (per 100 residents) were: Obiliq 45.4%, Gjilan 40.3%, Kamenica 38.6%, Vushtrri 31.3%, Fushë Kosova

28.3%, Suhareka 26.6%, Ferizaj 22.2%, Mitrovica 20.4%, Shtime 20.4%, etc. It should also be noted that external migration is the dominant form of migration throughout the observed period and in almost all municipalities in Kosova.

3. The Consequences of emigration

The unfavorable economic situation in Kosova, the decline in the standard of living for many citizens, the lack of opportunity to find work even in one's profession, long waits for employment, insufficient wages considering qualifications, an unfavorable climate, and the loss of prospects for a better life, especially among the youth, are some of the most important economic factors driving individuals to decide to emigrate temporarily or permanently from Kosovo.

In the UNDP Public Pulse survey of 2022, the unfavorable economic situation—unemployment (36.4%) and poverty (21.1%)—are the main problems Kosova currently faces **(9**). Unemployment, poverty, and the search for a better future for their families remain the primary reasons for migration among Kosovars, especially among the youth.

Among the youth, the primary reason for considering emigration was the lack of job opportunities in Kosova, according to 67% of respondents (55% in 2018). Another 45% cited the lack of personal prospects as a reason (32% in 2018), and 39% mentioned the unfavorable economic situation in their families/low income levels (38% in 2018). The findings from focus groups further emphasized the issues of unemployment, financial difficulties, and lack of prospects as possible reasons for migration **(10).**

Over the last twenty years, Kosova has been characterized by massive emigration, especially among highly educated youth. This is evidenced by the increase in the participation of emigrants with higher education (before emigration) from 17.8% in the 1990s to around 31.5% **(11)** in the first decade of the 21st century.

Particularly concerning is the recent trend of increased emigration not only of individuals, but also of entire families **(12).** Many of the young people who emigrate do not leave alone; in most cases, they move with their families, and many others start families in the host country, significantly impacting Kosovo's demographic landscape.

The consequences of migration manifest in all segments of life:

- **Demographic:** (the size of the population, causing the loss of the segment of the population that constitutes development potential, birth rates, natural population growth, and the structure of the population—demographic, economic, social, ethnic, etc.—leading to natural depopulation, brain drain, and population aging);
- **Socio-economic:** (low per capita GDP growth, slowed economic growth, loss of labor force, decreased competitiveness, negative impact on the social system and pensions, emigration of qualified individuals, etc.);
- **Education system:** (the reduction in the number of pupils and students as a result of emigration and declining natural growth—over the last seven years in Kosova, a reduction in the number of pupils by 16.1% in primary and lower secondary education, 11.2% in upper secondary education, and 21.3% in higher education has been observed in the last five years);
- **National security:** (In the 21st century, the concept of "security" has transformed significantly and is no longer equated only with military security but also includes other forms such as demographic, economic, ecological, political, and other types of security);
- **And more.**

Due to space constraints, only the consequences of migration on demographic developments in Kosova are addressed in this paper.

3.1. Demographic Consequences

Demographic issues are of crucial importance for the development of any state because development cannot be achieved under unfavorable demographic conditions where migration plays a significant role.

Migration affects the size of the population by causing the loss of that segment of the population which constitutes development potential, birth rates (with a decline in births), natural population growth, and the population structures (demographic, economic, social, ethnic, etc.), leading to natural depopulation, brain drain, and population aging.

As a result of the decrease in the number of births from 38,687 (2000) to 22,830 (2021), representing a decline of 15,857 births or nearly a halving of births (-41%), and the increase in the number of deaths, natural increase is characterized by an even faster decline compared to birth rates. Thus, compared to 2000 when the natural increase was 34,296 people, it decreased to 9,811 in 2021, representing a reduction of 24,485 people, or about 3/4 (-71.4%). The natural increase in 2021 is similar to that of the second half of the 1930s.

The scale of the decline in the number of births is illustrated by the fact that in 2008, an average of 94 babies per day were born in Kosova, while in 2021 this number decreased to 62 births per day, and regarding natural increase, from 76 new residents to only 27 residents.

The significant impact of migration on the decline in birth rates and natural increase is also evidenced by the increase in the percentage of births and natural increase that occurred abroad. From 2011 to 2021, the percentage of births outside Kosova increased from 19.3% to 31.8% of the total number of births, meaning that migration has also taken away a significant portion of the birth rate—about 1/3.

The rapid decline in natural increase and selective migration (ages 20-39 constitute nearly half of the emigrants) have accelerated the process of population aging. For example, while in 2011 people aged 60 and over constituted 9.6% of the population, in 2021 this age group increased to 13.3%. At the same time, the age group 0-19 years has shown a trend of decreasing participation from 38.1% to 32.3%. Population aging has negative consequences for demographic, economic, social developments, etc.

To prevent population aging due to the predominance of young age groups in migration flows, it is necessary to

discourage external migration of the population at a young age through improvements in conditions, opportunities, access, and integration of youth into professional training, vocational education, university education in market-demanded fields, and the labor market.
Alongside the concerning negative demographic trends of today, recent migration trends are increasingly impacting other areas of life, such as the labor market, destabilization of educational and health systems, and in the coming years will also affect the economic, social, and pension systems, inter alia, for an extended period. In the long term, the old structure of the workforce, negative natural increase, and the departure of youth from Kosovo will threaten the functioning of pension and disability insurance funds and health insurance, which will lack sufficient funds to cover future obligations.
To reduce the negative socio-economic effects of migration, it is necessary to adopt a series of measures and strategies for population policies, measures for migration sustainability, and a series of economic reforms that would improve the business environment, stimulate job creation, favor investments, and restore optimism among youth, which would mitigate and reduce the emigration contingent from Kosova, transforming migration from a negative process into a positive one.

4, Conclusion

Mass emigration from Kosova may now be considered a threat to the demographic, economic, and social prosperity of Kosovar society. Therefore, an imperative for Kosova's current and future development is that the emigration of its population becomes sustainable. Sustainable migration implies proactive demographic, economic, social, technological, and regional policies that will ensure that Kosova remains an attractive place to live, primarily for its residents.
Since migration is the most significant factor in the decline or stagnation of Kosova's population, it is necessary for the state to act to influence the reduction of the causes driving emigration. This can be achieved by increasing efforts to reduce economic and psychological insecurity, accelerating economic and social development, creating an atmosphere of prosperity, and supporting health and educational programs. If the causes driving the population to emigrate are not addressed, other measures aimed at increasing birth rates may simply result in more people leaving the country. Creating conditions for people, especially youth, to have confidence in building a future in their own country is key to stopping the demographic crisis in Kosova. If the population—particularly young people—hve access to quality education and healthcare, stable employment, and support for child-rearing, they will be less likely to emigrate and more likely to decide to have children.
However, if measures are not prompt and effective, merely reducing emigration and implementing the measures outlined above will not be sufficient. It is also necessary to consider strategies for attracting emigrants from other countries, which is a process fraught with many challenges.
Today, due to the lack of policies, emigration and the diaspora may be considered more of a loss and threat than an asset and partner, although in reality, the diaspora is a valuable asset in the establishment of the state of Kosova.

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Pravica do groba - možnosti pokopavanja na pokopališčih v Sloveniji

The Right to Grave - Possibilities of Burying in the Cemeteries in Slovenia

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Povzetek

V Sloveniji zakon dopušča pokop v krsti in upepeljevanje pokojnikov. Enoletna raziskava je pokazala, da je treba zavrniti ničelno hipotezo, da ni diskriminacije tiste manjšine, ki si želi pokopa v krsti. Lokalni predpisi tak pokop ponekod prepovedujejo, onemogočajo ali otežujejo, država pa z zakonom ne varuje pravice do groba.

Ključne besede

Diskriminacija, družina, pokopališče, pokopavanje, pravica do groba, upepelitev

Abstract

In Slovenia law allows for cremation and for burying of body in a coffin. In a one-year research it was shown, that the null hypothesis, that there is no discrimination of the minority, preferring burial in a coffin, has to be rejected. Such burial is in some places prohibited, disabled or made difficult by local regulations; the state in its legislation does not protect the right to grave.

Optional: Keywords

Discrimination, family, cemetery, burying, right to grave, cremation

1 Uvod

V Sloveniji zakon dopušča tri oblike pokopa: pokop s krsto, pokop z žaro in raztros pepela [1]. Pri prvi obliki gre za pokop telesa, pri drugi in tretji pa najprej za sežig telesa in zdrobitev kosti, potem pa pokop v žari ali raztros. Jedro članka je poročilo o raziskavi možnosti pokopa na pokopališčih v Sloveniji, ob ničelni hipotezi, da ni diskriminacije tiste manjšine, ki si želi pokopa v krsti. Za testiranje te hipoteze je bila potrebna posebna raziskava, ker država ne razpolaga s podatki, ki bi omogočili njeno preverbo.

Vsebina raziskave sodi v temo "pojavi in odnosi v sodobni družini«. Zakaj? Ker so rojstvo, poroka, smrt - vključno z vsemi, z njimi povezanimi občutji, obredi, obveznostmi - ključne točke družinskega življenja in družino ter odnose v njej močno določajo; tudi odločanje o številu otrok, s čimer smo že pri demografiji. Spoštovanje, odnos in ljubezen do živih članov družine, njenih korenin in vrednot ter odločanje za življenje so močno povezani s spoštovanjem mrtvih teles sorodnikov, posebej prednikov, načinom zadnjega slovesa od njih in odnosom do njihovih grobov kot točk izražanja ljubezni do njih in točk spoštljivega srečevanja družinskih članov. Spoštovanje družinskih korenin, povezano z željo, da se rod nadaljuje, in bodo vnuki in pravnuki ponosni na svoje dede in pradede ter se bodo nanje ljubeče spominjali ob spomenikih ter na grobovih, v katerih počivajo – to spoštovanje in te želje so težko združljive na primer z odločitvijo, da bi pokojnega družinskega člana poslali v postopek, v katerem mu bodo zdrobili lobanjo, ali da bi njegove ostanke »pokopali« z raztrosom, ki za njim zabriše vsako sled in ne ohranja mesta spomina nanj. Rezultati raziskave so lahko dragocena izhodišča za preučevanje pojavov in odnosov v sodobni družini, njenih ekonomskih, antropoloških in sociooloških vidikov ter ideoloških vplivov nanjo.

2 Potek raziskave

Raziskava ima dva dela. V prvem delu sem vsako od 212 slovenskih občin 24. 5. 2022 zaprosil za sedem podatkov: število vseh pokopališč v občini ter števila pokopališč, na katerih: ni mogoče dobiti novega prostora za klasični grob, je pa mogoč klasični pokop v obstoječi grob, če mu je potekla mirovalna doba; klasični pokop sploh ni mogoč, opravljajo pa se druge vrste pokopi; ni mogoče dobiti novega prostora za žarni grob oziroma nišo, je pa mogoč pokop žare v obstoječi klasični grob, žarni grob ali nišo; žarni pokop sploh ni mogoč, opravljajo pa se druge vrste pokopi; niso možni pokopi z raztrosom pepela, so pa možni drugačni pokopi; ni mogoč nikakršen pokop.

Tridesetim občinam je bilo treba ponovno poslati, ker nisem poslal na pravi naslov. Polovica vseh je odgovorila takoj, polovica preostalih po drugem pošiljanju; po tretjem 5. 10. 2022 jih je ostalo nekaj deset – od teh sem podatke dobil posamično,

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nekaj tudi po telefonu. Ponekod so pred odgovorom želeli podrobnejšo obrazložitev namena raziskave. Izkazalo se je, da ne le država ampak tudi mnoge občine nimajo teh podatkov, saj mnogo pokopališč upravljajo krajevne skupnosti. Za taka pokopališča (kakšna občina jih ima tudi več deset) je bilo treba poiskati kontakte krajevnih skupnosti in podatke dobiti od njih, večinoma po telefonu. Konec aprila 2023 sem imel vse odgovore.

V drugem delu sem pregledal nekatere občinske odloke o pogrebni in pokopališki dejavnosti in v njih poiskal z ničelno hipotezo povezane določbe.

3 Rezultati

Prvi del raziskave pove, da je vseh pokopališč 1 231. Število pokopališč ene občine se giblje od nič v dveh občinah do 45 v eni občini. Žare povsod pokopavajo v klasične grobove, nekatera pokopališča pa imajo za žare niše v žarnem zidu, žarna polja, ali posamične žarne grobove. Med skupno 212 občinami jih 67 na vseh svojih pokopališčih: zagotavlja pokope v krstah in v žarah; prostora za raztros nimajo; na voljo pa je prostor tako za najem novih klasičnih grobov kot tudi žarnih grobov oziroma niš. Na treh pokopališčih ne pokopavajo v krstah - tudi če je na voljo klasičen grob, ki mu je potekla mirovalna doba. Na 50 pokopališčih je sicer pokop v krsti mogoč v grob, ki mu je potekla mirovalna doba, ni pa na voljo novih prostorov za klasične grobove. Eno pokopališče ima prav zanimivo ureditev. Parcele za klasične in žarne grobove dobiš zastonj. Prostora je dovolj za ene in druge. Če zahtevaš nov klasični grob in nimaš svojega (družinskega), grob dobiš. Če pa zahtevaš klasični pokop in imaš svoj grob, se najprej opravi sondiranje. Če se pokaže, da je pokop v ta grob mogoč, se to naredi, če pa ni mogoč, stranka ne more dobiti novega prostora, ampak mora dati pokojnika v žaro, čeprav je prostora za grobove dovolj. Na drugem pokopališču imajo na enem delu pravilo, da se v klasični grob, ki mu je potekla mirovalna doba, sme v krsti pokopati samo ožjega sorodnika osebe, ki je bila zadnja pokopana.

Pokopališča, kjer ne bi bil mogoč žarni pokop, ni. Na 150 pokopališčih, sicer ni mogoče dobiti nove niše ali žarnega groba, je pa mogoč pokop žare v klasični grob. Prostor za raztros je urejen na 169 pokopališčih v 123 občinah in sicer v 89 občinah na enem, v 25 na dveh, v sedmih na treh, v eni na štirih in v eni na petih pokopališčih. Enajst pokopališč je v opuščanju in se na njih ne pokopava več.

4 Zaključki raziskave

Ničelno hipotezo o nediskriminaciji je treba zavrniti. Tisti, ki si želijo pokopa v krsti, so očitno diskriminirani: na treh pokopališčih, kjer sploh ni pokopa v krsti; na 50 pokopališčih, ki nimajo prostora za nove grobove; na pokopališču, kjer domačin ne more dobiti novega groba, čeprav prostor je; tam, kjer sme v krsti sme pokopati samo ožjega sorodnika osebe, ki je bila zadnja pokopana.

Drugi del raziskave je pokazal, da je pravica do groba oziroma, kot pravi Ustavno sodišče, »posmrtna zaščita osebnosti pokojnika in njegovega dostojanstva ter želja, da bodo njegove odločitve, ki so bile sprejete za časa življenja, spoštovane tudi po njegovi smrti« [2] grobo kršena tudi pri pokopu oseb, ki jih občina pokoplje na svoje stroške. Med 21 nenačrtno pregledanimi občinami - nobena ni mestna - sem v dvanajstih primerih v odloku o pokopališki in pogrebni dejavnost ter urejanju pokopališč našel določbo o obveznem sežigu; od teh dvanajstih je v šestih primerih določen raztros, v treh žara, v treh pa raztros ali žara; dve občini sta zapisali vse tri možnosti in ena od njih daje prednost pokopu v krsti; ena navaja krsto ali žaro; šest odlokov ne določa ničesar. Od dvanajstih mestnih občin jih šest določa sežig (tri raztros, tri pa žaro ali raztros), v šestih pa to v odloku ni določeno. V tistih šestih, ki določajo sežig, ni določbe, da je treba vprašati sorodnike ali upoštevati željo pokojnega; da si bo občina skušala povrniti strošek pokopa iz pokojnikove zapuščine, pač. Pregledal sem torej 33, oziroma dobrih 15 odstotkov vseh občinskih odlokov. To je le del celotne populacije 212 občin, za razliko od prvega dela raziskave, v kateri sem zbral podatke o celotni populaciji pokopališč. Vendar to zadošča za ugotovitev diskriminacije. Koliko te vrste diskriminacije bi našel, če bi pregledal vse občinske odloke, težko ocenim, saj vzorec 33 občin ni bil narejen po pravilih slučajnega vzorčenja. Ob tem je treba navesti, da so ti odloki v konkretnih primerih lahko protizakoniti, saj področni zakon določa, da se pogrebna slovesnost opravi v skladu z voljo pokojnika in na način, določen s pokopališkim redom, če pa pokojnik ni izrazil svoje volje o načinu pokopa in pogrebni slovesnosti, odloča o tem naročnik pogreba [3].

Do tu navedena diskriminacija temelji na predpisih, obstaja pa še diskriminacija pri izvajanju sicer nediskriminatornih predpisov. Ko je na papirju mogoče, dejansko pa nemogoče ali skoraj nemogoče.

Gospa, ki mi je potožila, da je bila zelo prizadeta, ker leta 2018 za njeno sestro ni bilo klasičnega groba na domačem pokopališču in jo je morala dati upepeliti, je iz občine, ki mi je v odgovoru na vprašalnik sporočila, da na vseh njihovih pokopališčih pokopavajo tudi v krstah in da imajo prostor za nove klasične grobove. Sama je bila takrat govorila z odgovornim pri pogrebnem podjetju in z delavcem na pokopališču; oba sta povedala, da nove grobne parcele ni. O tem neskladju informacij sem obvestil odgovornega pri tem podjetju. Pogledal je v kataster grobov in povedal, da so še prosti grobovi, da pa se bo še pozanimal, ker takrat še ni bil v tej službi. Poskrbel sem, da se je o tem pogovoril neposredno s prizadeto gospo. Povedal ji je, da je šele prvo leto na tem mestu, a ima informacije svojih ljudi in tudi iz katastra grobov je razvidno, da so grobne parcele sedaj - in so vedno bile - na voljo, in je možno sedaj, kakor je bilo tudi v preteklosti, dobiti nov grob. Dejansko sta res dva opuščena groba zravnana in v katastru zavedena kot prosta, vendar sta tako utesnjena, da je grob zelo težko izkopati; delavec bi moral sproti odnašati zemljo, ker ob grobu ni prostora zanjo. Tako da se delavci, s katerimi pride naročnik pokopa v stik, izogibajo kopanju teh grobov in rečejo, da to ni mogoče; med ljudmi v vasi zato že leta velja, da prostih klasičnih grobov na tem pokopališču ni. Drugje na primer se delavec – neposredni izvajalec – ob zahtevi za klasičen pokop zgrozi (“a potem bo pa treba kopat”) in pove, da bo v tem primeru pogreb lahko šele več

dni pozneje kot bi bil žarni. Ko stranka vztraja pri klasičnem pokopu, se izkaže, da lahko dobi isti termin kot pri žarnem.

Zaradi večjega napora pri kopanju klasičnega groba, morebiti pa tudi iz drugih razlogov, neposredni izvajalci marsikje - v časovni in duševni stiski sorodnikov umrlega marsikdaj uspešno - prepričujejo naročnike, naj se odločijo za upepelitev. Na papirju torej lahko dobiš grob, vendar Bog ne daj, da bi vztrajal, da ga res izkopljejo.

Raziskava torej ugotavlja diskriminacijo naročnikov klasičnih pokopov tako s predpisi kot tudi z izvajanjem predpisov:

- s krajevnimi predpisi na več deset pokopališčih, ki prepovedujejo klasičen pokop v krsti ali ne zagotavljajo prostora za nov klasični grob,
- z občinskimi predpisi v mnogih občinah, ki z odlokom določajo upepelitev oseb, ki jih občina pokoplje na svoje stroške,
- z državnimi predpisi, saj področni zakon ne prepoveduje navedene diskriminacije na krajevni in občinski ravni, ne zagotavlja enakih možnosti za izbiro načina pokopa in na državni ravni ne določa zbiraja podatkov o možnostih pokopa,
- s konkretnim izvajanjem sicer nediskriminatornih predpisov, ko uslužbenci pogrebnih podjetij ob naročanju pogreba odvračajo naročnike od izbire klasičnega pokopa.

5 Razmislek o vzrokih

Leta 2022 smo tu opozorili na neverjetno povečanje števila žarnih pokopov, ki ga ni mogoče pojasniti s podatki s področij gospodarjenja s prostorom, niti z ekonomskimi, etičnimi, verskimi in ekološkimi razlogi [4]. Ob ekoloških razlogih (Med upepelitvijo človeškega telesa nastane na primer 160, po nekaterih virih pa celo več kg toplogrednega plina CO2[5]), hudi energetski potratnosti upepeljevanja, posebej etični in verski razlogi govorijo v prid klasičnemu pokopu v krsti. Na koncu smo ostali brez razlage tako hitre rasti števila in deleža upepelitev pokojnikov.

Po ugotovitvi, da lokalne in državne oblasti diskriminirajo tiste, ki se odločajo za pokop v krsti, in torej pospešujejo upepeljevanje, se še ostreje zastavlja vprašanje o pravih vzrokih tega pospeševanja ter skupinah ali osebah, ki stojijo za njim.

Zahvala

Zahvaljujem se več sto prijaznim ljudem, ki so mi posredovali dragocene podatke in izkušnje ter mi potrpežljivo razložili, kar je bilo treba.

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Ocena bremena telesne neaktivnosti v Sloveniji
Physical inactivity burden assessment in Slovenia

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Povzetek

Prispevek ocenjuje breme telesne neaktivnosti v Sloveniji v letu 2019, in sicer na podlagi epidemiološkega pristopa osnovanega na populaciji, in sicer na podlagi relativnega tveganja prevalence treh vrst bolezni (srčno-žilnih bolezni, sladkorne bolezni in demence) zaradi telesne neaktivnosti in populacijskega pripisljivega deleža. Na podlagi tega pristopa ocenjujemo, da je bilo zaradi telesne neaktivnosti v Sloveniji leta 2019 med 13 in 17,5 tisoč srčno-žilnih obravnavanih pacientov, med 7 in 13 tisoč obravnavanih sladkornih pacientov in okrog 1.500 obravnavanih pacientov z demenco. Nadaljnje ocenjujemo, da je v letu 2019 zaradi telesne neaktivnosti in posledično srčno-žilnih bolezni, sladkorne bolezni in demence umrlo med 188 in 440 oseb, največ zaradi srčno-žilnih bolezni. Zaradi telesne neaktivnosti in posledično srčno-žilnih bolezni, sladkorne bolezni in demence je bilo izgubljenih 156.036 zdravih let življenja.

Ključne besede

Telesna neaktivnost, breme telesne neaktivnosti, umrljivost

Abstract

This paper assesses the burden of physical inactivity in Slovenia in 2019 based on an epidemiological top-down approach, grounded on the population and thus a prevalence approach using population attributable fraction. Using this method, we estimate that due to physical inactivity in Slovenia in 2019, there were between 13,300 and 17,600 cardiovascular patients, between 7,000 and 13,000 diabetic patients, and around 1,500 dementia patients. Furthermore, we estimate that in 2019, physical inactivity and consequently cardiovascular diseases, diabetes, and dementia resulted in the deaths of between 188 and 252 individuals, most due to cardiovascular diseases. Due to physical inactivity, a total of 156,036 disability adjusted life years were lost due to cardiovascular diseases, diabetes, and dementia.

Keywords

Physical inactivity, burden of physical inactivity, mortality

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1 Uvod

Redna in dovolj intenzivna telesna aktivnost je ključna za ohranjanje dobrega zdravja in dolgoživosti. Raziskave jasno kažejo, da telesna aktivnost znatno znižuje verjetnost za predčasno smrt in deluje kot preventivni ukrep proti številnim kroničnim nenalezljivim boleznim [1], [2]. Po podatkih Svetovne zdravstvene organizacije je telesna neaktivnost četrti vodilni dejavnik tveganja za nenalezljive bolezni po vsem svetu in naj bi letno povzročila med 3,2 in 5 milijonov smrti na globalni ravni [3]. V Sloveniji po podatkih Svetovne zdravstvene organizacije 73% odraslih dosega priporočene ravni telesne aktivnosti, ki vključujejo vsaj 150 minut zmerne intenzivne aerobne dejavnosti ali 75 minut visoko intenzivne dejavnosti na teden, 27% pa ne [4]. Temu vsled se povečuje tveganje za nenalezljive bolezni, predvsem za srčno-žilne bolezni, sladkorno bolezen, različne vrste raka, debelost, hipertenzijo, osteoporozo, osteoartritis, depresijo in kognitivni upad.

V tem prispevku se zato osredotočamo na tri vrste bolezni, ki so posledica telesne neaktivnosti: izbrane srčno-žilne bolezni, sladkorno bolezen in demenco. Namen prispevka je oceniti breme telesne neaktivnosti, ki izhaja iz bremena teh treh navedenih bolezni. Tako na podlagi relativnega tveganja za

nastanek posamezne vrste bolezni izračunamo populacijski pripisljivi delež, ki ga uporabimo za oceno prevalence teh bolezni zaradi telesne neaktivnosti ter oceno umrljivosti in izgubljenih zdravih let življenja.

2 Metodologija in podatki

Breme telesne neaktivnosti je ocenjeno na podlagi pristopa, ki posnema že obstoječe poskuse ocene bremena bolezni [5], [6]. Tako uporabimo epidemiološki pristop, pristop od zgoraj navzdol, ki je osnovan na populaciji (angl. population-based approach) in prevalenčni pristop. Pristop temelji na naslednjih korakih: 1) Ocenjena je prevalenca telesne neaktivnosti; 2) Ocenjeno je relativno tveganje za nastanek bolezni zaradi telesne neaktivnosti. Relativno tveganje je razmerje prevalence (števila primerov bolezni v opazovanem obdobju) med izpostavljenimi in neizpostavljenimi (npr. tveganje za opazovani dogodek v testni skupini/tveganje za opazovani dogodek v kontrolni skupini). Izpostavljena skupina je tista skupina, ki ni bila dovolj telesno aktivna – to so telesno neaktivni posamezniki. Neizpostavljena skupina je tista skupina, ki je bila dovolj telesno aktivna – to so telesno aktivni posamezniki. 3) Izračunan je populacijski pripisljivi delež (angl. PAF – population attributable faction). PAF predstavlja delež, ki ga je mogoče pripisati populaciji. Meri sorazmerno zmanjšanje populacijske bolezni ali umrljivosti, ki bi nastala, če bi izpostavljenost dejavniku tveganja zmanjšali na alternativni idealni scenarij izpostavljenosti [5], [7]. 4) Na podlagi PAF je ocenjena prevalenca bolezni zaradi telesne neaktivnosti, število umrlih in izgubljena zdrava leta življenja.

V oceni je upoštevano **relativno tveganje (RR)** iz dveh virov. Prvi vir relativno tveganje povzema po obstoječih študijah [5], drugi vir pa so podatki Nacionalnega inštituta za javno zdravje (v nadaljevanju NIJZ), in sicer iz Nacionalne raziskave o zdravju in zdravstvenem varstvu (European Health Interview Survey – EHIS, v nadaljevanju EHIS). Temu vsled uporabimo in izračunamo tudi dva različna populacijska pripisljiva deleža. [5] poroča o relativnem tveganju za srčno-žilne bolezni v višini 0,75 ter za sladkorno bolezen v višini 0,61. Na podlagi relativnega tveganja in deleža neaktivnih in uporabi formule (1) poročajo o populacijskem pripisljivem deležu - PAF za Slovenijo kot: 3,5% za srčno-žilne bolezni ter 4,4% za sladkorno bolezen. Demenca v študiji ni upoštevana, zato je uporabljen PAF iz študije [8] in znaša 4,5%.

$$PAF = \frac{P_e(RR-1)}{P_e(RR-1)+1} \cdot 100,\ P_e = delež\ telesno\ neaktivnih \qquad (1)$$

Na podlagi podatkov NIJZ pa smo po vzoru [9] izračunali delež izpostavljenih primerov (v nadaljevanju IP), in sicer z uporabo enačbe 2. Delež izpostavljenih primerov primerja dve množici (skupini ljudi), in sicer tisto, ki je bila izpostavljena dejavniku tveganja (v tem primeru telesni neaktivnosti) in je obolela, to je množica A, in tisto, ki ni bila izpostavljena dejavniku tveganja (niso bili telesno neaktivni) in so vseeno oboleli, to je množica B. IP je izračunan posebej za srčno-žilne bolezni in sladkorno bolezen.

$$IP = delež\ izpostavljenih\ primerov = \frac{n(A \cap B)}{n(B)} \qquad (2)$$

A …množica, ki je izpostavljena dejavniku tveganja in je obolela
B …množica, ki ni izpostavljena dejavniku tveganja in je obolela
n …število posameznikov

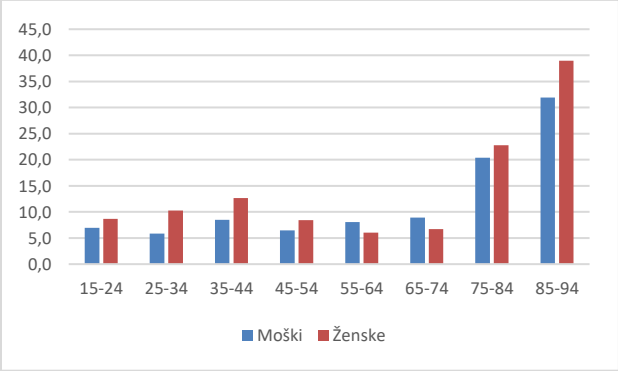
Nato je izračunan pripisljiv delež med izpostavljenimi (v nadaljevanju PDI), in sicer z uporabo enačbe 3, ki temelji na razliki med verjetnostjo (P) tveganja bolezni med izpostavljenimi in verjetnostjo tveganja bolezni med neizpostavljenimi, glede na tveganje bolezni med izpostavljenimi.

$$PDI\text{ - }pripisljiv\ delež\ med\ izpostavljenimi = \frac{P(B|A)-P(B|\overline{A})}{P(\overline{B}|A)} \qquad (3)$$

Na podlagi izračunov IP in PDI za srčno-žilne bolezni in sladkorno bolezen je izračunan PAF na podlagi enačbe 4. PAF za srčno-žilne bolezni znaša 4,6 %, za sladkorno bolezen pa 8,3 %. Izračun PAF za demenco na podlagi razpoložljivih podatkov ni bil mogoč, zato je uporabljen zgolj PAF iz literature.

$$PAF = IP \cdot PDI \qquad (4)$$

Podatki o telesni neaktivnosti izhajajo iz Nacionalne raziskave o EHIS, ki je bila nazadnje izvedena v letu 2019. Anketo je izvedel NIJZ na reprezentativnem vzorcu posameznikov starih 15 let in več, in sicer 9.900 oseb. Eden izmed sklopov EHIS ankete se nanaša tudi na telesno aktivnost/gibanje. Telesna aktivnost in neaktivnost je definirana na podlagi vprašanja: »Ali ste dnevno povprečno telesno dejavni vsaj 30 minut ali skupno 150 minut na teden? [Upoštevajte aktivnosti pri delu, vsakodnevnih opravilih in v prostem času.]« z možnim odgovorom DA ali NE. Ker meja 150 minut na teden ustreza priporočilom Svetovne zdravstvene organizacije je za potrebe tega prispevka telesna neaktivnost definirana z odgovorom NE na to vprašanje. Slika 1 prikazuje delež telesno neaktivnih po starostnih razredih in po spolu v letu 2019.



Slika 1: Delež telesno neaktivnih (v %) po starostnih kategorijah, 2019

Osredotočamo se na tri vrste bolezni, ki so posledica telesne neaktivnosti: izbrane srčno-žilne bolezni, sladkorno bolezen in demenco. Natančneje, izbrane srčno-žilne bolezni (s kodami po Mednarodni klasifikaciji bolezni MHB-10-AB, verzija 6): Esencialna (primarna) arterijska hipertenzija (I10), Hipertenzivna bolezen srca (I11), Angina pektoris (I20), Akutni miokardni infarkt (I21); Naslednji miokardni infarkt (I22); Kronična ishemična bolezen srca (I25); Ateroskleroza (I70) ter Ateroskleroza arterij udov (I70.2) ter Srčno popuščanje (I50). Za demenco so upoštevane naslednje bolezni: Demenca pri Alzheimerjevi bolezni (F00); Vaskularna demenca (F01);

Demenca pri drugih boleznih (F02); Neopredeljena demenca (F03); Alzheimerjeva bolezen (G30). Za sladkorno bolezen pa: Sladkorna bolezen tipa 1 (E10); Sladkorna bolezen tipa 2 (E11); Druge vrste sladkorna bolezen (diabetes) (E13); Sladkorna bolezen neopredeljenega tipa (E14).

Podatki o številu obravnavanih bolnikov izhajajo iz naslednjih virov: za srčno-žilne bolezni [10], za sladkorne bolnike [11], za demenco pa [12]. Vsi podatki so za leto 2019, razen za demenco, za katero so podatki za leto 2018. **Podatki o številu umrlih** so pridobljeni s strani NIJZ, o **izgubljenih zdravih letih življenja** pa iz Inštituta za metrike in ocenjevanje zdravja ("Institute for Health Metrics and Evaluation"- IHME). Inštitut poroča o izgubljenih zdravih letih življenja za vse srčno-žilne bolezni (ne samo za izbrane in predstavljene predhodno), za diabetes tipa 2 ter Alzheimerjevo bolezen in druge oblike demenc.

3 Rezultati

Ocena števila bolnikov izbranih bolezni zaradi telesne neaktivnosti kaže, da se število bolnikov razlikuje od populacijskega pripisljivega deleža (Tabela 1). Ocenjujemo, da je bila večina pacientov obravnavanih zaradi izbranih srčno-žilnih bolezni, in sicer med 13.300 in 17.600 bolnikov (ponovno odvisno po uporabljenega populacijskega pripisljivega deleža), število obravnavanih pacientov zaradi sladkorne bolezni je bilo med slabih 7 tisoč in 13 tisoč, obravnavanih pacientov z demenco pa okrog 1.500.

Podobno je tudi ocena števila umrlih zaradi telesne neaktivnosti odvisna od populacijskega pripisljivega deleža. Ocenjujemo, da je bilo število umrlih zaradi izbranih bolezni, ki so posledica telesne neaktivnosti, med 188 in 252, največ zaradi srčno-žilnih bolezni. Ocenjujemo, da je bilo število umrlih zaradi telesne neaktivnosti, ki so umrli zaradi sladkorne bolezni precej nižje, in sicer med 17 in 31 umrlimi, podobno tudi v primeru demence, ko je bilo število umrlih zaradi telesne neaktivnosti 16.

Število izgubljenih zdravih let življenja pa je zaradi srčno-žilnih bolezni znašalo 115 tisoč, dodatno še dobrih 20 tisoč zaradi sladkorne bolezni in 20.200 zaradi demence, skupaj torej 156 tisoč let življenja.

Tabela 1: Ocena bremena telesne neaktivnosti

	Število obravnavanih pacientov		Število umrlih		DALYs
Bolezni	PAF1	PAF2	PAF1	PAF2	
Izbrane srčno-žilne bolezni	13.340	17.608	155	204	115.062
Sladkorna bolezen	6.894	12.967	17	31	20.680
Demenca	1.536		16		20.294
Skupaj			188	252	156.036

4 Zaključek

V prispevku ugotavljamo, da zaradi telesne neaktivnosti v Sloveniji nastaja breme, ki se med drugim odraža v številu obolelih, umrlih in izgubljenih zdravih letih življenja. Na primer, zaradi telesne neaktivnosti in posledičnih srčno-žilnih bolezni, sladkorne bolezni in demence je v letu 2019 umrlo med 188 in 252 posameznikov. To sicer predstavlja en oziroma dva odstotka vseh umrlih, vendar zaradi telesne neaktivnosti in posledičnih bolezni nastajajo znatni stroški [13]. Ti vključujejo neposredne in posredne stroške, med njimi neposredne zdravstvene in nezdravstvene stroške ter posredne stroške, ki so posledica izgub produktivnosti zaradi bolniškega staleža (absentizma), prezentizma, pa tudi prezgodnje umrljivosti, prezgodnjega upokojevanja, delovne neaktivnosti in stroškov podjetij, ki morajo zaradi izgube zaposlenih iskati in usposabljati nove zaposlene.

Čeprav Slovenija velja za športen narod, podatki kljub temu kažejo, da se delež telesno neaktivnih med starostnimi razredi razlikuje in je visok predvsem pri starejših. Zato prispevek ponuja tudi nekaj vhodnih informacij za snovalce nacionalnih preventivnih programov, v sinergiji z dosedanjimi aktivnostmi krovnih institucij, ki pripravljajo programe in politike športno/gibalnih aktivnosti.

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Cohort Fertility Trends in Post-Yugoslav States[1]

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Abstract

This study provides an in-depth analysis of cohort fertility, parity progression, and family size in the former Yugoslav countries, which include Bosnia-Herzegovina, Croatia, Kosovo, Montenegro, North Macedonia, Serbia, and Slovenia. Though politically united for much of the 20th century, these countries exhibit diverse fertility patterns due to their distinct socio-economic and cultural histories. The analysis utilizes census data to compute completed cohort fertility rates (CFR) and parity progression ratios (PPR), revealing the different paces of fertility decline. Slovenia, Croatia, and Serbia form a low-fertility cluster, with cohort fertility stabilizing at around two children per woman by the 1930 cohort. Bosnia-Herzegovina, North Macedonia, and Montenegro constitute a high-fertility cluster where the fertility transition occurred more gradually. Kosovo remains unique with persistently high fertility, though it has experienced substantial declines in recent cohorts. The findings highlight how socio-economic transformations, cultural norms, and historical legacies have shaped fertility behaviours in each country, providing insights into long-term fertility trends.

Keywords: Cohort fertility, parity progression, family size, former Yugoslavia

Introduction

The former Yugoslav countries are an interesting case study for demographic analysis due to their shared historical and political past, yet vastly different socio-cultural trajectories. The region has experienced a complex process of demographic transition, influenced by varying degrees of industrialization, urbanization, and shifts in family norms and gender roles. Yugoslavia's political dissolution in the 1990s further differentiated the trajectories of its successor states, as each country embarked on distinct political and economic paths. Fertility decline, an integral component of demographic transition, occurred at different pace across the region, influenced by both economic factors and deeply rooted cultural traditions (Breznik, 1991; Rašević, 1971).

The countries that made up Yugoslavia were heterogeneous in terms of religion, ethnic composition, and socio-economic development. For example, Slovenia, with its history of Austro-Hungarian influence, had long experienced lower fertility rates and higher economic development compared to Kosovo, which was marked by a deeply agrarian, patriarchal society (Erlich, 1966). The question this study addresses is whether the fertility behaviour of the former Yugoslav countries has converged or if the region continues to exhibit significant diversity in cohort fertility trends. This analysis is important

1 This presentation draws on research previously published in Comparative Population Studies, presenting key insights from the article Cohort Fertility, Parity Progression, and Family Size in Former Yugoslav Countries by Ivan Čipin, Kryštof Zeman, and Petra Međimurec.

for understanding the demographic evolution of these countries in the context of their socio-economic and cultural histories.

Fertility in Context: Socioeconomic and Cultural Influences

The fertility transition in the former Yugoslav countries was influenced by economic, cultural, religious, and institutional factors, leading to regional differences in fertility patterns. Yugoslavia's complex historical and political background shaped the socio-economic trajectories of its republics, affecting their fertility behaviours. Yugoslavia was historically split between Western (Austro-Hungarian) and Eastern (Ottoman) cultural spheres, influencing marriage patterns and family structures. Slovenia and Croatia, with more Western European influences, transitioned to lower fertility rates earlier due to urbanization, industrialization, and expanded education for women. By contrast, Bosnia-Herzegovina and Kosovo, with strong Ottoman legacies, maintained traditional patriarchal family structures for longer, resulting in higher fertility (Erlich, 1966; Breznik, 1991). Religious diversity across the region also shaped fertility norms. Catholic regions like Croatia and Slovenia experienced earlier fertility decline, in part due to more progressive attitudes toward birth control, while predominantly Muslim Kosovo adhered to traditional norms, leading to higher fertility rates (Rašević, 1971; Breznik, 1991). Women's education and labour force participation were critical factors in fertility change. In Slovenia and Croatia, higher education led to delayed marriage and smaller family sizes, while in Bosnia-Herzegovina and Kosovo, lower educational attainment for women delayed fertility transition (Woodward, 1985; Rašević, 1971).

The socialist era brought further changes, promoting gender equality and female workforce participation, particularly in urban areas, which contributed to declining fertility. However, traditional values persisted in rural areas, slowing this transition. Institutional factors also played a role. Unlike many socialist states, Yugoslavia did not implement strong pronatalist policies and allowed for regional variation in family planning. Slovenia facilitated access to contraception and abortion, while Kosovo, influenced by its traditional values, maintained higher fertility levels. (Breznik, 1991; Drezgić, 2010). The economic instability of the 1990s further reduced fertility as large families became less viable (Calic, 2019; Kapor-Stanulović & David, 1999).

Overall, the fertility transition in former Yugoslav countries were shaped by a combination of socio-economic modernization, cultural norms, and institutional policies. While modernization spurred fertility decline in some regions, strong religious and cultural traditions delayed it in others, reflecting the complex socio-political dynamics of the region.

Data and Methods

The study analyses census data covering women born between 1868 and 1973, offering a comprehensive look at fertility trends over more than a century. Completed cohort fertility rates (CFR) and parity progression ratios (PPR) were calculated for the seven successor states of Yugoslavia. The census data used for this analysis span multiple decades, from the first post-war census in 1948 to the censuses conducted in the 2010s. The CFR measures the average number of children born to women by the end of their reproductive years, while the PPR shows proportion of women who progress from one parity to the next. These indicators provide a detailed understanding of how family size and fertility behaviour have evolved in the region.

To examine the similarities and differences between the countries, the study also analyses the parity composition of families, looking at the proportion of women with different numbers of children. The results are grouped into clusters based on similar fertility patterns. This methodological approach

allows for the identification of key trends in fertility decline and provides a basis for understanding the factors contributing to these patterns.

Results

The completed cohort fertility of women born between 1868 and 1973 in the former Yugoslav republics shows high fertility rates before the demographic transition. In the 1870 cohort, fertility ranged from 4.3 to 6.0 children per woman. Serbia, Slovenia, and Croatia experienced early fertility declines, while Bosnia-Herzegovina, North Macedonia, and Montenegro maintained higher fertility until around 1900 cohort. By the 1930 cohort, fertility in Serbia, Croatia, and Slovenia had dropped below 2 children per woman, while Bosnia-Herzegovina, North Macedonia, and Montenegro had declined to around 3.5 children per woman. Kosovo, however, retained high fertility levels at 5.7 children per woman.

The analysis reveals three distinct clusters of cohort fertility behaviour. Croatia, Slovenia, and Serbia represent a low-fertility cluster, where fertility declined rapidly during the first half of the 20th century and stabilized at around two children per woman by the 1930 cohort. This early fertility decline is attributed to factors such as industrialization, urbanization, rising female education, and changing family norms. For instance, Slovenia, the most economically advanced of the Yugoslav republics, exhibited fertility patterns similar to those seen in Western Europe, with high levels of childlessness and smaller family sizes becoming the norm by the mid-20th century.

The second cluster consists of Bosnia-Herzegovina, North Macedonia, and Montenegro, where fertility remained high until the mid-20th century but began to decline more gradually. These countries saw a slower fertility transition due to their more traditional social structures and slower socio-economic modernization. In these regions, large families remained more common, and the fertility decline was less pronounced until the 1960s and 1970s cohorts. The persistence of higher parity progression ratios to third and subsequent children in these countries illustrates the slower pace of change compared to the low-fertility cluster.

Kosovo, meanwhile, stands out as a unique case with persistently high cohort fertility throughout much of the 20th century. Fertility in Kosovo remained at around six children per woman until the 1940 cohort, only beginning to decline significantly in later cohorts. By the 1970 cohort, fertility had fallen to just under three children per woman, but this remains exceptionally high compared to other European countries. The high fertility in Kosovo is linked to its agrarian economy, patriarchal family structures, and lower levels of female education and labour force participation (Breznik, 1991). Traditional family norms and the strong influence of religion contributed to the slower adoption of birth control and smaller family sizes in Kosovo.

Conclusion

The findings of this study highlight the significant diversity in fertility patterns across the former Yugoslav countries, underscoring the importance of historical, socio-economic, and cultural contexts in shaping fertility behaviour. The clustering of countries into three distinct groups—low-fertility, high-fertility, and Kosovo as an outlier—demonstrates how varying levels of modernization, economic development, and cultural traditions have influenced cohort fertility trends over the past century. While some convergence in fertility behaviour is evident, particularly in the gradual decline of fertility in the high-fertility cluster, significant differences remain.

Slovenia, Croatia, and Serbia transitioned to below-replacement fertility levels earlier due to socio-economic modernization and changing family norms. In contrast, Bosnia-Herzegovina, North

Macedonia, and Montenegro experienced a more gradual decline, influenced by cultural factors that supported larger families for a longer period. Kosovo, with its persistently high fertility rates, represents a case where traditional family structures and slow socio-economic development delayed the fertility transition.

These results contribute to the broader understanding of fertility transition in the region and suggest that while economic and structural changes play a significant role in fertility decline, cultural and religious factors can slow or accelerate this process. The study provides a foundation for further research into the complex interplay of socio-economic and cultural factors that continue to shape fertility behaviour in the former Yugoslav countries.

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Pregled planetarnih in lokalnih demografskih projekcij
Overview of Demographic Global and Local Projections

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Abstract / Povzetek

Prispevek obravnava globalne in lokalne demografske spremembe, ki vključujejo zmanjševanje rodnosti, staranje prebivalstva in upad delovno aktivnih prebivalcev. Globalna rast prebivalstva se je skoraj ustavila, z izjemo Afrike, kjer se rodnost sicer še povečuje, a tudi tam počasi upada. Evropa, vključno s Slovenijo, se sooča s stagnacijo in celo upadom prebivalstva, kar povzroča dolgoročne socialne in gospodarske izzive. Prispevek poudarja potrebo po strateških rešitvah, kot so spodbujanje rodnosti in ustrezna migracijska politika, da bi preprečili dolgoročno demografsko krizo in ohranili stabilno rast prebivalstva.

Ključne besede

Demografske spremembe, rodnost, staranje prebivalstva, globalna rast, Slovenija

Abstract

The paper discusses global and local demographic changes, focusing on declining birth rates, population aging, and the shrinking working-age population. Global population growth has nearly halted, except in Africa, where birth rates are still rising but slowly declining as well. Europe, including Slovenia, is facing population stagnation or even decline, creating long-term social and economic challenges. The paper highlights the need for strategic solutions, such as promoting birth rates and adopting appropriate migration policies, to prevent a long-term demographic crisis and ensure stable population growth.

Keywords

Demographic changes, Birth rates, Population aging, global growth, Slovenia

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1 Uvod

Demografske spremembe predstavljajo enega ključnih izzivov današnjega časa, saj se svet sooča s prehodom iz obdobja eksponentne rasti prebivalstva v fazo stagnacije in potencialnega upadanja. Razvite države, vključno s Slovenijo, že beležijo negativne demografske trende, ki se kažejo v nizki rodnosti, staranju prebivalstva in zmanjšanju delovno aktivnega prebivalstva. Takšne spremembe vplivajo na vse družbene podsisteme, od gospodarstva do zdravstva in socialnih sistemov [1]. Po podatkih Rimskega kluba bo svetovno prebivalstvo v naslednjih desetletjih verjetno upadlo na šest milijard, kar prinaša nove izzive na globalni ravni [2].

Demografski premiki so rezultat kompleksnih dejavnikov, kot so izboljšan dostop do izobraževanja, večja udeležba žensk na trgu dela, urbanizacija in dostopnost kontracepcije. Wolfgang Lutz [3] v svoji študiji navaja, da so ti dejavniki bistveno prispevali k padcu rodnosti, predvsem v državah z visokim življenjskim standardom. Ob tem pa ne moremo zanemariti tudi vplivov, kot so spremembe v družinskih vrednotah in zakasnitev rojstev. Phillip Longman [4] poudarja, da imajo te spremembe dolgoročne posledice na gospodarski razvoj, saj manjše število mladih vpliva na inovativnost in produktivnost, hkrati pa povečuje pritisk na socialne sisteme.

Vse bolj aktualna postaja tudi razprava o okoljskih posledicah zmanjševanja prebivalstva. Medtem ko manjše število ljudi potencialno zmanjšuje pritisk na naravne vire, pa upad prebivalstva prinaša tudi tveganje urbanega propadanja in zanemarjanja infrastrukture, kar izpostavlja Alan Weisman [5] v svoji knjigi *The World Without Us*. Prav tako se države soočajo z izzivom, kako oblikovati ustrezne politike za naslavljanje teh sprememb. Nekatere države se zatekajo k spodbujanju rojstev, druge pa k priseljevanju, kar pa odpira etična in politična vprašanja, povezana z integracijo priseljencev in ohranjanjem kulturne identitete [6]. Mediji in množice še vedno živijo v prepričanju, da prihaja eksponentna rast prebivalstva, ampak ta se je že iztekla, nastavki za upad in izumiranja posameznih narodov pa so že nastavljena [7].

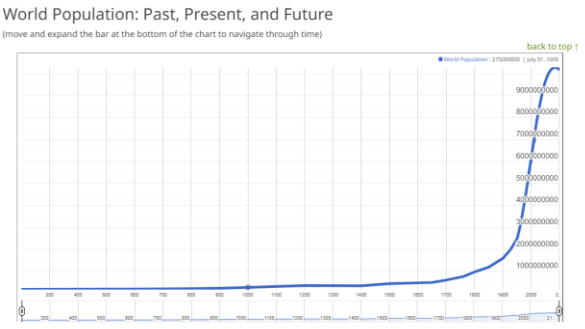
Zato je nujno, da se na demografske spremembe odzovemo celostno, s strateškimi politikami, ki upoštevajo tako gospodarske, socialne kot okoljske vidike. Učinkovite rešitve morajo temeljiti na poglobljenem razumevanju vzrokov in posledic teh sprememb ter na sprejemanju inovativnih pristopov za dolgoročno trajnostno upravljanje prebivalstva.

V prispevku prikažemo projekcije in tabele, ki potrjujejo uvodne misli: svet bo iz eksponentne rasi prešel v (skoraj)

ekonomski upad, ki bo morda ogrozil tudi rast človeške civilizacije. Pregled demografskih projekcij je narejen pretežno iz dveh virov: Eurostat, Worldometer, delno Wikipedije.

Pregled po svetu je predstavljen v sekciji 2, nato je v sekciji 3 predstavljen pregled po Sloveniji in na koncu sledi diskusija v zadnji sekciji.

2 Svet



Slika 1: Število prebivalcev na zemlji od začetka štetja do danes. Vir: World population, Worldometer

Svetovno prebivalstvo je po precej stabilnem stanju, ki je trajalo več kot tisočletje, okoli leta 1500 prešlo v obdobje eksponentne rasti. Ta nenaden porast prebivalstva je bil posledica izboljšane prehrane, napredka v medicini in industrijski revoluciji, ki so omogočili zmanjšanje umrljivosti in povečanje rodnosti. Kljub temu pa se ta eksponentna rast v sodobnem času počasi ustavlja. Po zadnjih podatkih je bilo 17. septembra 2024 na svetu 8,177,068,100 prebivalcev (Slika 1 in Tabela 1). Napovedi za prihodnost nakazujejo, da bo svetovno prebivalstvo doseglo vrhunec okoli sredine tega stoletja, nato pa bo začelo upadati, predvsem zaradi zmanjšane rodnosti in staranja prebivalstva.

Tabela 1: Rast števila prebivalcev od 1955 dalje. Vir: Worldometer.

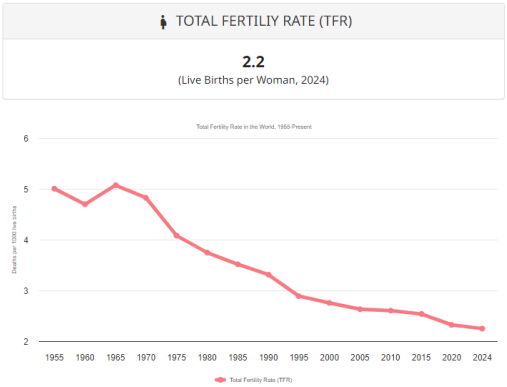
World Population (2024 and historical)

View the complete population historical table

Year (July 1)	Population	Yearly % Change	Yearly Change	Median Age	Fertility Rate	Density (P/Km²)
2024	8,161,972,572	0.87 %	70,237,642	30.6	2.25	55
2023	8,091,734,930	0.88 %	70,327,738	30.4	2.25	54
2022	8,021,407,192	0.84 %	66,958,801	30.1	2.27	54
2021	7,954,448,391	0.86 %	67,447,099	29.8	2.29	53
2020	7,887,001,292	0.97 %	75,707,594	29.6	2.32	53
2015	7,470,491,872	1.25 %	89,751,945	28	2.54	50
2010	7,021,732,148	1.29 %	86,952,403	27	2.60	47
2005	6,586,970,132	1.31 %	83,053,428	26	2.63	44
2000	6,171,702,993	1.39 %	82,564,802	25	2.75	41
1995	5,758,878,982	1.57 %	86,215,174	24	2.89	39
1990	5,327,803,110	1.82 %	91,771,929	23	3.31	36
1985	4,868,943,465	1.83 %	84,267,446	22	3.52	33
1980	4,447,606,236	1.79 %	75,374,192	21	3.74	30
1975	4,070,735,277	1.96 %	75,210,297	21	4.08	27
1970	3,694,683,794	2.07 %	72,030,018	20	4.83	25
1965	3,334,533,703	2.03 %	63,812,562	21	5.07	22
1960	3,015,470,894	1.93 %	55,051,420	21	4.70	20
1955	2,740,213,792	1.91 %	49,424,189	22	5.00	18

Source: Worldometer (www.Worldometers.info)

Različne študije poudarjajo, da smo priča prelomnemu trenutku v demografskih spremembah. Na primer, po podatkih, ki jih navaja Darrell Bricker in John Ibbitson v svoji knjigi Empty Planet: The Shock of Global Population Decline (2019) [7], bo svetovno prebivalstvo v prihodnjih desetletjih začelo upadati, kar bo prineslo pomembne gospodarske, družbene in okoljske spremembe. Avtorja poudarjata, da se bo zaradi tega svet soočal z izzivi, kot so zmanjšanje delovne sile, upad inovacij in naraščajoč pritisk na socialne sisteme. Po drugi strani pa bo ta upad prinesel tudi olajšanje glede pritiskov na naravne vire in okolje. A po mnenju Elona Muska, skladno z mnenjem Matjaža Gamsa [8] bo ta upad lahko pomenil zaton človeške tehnološke civilizacije.



Slika 2: Rodnost kot število otrok na žensko od leta 1955 do danes. Vir: Worldometer.

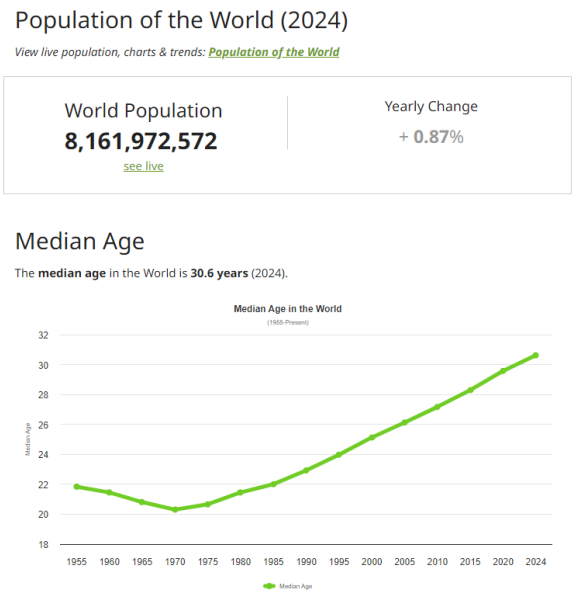
Rodnost je bila leta 1950 približno 5 otrok na žensko, kar pomeni, da je povprečna ženska v tem obdobju rodila pet otrok. To obdobje visoke rodnosti je bilo značilno za države po vsem svetu, zlasti v manj razvitih regijah, kjer so bili otroci pomemben vir delovne sile in opora za starejše generacije. Vendar pa se je sredi 20. stoletja začela globalna preobrazba, ki je postopoma privedla do zmanjšanja rodnosti.

Od leta 1950 dalje je rodnost začela upadati, saj so države v različnih fazah razvoja uvedle politike, ki so spodbujale uporabo kontracepcije, povečale dostop do izobraževanja (zlasti za ženske) in podprle večjo udeležbo žensk na trgu dela. Do danes se je globalna rodnost znižala na približno 2.2 otroka na žensko, kar je le nekoliko nad trajno rodnostjo 2.1, ki je potrebna za ohranjanje stabilnega prebivalstva (Slika 2).

Zmanjševanje rodnosti je kompleksen pojav, ki vključuje tako gospodarske, družbene kot kulturne dejavnike. Wolfgang Lutz [3] v svoji študiji The End of World Population Growth navaja, da so višje stopnje izobrazbe, predvsem pri ženskah, močno vplivale na zmanjšanje rodnosti, saj so izobražene ženske bolj nagnjene k odlaganju rojstev in imajo na splošno manj otrok. Poleg tega je dostop do kontracepcije in izboljšana zdravstvena oskrba omogočila boljšo reproduktivno izbiro, kar je še dodatno zmanjšalo rodnost.

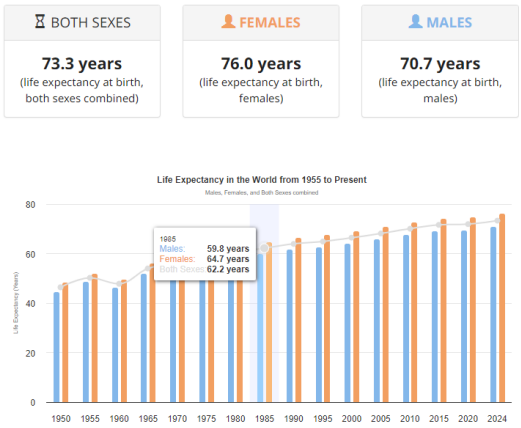
Tudi Phillip Longman [4] v svoji knjigi The Empty Cradle opozarja na gospodarske posledice nizke rodnosti, saj zmanjšano število otrok v razvitem svetu pomeni manj delovne sile v prihodnosti in večje breme za socialne sisteme, ki se soočajo s staranjem prebivalstva. Po drugi strani pa Alan Weisman [5] v knjigi The World Without Us izpostavlja okoljske prednosti nižje rodnosti, saj zmanjšano prebivalstvo pomeni manjši pritisk na naravne vire in manjše emisije ogljikovega dioksida.

Hkrati z zmanjševanjem rodnosti se je povečevala povprečna življenjska doba na našem planetu, z 20-tih let leta 1970 je zrasla na 30 let leta 2024 (Slika 3), to je za 50%. Tudi pričakovana življenjska doba je rasla od leta 1959 do leta 2024, ko znaša v povprečju 73.3 leta, za moške 70.7 let in za ženske 76.0 (Slika 4). Razlika v dolgosti življenja med moškimi in ženskami je opazna od začetka merjenja do danes, ko znaša 7%.



Slika 3: Povprečna starost, vir Worldometer, od leta 1970 (20 let) stalno narašča in je v letu 2024 30 let.

Pričakovana življenjska doba se je iz leta 1950 (46 let) do leta 2024 dvignila na 73 let. To podaljševanje življenjske dobe in zamik (ljudje živijo cca 40 let po obdobju rojstev) povzroča vtis, da se demografski padec še ni začel, medtem ko se v praksi že je. Nova študija Rimskega kluba [2] je napovedala, da bo svetovno prebivalstvo v najbolj verjetnem scenariju verjetno upadlo v naslednjem stoletju na 6 milijard.



Slika 4: Rast življenjske dobe. Vir: Worldometer.

Število prebivalcev Zemlje naj bi se v prihodnjih desetletjih še naprej povečevalo, pri čemer naj bi doseglo vrhunec med letoma 2050 in 2060, kot je prikazano v Tabeli 2. Projekcije kažejo, da bo globalna populacija do takrat dosegla približno deset milijard ljudi, kar predstavlja znatno rast glede na trenutno stanje. Tabela 2 ponazarja ta trend rasti in vključuje ključne podatke, ki kažejo na upočasnjevanje rasti v kasnejših letih, predvsem zaradi nižje rodnosti in staranja prebivalstva. Kljub temu ostaja vprašanje, kako se bodo družbeni, gospodarski in okoljski sistemi prilagodili na tako obsežno število prebivalcev.

Tabela 2: Predvidena rast prebivalcev po svetu.

World Population Forecast (2025-2050)

View population projections for all years (up to 2100)

Year (July 1)	Population	Yearly % Change	Yearly Change	Median Age	Fertility Rate	Density (P/Km²)
2025	8,231,613,070	0.86 %	68,922,356	31	2.24	55
2030	8,569,124,911	0.81 %	67,502,368	32	2.20	58
2035	8,885,210,181	0.73 %	63,217,054	33	2.15	60
2040	9,177,190,203	0.65 %	58,396,004	34	2.13	62
2045	9,439,639,668	0.57 %	52,489,893	35	2.12	63
2050	9,664,378,587	0.47 %	44,947,784	36	2.10	65

Source: Worldometer (www.Worldometers.info)

Elaboration of data by United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2024 Revision. (Medium-fertility variant).

Po celinah so prebivalci razporejeni glede na Tabelo 3 in po državah glede na Tabelo 4.

Tabela 3: Prebivalstvo in drugi osnovni podatki po celinah.

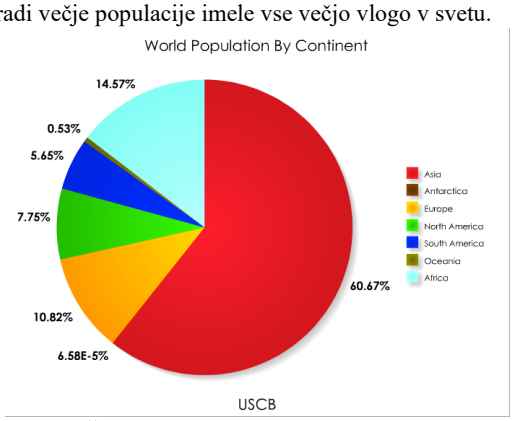
World Population by Region

back to top ↑

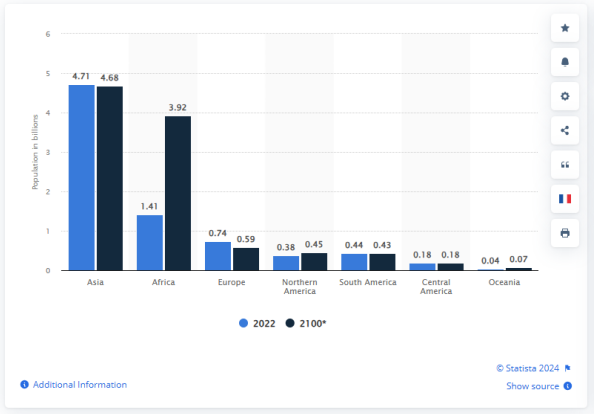
#	Region	Population (2024)	Yearly Change	Net Change	Density (P/Km²)	Land Area (Km²)	Migrants (net)	Fert. Rate	Med. Age	Urban Pop %	World Share
1	Asia	4,806,898,007	0.6 %	28,893,521	155	31,033,131	-2,335,416	1.9	32	52.9 %	58.9 %
2	Africa	1,515,140,849	2.32 %	34,370,324	51	29,648,481	-644,272	4	19	44.5 %	18.6 %
3	Europe	745,083,824	-0.07 %	-519,051	34	22,134,900	1,566,027	1.4	43	75.6 %	9.1 %
4	Latin America and the Caribbean	663,466,072	0.69 %	4,574,555	33	20,139,378	-382,944	1.8	31	85.2 %	8.1 %
5	Northern America	385,295,105	0.62 %	2,392,363	21	18,651,660	1,654,440	1.6	39	82.2 %	4.7 %
6	Oceania	46,088,716	1.15 %	525,929	5	8,486,460	142,167	2.1	33	66.1 %	0.6 %

Tabela 3 prikazuje razporeditev prebivalcev po posameznih celinah, Slika 5 pa grafično pokaže ta razmerja. Slika 6 kaže rast prebivalstva po celinah, pri čemer jasno izstopa rast prebivalstva v Afriki, medtem ko se v Evropi in Severni Ameriki pričakuje stagnacija oziroma upad. Ti podatki kažejo na pomembne regionalne razlike, ki bodo vplivale na globalno demografsko sliko v prihodnjih desetletjih, pri čemer bo rast v nekaterih delih sveta močno presegla rast v drugih.

Te demografske spremembe bodo imele daljnosežne posledice za mednarodno politiko, gospodarstvo in trajnostni razvoj, saj bodo države z največjo rastjo morale obvladovati vse večje pritiske na svoje vire in infrastrukturo, hkrati pa bodo zaradi večje populacije imele vse večjo vlogo v svetu.

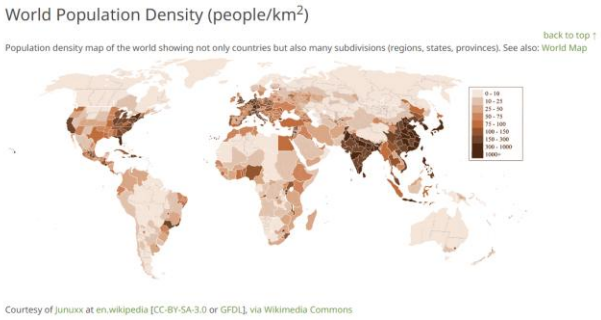


Slika 5: Število prebivalcev po celinah.



Slika 6: Napovedi razmerij med celinami.

Slika 7 prikazuje gostoto prebivalstva po celinah, pri čemer Kitajska in Indija močno izstopata kot najbolj gosto poseljeni regiji na svetu. Prav tako so opazne višje stopnje poseljenosti v nekaterih delih Združenih držav Amerike in Evropske unije, kjer koncentracija prebivalstva vpliva na infrastrukturne in gospodarske izzive.



Slika 7: Gostota prebivalstva po celinah.

Tabela 4: Največje države sveta.

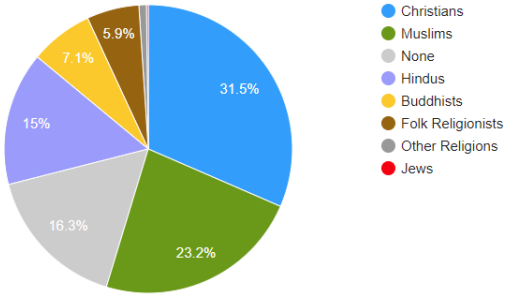
World Population by Country

Show 10 entries Search:

#	Country (or dependency)	Population (2024)	Yearly Change	Net Change	Density (P/Km²)	Land Area (Km²)	Migrants (net)	Fert. Rate	Med. Age	Urban Pop %	World Share
1	India	1,450,935,791	0.89 %	12,866,195	488	2,973,190	-630,830	1.962	28	36.6 %	17.8 %
2	China	1,419,321,278	-0.23 %	-3,263,655	151	9,388,211	-318,992	1.013	40	66.4 %	17.4 %
3	United States	345,426,571	0.57 %	1,949,236	38	9,147,420	1,286,132	1.622	38	82.4 %	4.2 %
4	Indonesia	283,487,931	0.82 %	2,297,864	156	1,811,570	-38,469	2.115	30	59 %	3.5 %
5	Pakistan	251,269,164	1.52 %	3,764,669	326	770,880	-1,401,173	3.547	20	34.1 %	3.1 %
6	Nigeria	232,679,478	2.1 %	4,796,533	255	910,770	-35,202	4.382	18	53.9 %	2.9 %
7	Brazil	211,998,573	0.41 %	857,844	25	8,358,140	-225,510	1.614	34	91 %	2.6 %
8	Bangladesh	173,562,364	1.22 %	2,095,374	1,333	130,170	-473,362	2.138	26	42 %	2.1 %
9	Russia	144,820,423	-0.43 %	-620,077	9	16,376,870	-178,042	1.457	40	74.6 %	1.8 %
10	Ethiopia	132,059,767	2.62 %	3,368,075	132	1,000,000	30,069	3.909	19	22.1 %	1.6 %

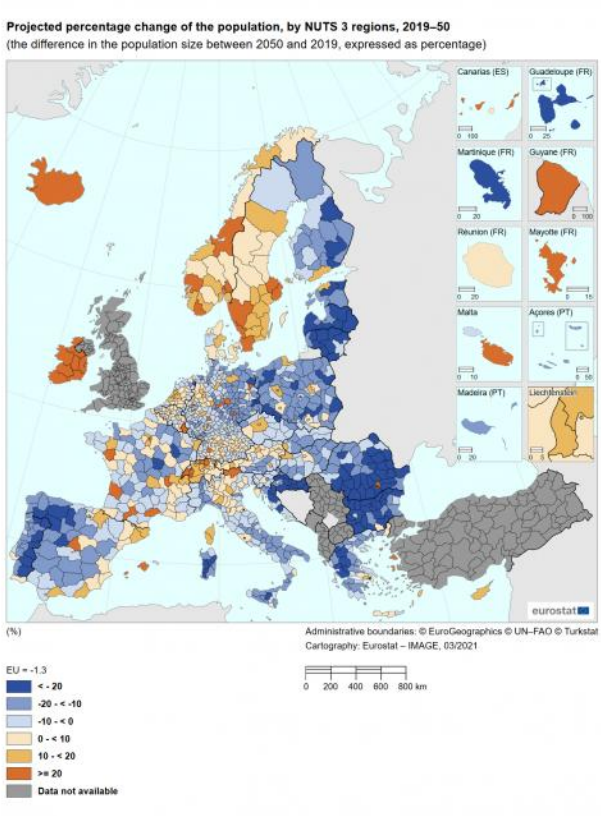
V Tabeli 4 so prikazane največje države sveta glede prebivalstva, pa tudi drugi osnovni podatki kot površina. Indija je prehitela Kitajsko, skupaj pa imata 3 milijarde prebivalcev od 8 na svetu. Na tretjem mestu bi morala biti EU, a je v vseh statistikah prikazana kot posamezne države. Zato so tretje ZDA, sledi Indonezija, Pakistan, Nigerija itd.

Morda je zanimiv prikaz števila vernikov po posameznih državah, kot je to razvidno iz Slike 8.



Slika 8: Razmerja med verniki različnih verstev.

3 Evropa in Slovenija



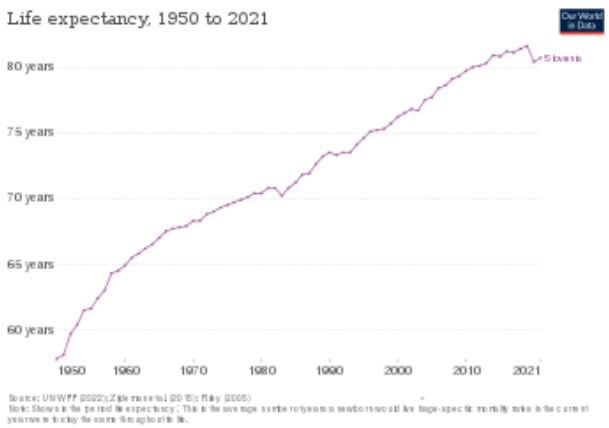
The EU population is projected to decrease by 1.3 % between 2019 and 2050
Source: Eurostat (proj_19np) and (proj_19rp3)

Slika 9: Projekcije Evrope do leta 2050.

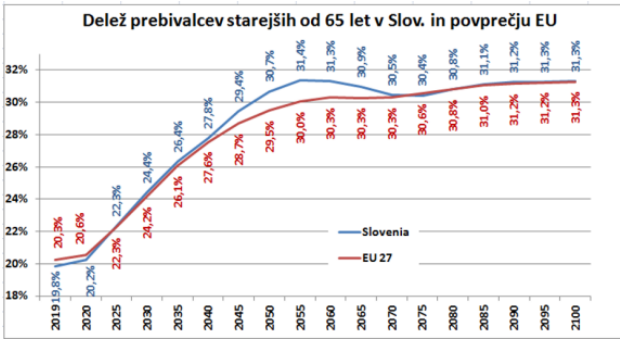
Slika 9 predstavlja rezultate najnovejših demografskih projekcij regionalnih vzorcev prebivalstva v 31 državah (27 držav članic Evropske unije (EU) in štirih članic Evropskega združenja za prosto trgovino (EFTA). Ponuja strnjen pregled rezultatov za regije na ravni NUTS 3, uporabljenih pri zadnjih evropskih demografskih projekcijah, temelječih na podatkih EUROPOP2019.

Te regionalne projekcije prebivalstva zajemajo časovno obdobje do konca stoletja, pri čemer se rezultati, predstavljeni tukaj, nanašajo na leto 2050. Projekcije temeljijo na podatkih o prebivalstvu in življenjskih dogodkih do leta 2018, uporabljena pa je bila klasifikacija NUTS-2016, ki deli ozemlja teh 31 držav na 1.216 geografskih enot na ravni NUTS 3. Za enostavnejšo razlago "EU+" v tem primeru zajema vseh 31 držav, vključno s štirimi članicami EFTA (Islandija, Lihtenštajn, Norveška in Švica). Za predstavitev podatkov EUROPOP2019 na nacionalni ravni se sklicuje na članek o demografskih projekcijah v EU.

Slovenske podatke začenjamo z rastjo pričakovane življenjske dobe na Sliki 10, ki je skozi desetletja postopoma naraščala zaradi izboljšane zdravstvene oskrbe, življenjskih pogojev in dostopa do izobraževanja. Na desnem robu slike je jasno razviden upad v pričakovani življenjski dobi, ki ga je povzročila pandemija COVID-19, kar je posledica povečane umrljivosti, predvsem pri starejših prebivalcih in rizičnih skupinah. Ta upad je pokazatelj, kako lahko nepričakovani zdravstveni krizni dogodki začasno prekinijo pozitivne trende v izboljševanju življenjske dobe, vendar se pričakuje, da bo z obvladovanjem pandemije pričakovana življenjska doba ponovno naraščala.

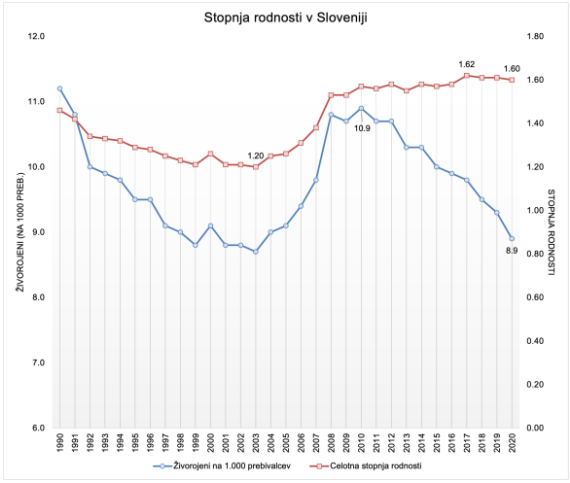


Slika 10: Rast pričakovane življenjske dobe prebivalcev Slovenije – razviden je učinek kovida na desnem robu.



Slika 11: Delež starejših kot 65 let.

Daljša življenjska doba v kombinaciji z nizko rodnostjo, kot je to značilno za Slovenijo (Sliki 11 in 12), pomeni, da se delež starejših prebivalcev, predvsem tistih nad 65 let, vztrajno povečuje, kar postaja vse bolj izrazit trend v mnogih razvitih državah. Posledično se zmanjšuje delež delovno aktivnega prebivalstva, kar ustvarja pritisk na pokojninske in zdravstvene sisteme, ki morajo zagotavljati skrb za starajoče se prebivalstvo. Ta demografski premik vodi tudi do sprememb v družbenih strukturah, saj postajajo starejši vse bolj odvisni od mlajših generacij in javnih storitev, kar bo dolgoročno zahtevalo prilagoditve v politikah in socialnih sistemih.



Slika 12: Stopnja rodnosti in število novorojenih v Sloveniji.

Slika 12 prikazuje stopnjo rodnosti, ki je že vrsto let precej pod mejo 2,1 otroka na žensko, kar je minimalna stopnja za ohranjanje stabilnega prebivalstva. Nizka stopnja rodnosti pomeni, da prebivalstvo ni sposobno nadomestiti izgubljenih generacij, kar vodi v dolgotrajen demografski upad. Če se ta trend nadaljuje, bi lahko določene populacije kot slovenska v nekaj stoletjih postopoma izumrle, saj brez zadostne rodnosti ni mogoče zagotoviti zadostne reprodukcije in nadaljnje rasti prebivalstva. Takšni scenariji postavljajo družbe pred številne izzive, saj bodo morale sprejeti ukrepe za spodbujanje rodnosti, da bi preprečile dolgoročno demografsko krizo in posledično genetsko izumrtje.

4 Diskusija

V prispevku so predstavljene ključne demografske razmere in prihodnje projekcije. Svetovna rast prebivalstva se je skoraj povsem ustavila, pri čemer afriške države še vedno beležijo rast, vendar tudi tam stopnja rodnosti počasi upada. V Evropi in nekaterih drugih delih sveta pa že prihaja do stagnacije ali celo upadanja prebivalstva. Slovenija se sooča s podobnim izzivom, saj nizka rodnost in majhnost države nakazujeta dolgoročno demografsko krizo, ki bi lahko vodila v znatno zmanjšanje prebivalstva. Kljub tem opozorilom javnost pogosto napačno razume situacijo, pri čemer prevladuje napačno prepričanje, da je na svetu preveč ljudi. V resnici se pričakuje, da bo čez nekaj sto let svetovna populacija bistveno nižja kot danes, medtem ko bi lahko Slovenci povsem izginili, če ne pride do temeljite spremembe v politikah in odnosu do demografskih vprašanj. Vizionarji, ki že desetletja opozarjajo na te trende in se zavzemajo za trajnostne demografske rešitve, bi morali biti cenjeni in priznani, namesto da so pogosto tarča kritik.

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Pokritost strokovne in znanstvene produkcije v Sloveniji v področju epidemiologije depresije kot dela demografije zdravja v COBISS.SI

Coverage of professional and scientific production in Slovenia in the field of epidemiology of depression as part of health demography in COBISS.SI

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Povzetek

Informacijsko znanost in informacijsko tehnologijo uporabljajo vse druge znanosti kot uporabno epistemologijo. Podana je spodbuda k premisleku o izdelavi sheme védenja demografije, ki naj bi zajemala demografijo zdravja in epidemiologijo na koherenten način, saj se v sedanji znanstveni praksi povezuje demografija različno s drugimi znanstvenimi področji. Enkrat predstavlja z ekonomsko teorijo posebno podklaso v klasi družbenih ved, drugič je del statistike itp. Odgovornost za izdelavo sheme védenja demografije lahko avtoritativno prevzamejo le znanstveniki in strokovnjaki s področja demografije. MIRA nacionalni program duševnega zdravja je prvi tovrstni strateški dokument, ki povezuje službe duševnega zdravja vseh odgovornih sektorjev zdravstva, socialnega varstva, vzgoje in šolstva za obdobje 2018-2028 v Republiki Sloveniji. Ciljana pokritost je preverjana z iskanjem v COBISS.SI.

Ključne besede

shema védenja demografije, demografija zdravja, epidemiologija depresije, MIRA, COBISS.SI, SGC

Abstract

Information science and the information technology with which it is fused are used by all other sciences as an applied epistemology. An incentive is given to consider the creation of a knowledge map of demography, which should cover health demography and epidemiology in a coherent way, since in current scientific practice, demography is connected differently with other scientific fields. One time it represents a special subclass in the class of social sciences with economic theory, the other time it is part of statistics, etc.. Only scientists and experts in the field of demography can authoritatively assume the responsibility for creating a knowledge map of demography.The MIRA national mental health program is the first strategic document of its kind that connects the mental health services of all responsible sectors of health, social care and education for the period 2018-2028 in the Republic of Slovenia. Targeted coverage is checked by searching COBISS.SI.

Keywords

knowledge map of demography, healh demography, epidemiology of depression, MIRA, COBISS.SI, SGC

1 Uvodna opomba

Lani sva s kolegom Šobotom predstavila rezultate komparativne bibliografske raziskave o odzivu sistema COBISS.SI in COBISS.SR znotraj mreže COBISS.net na zahteve uporabnikov po informacijah o znanstveni produkciji v področju demografije in sociologije prebivalstva v Republiki Sloveniji in Republiki Srbiji. [1]

Na vabilo k sodelovanju s prispevkom na letošnji konferenci Demografske in družinske analize - IS2024 sva se odločila s kolegico Muhvič pripraviti prispevek o bibliografski pokritosti strokovne in znanstvene produkcije v Sloveniji v področju socialnih, bioloških in genetskih razsežnosti epidemiologije psihiatričnih motenj kot dela demografije zdravja (Health demography).

2 Shema védenja demografije – spodbuda k premisleku

»Na začetku je bila informacija, beseda je prišla kasneje.« [2]

Informacijsko znanost in informacijsko tehnologijo uporabljajo vse druge znanosti kot uporabno epistemologijo. Sprememba paradigme je bila prepoznana v začetku leta 2000. Nova paradigma pomeni premik od uporabe tehnologij, računalništva

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Information Society 2024, 7–11 October 2024, Ljubljana, Slovenia
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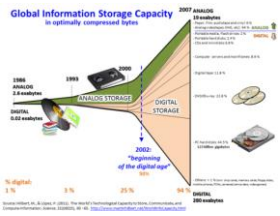
http://doi.org/10.70314/is.2024.dem.11

in inženirstva kot podpore raziskovalnem delu in znanju k integraciji tehnologij, računalništva in inženirstva v strukturo vseh drugih znanosti. Niti nekoč sila uspešen slogan »podpora znanju« več ne izraža bistva nove paradigme o integraciji!
Bilo je ugotovljeno, da se je l. 2002 začela »digitalna doba«. [3]



Slika 1: Leto 2002 - začetek digitalne dobe [3]

Oblikovati »knowledge map« ali shemo védenja pomeni določiti meje znanstvenega področja, opredeliti njegove glavne dele po predmetu in odnose med njimi.
Shema védenja demografije (demography knowledge map) ni dorečena na način, ki ga je pred dvadesetimi leti kot »standard« postavil Zins na primeru sheme védenja informacijske znanosti. [4][5]
Običajna definicija demografije ne vključuje ravno demografije zdravja (Health demography).
Po nekem pristopu sta demografija in epidemiologija deli statistike. Statistika (običajni pomen popis številčnega stanja; izvirno iz nemščine Statistica Staatslehre, Staatswissenschaft državoslovje, državna teorija, politična znanost, status nlat tudi Staat, Status, država) se ukvarja z zbiranjem, organizacijo, analizo, interpretacijo in predstavitvijo podatkov o gospodarskih, socialnih ipd. procesih.
Z uporabo statistike so se razvile številne specialnosti v različnih področjih.
Demografija je preučevanje (study) vseh vrst populacij in je zelo splošna znanost, ki jo je mogoče uporabiti za katerokoli dinamično populacijo, torej tisto, ki se spreminja skozi čas ali prostor.
Epidemiologija je preučevanje dejavnikov, ki vplivajo na zdravje in bolezen prebivalstva, ter služi kot temelj posegov v interesu javnega zdravja in preventivne medicine.
Znane knjižnične klasifikacije niso sheme védenja neke znanosti.
Najzgodnejša znana knjižnična klasifikacijska shema je bila klasifikacija knjig Pinakesa Kalimahe, učenjaka v Aleksandrijski knjižnici v tretjem stoletju pred našim štetjem.
Knjižnični klasifikacijski sistemi se razlikujejo glede na označevanje, zgodovino, uporabo številčenja, hierarhijo in fasete.
Razdelitve človeškega znanja po posameznih znanstvenih področjih je mogoče najti v univerzalnih shemah, kot so Klasifikacija Kongresne knjižnice (LCC), Deweyjeva decimalna klasifikacija (DDC), Univerzalna decimalna klasifikacija (UDC) in Klasifikacija Colon (CC), sheme za določeno področje (npr. klasifikacija za medicino NLM), za posamezno državo (npr. SAB, švedski knjižnični klasifikacijski sistem), klasifikacijske sheme v bibliografskih virih, informacijskih servisih in zbirkah podatkov.
Obstajajo

- naštevalne (predmetne značnice (subject heading) so navedene po abecedi, s številkami, ki so dodeljene vsaki značnici po abecednem vrstnem redu),
- hierarhične (po stopnjah, predmeti so razdeljeni hierarhično, od najbolj splošnih do najbolj specifičnih) in
- fasetno/analitično-sintetične (predmeti so razdeljeni na medsebojno izključujoče pravokotne fasete) klasifikacije.

Naloga klasifikacije in kategorizacije dokumentov se sestoji iz dodeljevanja dokumentov enemu ali več razredom ali kategorijam. To je mogoče narediti "ročno" (ali "intelektualno") in algoritemsko. Intelektualna klasifikacija dokumentov je večinoma področje bibliotekarstva, algoritemska klasifikacija dokumentov pa predvsem informacijske znanosti in računalništva.
Obstajata dve glavni filozofiji predmetne klasifikacije dokumentov:

- pristop, ki temelji na vsebini (content-based), in
- pristop, ki temelji na zahtevi (request-based).

Vsebinska klasifikacija je klasifikacija, pri kateri teža, dodeljena posameznim temam v dokumentu, določa razred, v katerega je dokument uvrščen.
Na zahtevo usmerjeno razvrščanje (ali indeksiranje) je razvrščanje, pri katerem pričakovana zahteva uporabnikov vpliva na to, kako so dokumenti razvrščeni. Klasifikator se sprašuje: "Pod katerimi deskriptorji naj se nahaja ta entiteta?" in »Pomislite na vse možne poizvedbe in se odločite, za katere je zadevna entiteta ustrezna«. [6]
Razlikujemo dodeljevanje dokumentov v razrede ("klasifikacija") in dodeljevanje predmetov dokumentom ("predmetno indeksiranje"), vendar to razlikovanje ni plodno. »Te terminološke razlike so povsem nesmiselne in povzročajo samo zmedo«. [7]
Obstajajo številne tehnike samodejnega (avtomatskega) razvrščanja dokumentov.
Narodna in univerzitetna knjižnica (NUK) je leta 1994 izdala navodila za oblikovanje predmetnih oznak Vsebinska obdelava v vzajemnem katalogu. Leta 2000 se je v IZUM-u začel razvoj Splošnega geslovnika COBISS.SI (SGC), ki sega na vsa področja človeškega znanja in je namenjen predmetnemu označevanju v sistemu COBISS.SI. [8] Na iskalno besedo »demografija« dobimo 29 predmetnih točk dostopa.

Zinsova študija »Knowledge Map of Information Science« je bila namenjena raziskovanju temeljev informacijske znanosti, izvedena pa je bila z metodo Delphi in analizo področja (domain analysis, DA) v letih 2003–2005.
Metodo Delphi je Zins uporabil za zbiranje podatkov in za kritično in strukturirano debato (s pomočjo treh vprašalnikov) med ekspertom.
Izraz »Delfi« izvira iz starogrške mitologije. Stari Grki so verjeli, da so območje glavne prerokinje Pitije v preročišču Delfi in so tam bile narejene prerokbe, ki so narekovale in usmerjale vitalne državne zadeve. [9]
Metodo analize področja je Zins uporabil za izdelavo sheme védenja informacijske znanosti.
Domena je družbeno in teoretično definirano znanje skupine znanstvenikov istega ontološkega in epistemološkega interesa. [10]
Domene so v bistvu sestavljene iz treh vrst teorij in konceptov:

- ontoloških teorij in konceptov o predmetih človeške dejavnosti;
- epistemoloških teorij in konceptov znanja in načinov pridobivanja znanja, ki implicirajo metodološka načela o načinih raziskovanja predmetov; in
- sociooloških konceptov o skupinah ljudi, ki se ukvarjajo z istimi predmeti.

Kot formalne predstavitve množice konceptov z nekega področja in razmerij med njimi imajo ontologije nepogrešljivo vlogo pri razvoju informacijskih sistemov s semantično komponento. [11] [12][13][14]

Različne znanosti, ki proučujejo iste predmete in probleme iz svoje perspektive, se udeležujejo vzajemenega delovanja.
Obstajata "mala" in "velika" interdisciplinarnost.
"Mala" interdisciplinarnost je povezovanje specialnosti znotraj neke širše discipline, med katerimi je "oddaljenost" majhna.
"Velika" interdisciplinarnost je povezovanje različnih znanstvenih disciplin, med katerimi je "oddaljenost" velika. [15]
Rinia je meril in vrednotil interdisciplinarno naravo raziskav in prenos znanja med disciplinami z uporabo kvantitativnih analiz citiranja. Citiranje je način, na kateri znanost funkcionira kot industrija znanja. Neki znanstveni članek najboljše »indeksirajo« citati virov. Rezultati analize citiranja kažejo na velik pretok znanja med disciplinami. Citatna analiza razkriva veliko dinamičnost sodobne znanosti, medtem ko so se knjižnične klasifikacijske sheme (LCC, DDC, UDC in dr.) za organizacijo shranjevanja knjižničnega gradiva v prostoru pokazale za dokaj statične.

Slika 2: Primer police podrazreda

3 Program MIRA – Nacionalni program duševnega zdravja v Republiki Sloveniji

Socialna in psihiatrična epidemiologija je področje, ki preučuje porazdelitev in dejavnike duševnega zdravja znotraj populacij. Raziskuje, kako družbeni dejavniki, kot so socialno-ekonomski status, mreže skupnosti in življenjski dogodki, vplivajo na incidenco in razširjenost psihiatričnih motenj. Ta veja epidemiologije pogosto vključuje interdisciplinarne raziskave, ki združujejo vpoglede iz socialne psihologije, sociologije, antropologije in javnega zdravja, da bi razumeli kompleksne interakcije med družbenimi okolji in rezultati duševnega zdravja. Duševne motnje spadajo med deset poglavitnih vzrokov oviranosti v svetu s hudimi družbenimi in gospodarskimi posledicami za posameznike, družine in skupnosti. Slabo duševno zdravje tako pomeni izgubo najmanj 3 do 4 % bruto domačega proizvoda, po nekaterih ocenah pa še več. Svetovna zdravstvena organizacija kot Evropska unija in Slovenija namenjajo promociji in varovanju duševnega zdravja vedno več pozornosti in sredstev.

Učinki razrednih odnosov na depresijo in anksioznost presegajo učinke SES (socioeconomic stratification), kar kaže na premalo raziskane mehanizme v socialni epidemiologiji, npr. dominacijo in izkoriščanje. [16][17]
Po podatkih Eurostata za leto 2019 je 7,2 % prebivalcev držav članic Evropske unije poročalo o kronični depresiji. To je skoraj pol odstotne točke več kot pet let pred tem. Slovenija je v samem vrhu lestvice. Pri nas je takšnih namreč kar 15,1 odstotka prebivalcev, kar je skoraj tri odstotne točke več kot na Portugalskem, ki zaseda drugo mesto in skoraj osem odstotnih točk več od evropskega povprečja. Na tretjem mestu depresivcev so Švedi z 11,7 odstotka takšnih, ki so poročali o kronični depresiji. Slovenija se uvršča med države z najvišjim odstotkom depresivnih moških (14,3 %).
Najpomembnejši strateški dokumenti Evropske unije za duševno zdravje so Evropski pakt za duševno zdravje in dobro počutje in Sklepi Sveta o Evropskem paktu za duševno zdravje in dobro počutje.
Državni zbor RS je sprejel leta 2018 Nacionalni program duševnega zdravja 2018–2028 MIRA.
Program MIRA je Nacionalni program duševnega zdravja, ki kot prvi tovrstni strateški dokument v Republiki Sloveniji celovito naslavlja in ureja področje duševnega zdravja. Program povezuje obstoječe ter dodaja nove službe in strukture ter tako odgovarja na potrebe ljudi na področju duševnega zdravja. Glavni poudarki programa so krepitev duševnega zdravja ter preprečevanje in celostna obravnava duševnih motenj. S tem namenom povezuje službe vseh odgovornih sektorjev, torej zdravstva, socialnega varstva, vzgoje in šolstva.
Cilj programa je vzpostaviti dobro podporno okolje na vseh področjih varovanja duševnega zdravja. Službe in storitve poskuša približati uporabnikom in jih spodbuditi k zgodnjemu iskanju pomoči ter na tak način zmanjšati institucionalizacijo na področju duševnega zdravja. [18]

4 Rezultati iskanj v področju demografije zdravja in epidemiologije depresije

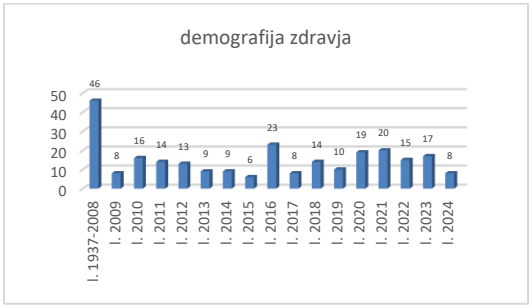
Pokritost smo preverjali z iskanjem v COBISS.SI.

Iskalni niz	Št.zadetkov
Demografija zdravja Slovenija	255
Duševno stanje demografija Slovenija	90
Depresija demografija Slovenija	53
Duševno zdravje MIRA Slovenija	130
Demografija MIRA	46
MIRA demografija Slovenija	31
Epidemiologija depresije	289

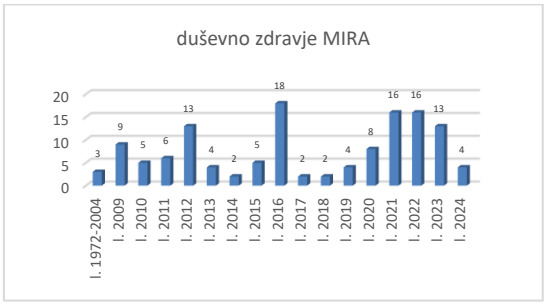
Slika 3: Iskanja v COBISS.SI po področjih

Rezultati začetnih poizkusnih iskanj po ključnih besedah v COBISS+ v t.i. osnovnem iskanju (pomeni nediferencirano iskanje, ki ga uporabimo predvsem, kadar imamo dokaj popolne podatke; z uporabljenimi iskalnimi pojmi se sproži iskanje po vseh podatkih znotraj enega bibliografskega zapisa, tudi po morebitnih povzetkih in celotnem besedilu, če je le-to dostopno online):
Analiza najdenih zadetkov nam pokaže:

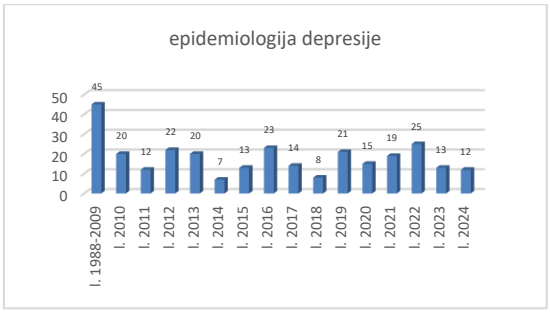
- **kako so se dela iz navedenega področja objavljala skozi leta**



Slika 4: »demografija zdravja« skozi leta

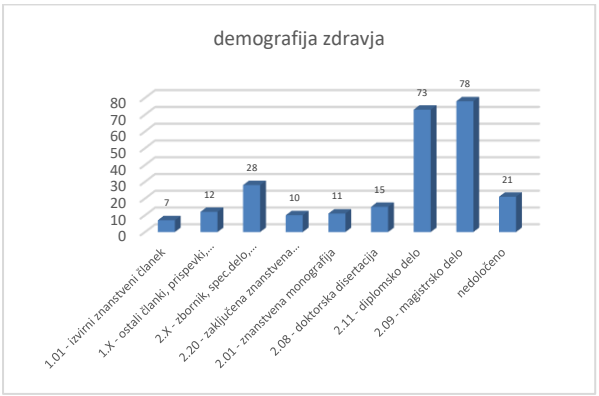


Slika 5: »duševno zdravje MIRA« skozi leta



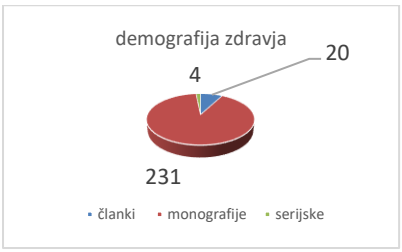
Slika 6: »epidemiologija depresije« skozi leta

- **kakšne tipologije so dela**



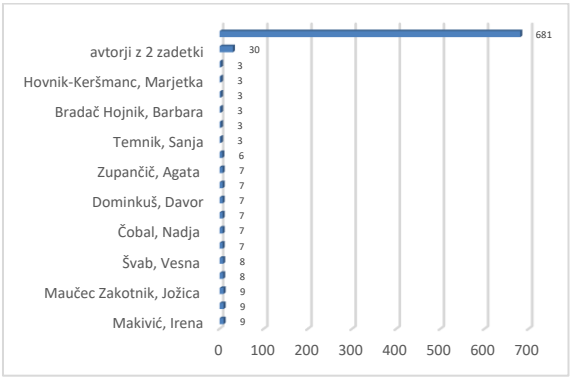
Slika 7: področje »demografija zdravja« in tipologija del

- **prevladujejo monografske publikacije nad članki**



Slika 8: področje »demografija zdravja« in oblika gradiva

- **avtorji del iz obravnavanih področij**



Slika 9: aktualni avtorji za obravnavana področja

5 Zaključni premisleki

V splošnem angleško-slovenskem (in slovensko-angleškem) modernem slovarju Daše Komac [19] v izrazu »demography« sledi prevodnemu ustrezniku »demografija« razlaga »statistično proučevanje sestava/rasti prebivalstva«, ki naj bi uporabnike vodila do »pravilne izbire besede, stalne zveze ali fraze«!

»Definitio fi(a)t per genus proximum et differentia specifica« spada v filozofijo in je sholastična formulacija klasičnega definicijskega pravila, ki sega vse do Aristotela. Klasičen primer je opredelitev ljudi kot razumnih živali.

V razlagi definicije demografije je »statistično proučevanje« (statistika) »genus proximum«, »differentia specifica« proučevanje »sestava/rasti prebivalstva«.

Takšne definicije so praviloma redke v pogovornem (kolokvijalnem) jeziku. [20]

»Genus proximum« je »višji« rodovni pojem, vendar so odnosi med znanostmi horizontalni in ne vertikalni in ne moremo trditi, da je ena kot višja nadrejena drugi!

Z bibliometričnimi raziskavami se lahko meri in vrednoti prenos znanja (knowledge transfer). med demografijo in drugimi vedami. Tako odkrita interdisciplinarnost kaže na dele drugih ved, ki ne sodijo v demografijo. [15]

		INTERDISCIPLINARNOST	
		Majhna	Velika
INOVACIJE	Znanstvena	biološka fizika	Projekt človeškega genoma
	Družbena, ekonomska, tehnološka	jedrska magnetna resonanca	raziskava jedrske fuzije

Slika 10: Shematski prikaz razmerja med vrstami interdisciplinarnosti in vrstami inovativnosti (v poljih podan tipičen primer) [15]

V LCC so »družbene vede« razred H. Podrazred HA je »statistika«. Podrazred HB je »ekonomska teorija« in »demografija«.

V Wikipediji, prosti enciklopediji, stran "Oris (Outline) demografije" ne obstaja. Obstaja le članek o demografiji kot disciplini. Prav tako v Wikipediji ne obstaja stran "demografija zdravja" (Health Demography«. Obstaja le članek o »epidemiologiji depresije«

Proučevanja v področju epidemiologije depresije kot dela demografije zdravja so pokazala, da je depresija glavni vzrok obolevnosti in umrljivosti ljudi povsod po svetu!

Rezultati iskanja po bibliografskih bazah podatkov v sistemu COBISS.SI predstavljajo:

- podlago za dopolnitev SGC z dvema novima predmetnima oznakama »demografija zdravja« (health demography) in »epidemiologija depresije« iskalne besede »demografija«, kar naj bi upoštevali tudi pri izdelavi sheme védenja demografije (knowledge map of demography);
- prispevek k nastajanju znanstvene podpore Nacionalnemu programu duševnega zdravja v Republiki Sloveniji MIRA 2018-2028.

Odgovornost za izdelavo sheme védenja demografije (knowledge map of demography) lahko avtoritativno prevzamejo le znanstveniki in strokovnjaki s področja demografije.

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Ethical Consideration and Sociological Challenges in the Integration of Artificial Intelligence in Mental Health Services

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Abstract

This article explores the transformative potential of artificial intelligence (AI) in the field of mental health, with a particular focus on ethical considerations and social challenges. As AI tools become increasingly sophisticated, their ability to support mental health interventions presents both opportunities and challenges. We discuss the importance of a human-centered approach to AI development and the need for comprehensive ethical guidelines to ensure patient safety and well-being. In addition, this paper explores key social trends such as the evolving dynamics of modern* families, aging population, migration and considers how AI can be integrated into these contexts to improve mental health care.

Keywords:

Artificial Intelligence, Mental Health, Human-Centered Approach, Ethics, Modern Family Dynamics, Aging Populations, Migration

1 Introduction

1.1 Artificial intelligence in mental health services

Research on the application of AI in mental health care has shown some positive effects on the treatment of mental health problems [1], including early detection [2,3], providing feedback and personalized treatment plans [4], and developing of novel diagnose tools [2].

AI in mental health services is implemented through models like chatbots, digital platforms, and avatar therapy, enhancing accessibility and treatment options. Chatbots provide therapy via natural language processing [5], while digital platforms support online mostly cognitive behavioral therapeutic interventions [6]. Avatar therapy uses AI to help patients manage conditions like dementia, autism spectrum disorder, and schizophrenia [7].

1.2 The Prospect of artificial intelligence in mental health services

The future orientation underlines the importance of digital health in overcoming challenges such as limited access to services, especially in underserved regions, and outlines measures to ensure equitable access to digital health solutions across the European region [8]. The use of AI in mental health services raises questions about the role of non-human interventions, transparency in the use of algorithms and the long-term impact on the understanding of illness and the human condition [9]. There are also concerns about potential bias, gaps in ethical and legal frameworks, and the possibility of misuse [10,11].

However, there are at least two potentially positive effects of the use of AI in healthcare: Accessibility and personalization of services.

AI offers new mechanisms to reach those who might not otherwise be served. AI-supported tools can improve the early detection and diagnosis of mental disorders [12]. AI chatbots have shown promise in increasing referrals to mental health services, especially for minority groups who are blocked from accessing traditional care [13]. These technologies can provide initial assessments, psychoeducation and even treatment, expanding access to mental health support [12]. AI-driven virtual assistants

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and wearable devices enable continuous monitoring and personalized care, which could improve patient outcomes [11,14].

The integration of artificial intelligence into mental health services represents a promising avenue for the development of personalized treatment plans through the sophisticated analysis of large datasets, enabling the identification of optimal therapeutic strategies tailored to specific client profiles [15,16]. This data-driven methodology enables the dynamic adaptation of therapy to the evolving needs of the client.

2 Overcoming Sociological Challenges through the Integration of Artificial Intelligence in Mental Health Services

2.1 Modern Family Dynamics

Modern family trends show that family structures and attitudes have changed significantly in recent decades [17]. There is a growing acceptance of different family forms, including unmarried cohabitation, same-sex relationships and joint custody arrangements [18]. These changes reflect an expansion of developmental idealism and increasing support for individual freedom in family choice [17].

On the other hand, there is a growing need for mental health services for families [19]. As the most vulnerable members of the family - the children - are usually also at risk, quick and effective action in family mental health is of great importance. Many families are struggling with various psychological problems. Together with the changing family structure, this means a great burden for every family member. In addition, access to psychologists, psychiatrics and therapists is limited, leading to an acute shortage of mental health professionals worldwide.

The accessibility of services is probably the strongest argument for the integration of AI in healthcare [12]. AI-powered conversational agents can improve the accessibility of mental health services by being available online at all times and in underserved areas, being scalable, reliable, fatigue-free, and providing consistent support, being culturally sensitive to adapt, and helping with education and symptom management.

2.2 Aging Populations

AI offers promising solutions for supporting an aging population, particularly in addressing cognitive decline and mental health challenges. AI applications can monitor vital signs, health indicators, and cognition, as well as provide support for daily activities [20]. With an increasing number of elderly individuals, AI can support mental health care by providing companionship through intelligent animal-like robots (e.g., Paro, Harp seal) and assisting in monitoring and managing conditions like dementia [21,22]. AI can also help in tracking cognitive health and providing timely interventions to maintain mental well-being in older adults. These technologies have the potential to enhance independent living and quality of life for older adults and their families.

2.3 Migration

Migrants often face mental health challenges due to displacement, cultural adjustment and language barriers. AI can help migrants access mental health services by providing culturally and linguistically relevant resources and support. Chatbots and AI-driven platforms can bridge gaps in care by providing immediate help and continuity of care across different regions [23].

Recent research highlights the increasing role of digitalization and artificial intelligence (AI) in migration and mobility systems, especially in the context of the COVID-19 pandemic [24]. While these technologies offer opportunities for improving human rights and supporting international development, they also bring challenges that require careful consideration of design, development and implementation aspects. The integration of AI into migration processes requires a focus on human rights at all stages that goes beyond technical feasibility and companies' claims of inclusivity [24].

3 Ethical Consideration in the Integration of Artificial Intelligence in Mental Health Services

One of the main caveats to the use of AI in mental health is the introduction of new ethical standards to ensure user safety. The approach to integrating AI into services should therefore be human-centered [25]. Any innovation should

therefore focus on people in their most vulnerable position. It is important to assess all risks with sufficient accuracy and avoid misuse of AI as much as possible. The most important areas for ethical consideration when integrating AI into mental health services should be privacy, bias, transparency, security.

Data privacy and security are critical in digital healthcare and require robust measures to protect sensitive information and prevent unauthorized access. Protecting privacy rights and ensuring informed consent are critical to maintaining trust and ethical standards in the use of personal health data [11]. Combining multiple data streams increases the risk of unauthorized use, which exacerbates privacy issues. Ensuring informed consent and maintaining transparency, especially in emergency operations, are critical to addressing these ethical concerns and protecting the rights of participants [26].

The use of AI in mental health treatment raises ethical concerns about bias, particularly among marginalized populations who are already discriminated against and lack access to mental health care. It is uncertain whether AI-assisted psychotherapy can effectively address cultural differences and close treatment gaps in diverse populations [27]. In addition, populations that are traditionally marginalized in fields such as psychology and psychiatry are most vulnerable to algorithmic biases in AI and machine learning [27,28]. These biases limit the ability of AI to provide culturally and linguistically appropriate mental health resources, exacerbating existing inequalities. The persistence of such biases in AI systems not only risks increasing health inequalities, but also exacerbates existing social inequalities and raises critical ethical considerations [9].

The future of artificial intelligence in clinical settings is affected by a significant ethical dilemma concerning the trade-off between the performance and interpretability of machine learning models [29]. The lack of transparency in AI models makes it difficult to detect and correct biases. This underscores the need for greater transparency to ensure ethical and fair clinical decision-making.

In summary, the integration of AI into mental health services requires the establishment of strict ethical standards to protect the safety and privacy of users. A human-centered approach is essential, with a focus on dealing with potential bias, especially among marginalized groups, the risks associated with data privacy and security, and the challenges posed by the lack of transparency of AI models.

4 Conclusion

We propose to define AI as a new ethical entity in the field of mental health [30]. AI represents a novel artifact that changes interactions, concepts, epistemic fields and normative requirements. This change requires a redefinition of the role of AI, which lies on a spectrum between a tool and an agent. This shift underscores the need for new ethical standards and guidelines that recognize the unique status of AI as a distinct and influential actor in the field of mental health.

The integration of AI into services can, on the one hand, provide more efficient and faster solutions to some of the sociological challenges of today's society, but on the other hand, requires a precise and correct definition of the limits within which these models can be used. These efforts aim to bridge the gap between technology and human-centered care and ensure that AI complements, rather than replaces, the therapeutic benefits of human interaction.

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Novejši razvoj rodnosti po redu rojstva v Sloveniji

Recent Development of Fertility in Slovenia by Birth Order

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POVZETEK

Med demografi vse bolj prevladuje mnenje, da rodnosti tako v Sloveniji kot drugod po Evropi v prihodnjih letih in desetletjih ne bo mogoče povečati na raven, ki bi dolgoročno zagotavljala enostavno obnavljanje prebivalstva. Kljub temu pa je še zmeraj tudi živa ideja, da bi spodbujanje rojevanja drugega in tretjega otroka, morda pa tudi četrtega otroka v družini, lahko dvignilo rodnost na raven, ki bi skupaj z zmernimi neto pozitivnimi in selekcioniranimi migracijami zagotovila dolgoročno nemoteno obnavljanje prebivalstva. Zaradi tega je pomembna analiza rodnosti po redu rojstva, ki smo jo opravili v tem besedilu. Analiza za zadnja desetletja kaže za Slovenijo, da v razmerah prenizke rodnosti prevladujejo rojstva nizkih redov rojstva. To sta največkrat prva dva reda rojstva. Verjetnost povečanja družine, ki kaže, koliko družin z dvema otrokoma se odloči za rojstvo tretjega otroka, se po vseh naših tablicah drastično zniža v primerjavi z verjetnostjo, da družina z enim otrokom dobi drugega otroka. Hkrati pa nekaj večje verjetnosti povečanja družine za rojstva višjih redov ne morejo kompenzirati tega ključnega padca, ker je rojstev višjih redov v razmerah prenizke rodnosti zelo malo. Vse to pa je skupaj s trdno uveljavljeno normo rojevanja le enega do dveh otrok v povprečju na družino v Sloveniji zelo slaba popotnica za učinkovitost prebivalstvene politike, ki bi želela dvigniti normo na povprečno dva do tri otroke na družino.

ABSTRACT

According to the opinion of more and more demographers in developed world sub-replacement fertility in developed countries is here to stay. However, the idea that pronatalist economic and other population policy measures can somehow help to increase births of the second, the third or even the fourth child in the family is still alive too. Therefore, the analysis of the fertility by birth order is of the special interest. This paper shows that Slovenian sub-replacement fertility in the last three to four decades has been deeply founded in the prevalence of the births of the first and the second birth orders as well as in the sharp decline of the births of the higher orders. The probability that the family with two children will get the third one drastically decline in the comparison with the probability that the family with one child will get the second one is shown in the fertility tables by birth order for Slovenia in the years 2011 and 2021. Higher order births in Slovenia have been very low since the beginning of the 1980s. Fertility data by birth order and our analysis show the prevalence of the very low reproductive norms in Slovenia. The prospects for effective pronatalist policy and for the increase of the number of births of all birth orders and especially of the third and

eventually the fourth birth in Slovenia are weak and uncertain.

1 UVOD

Prebivalstvo Slovenije je podobno kot druga prebivalstva razvitih evropskih držav končalo demografski prehod po koncu začasnega izbruha rodnosti po drugi svetovni vojni. To pomeni, da je zanj že nekaj več kot šestdeset let značilen moderni režim obnavljanja prebivalstva z nizko rodnostjo in nizko smrtnostjo. V zadnjih dveh tretjinah tega obdobja je splošna rodnost tako nizka, da ne zagotavlja več dolgoročno nemotenega obnavljanja prebivalstva. Slovensko in cela vrsta drugih evropskih prebivalstev lahko počasi še naraščajo zaradi dovolj velikih pozitivnih neto migracij. Kjer pa teh ni, ali pa so prisotne celo bolj ali manj velike neto emigracije, pa se prebivalstva takšnih evropskih držav zmanjšujejo. Vendar tudi Slovenija in podobne države z rastjo prebivalstva zaradi večjega priseljevanja od odseljevanja ne morejo računati na dolgoročno kompenzacijo prenizke rodnosti z dovolj velikimi neto priselitvami zaradi prenizke ravni rodnosti, zelo majhnih možnosti, da bi se raven rodnosti v zadostni meri dvignila in zaradi nepripravljenosti velikega dela prebivalstev teh držav, da bi sprejeli dovolj veliko število novih imigrantov. Demografski modeli in projekcije kažejo, da bi že v nekaj desetletjih morale biti pozitivne neto migracije na leto večje od letnega števila živorojenih. To pa bi vodilo do politične nestabilnosti in veliko večjega nasprotovanja imigracijam, kot ga vidimo v Sloveniji in Evropi v zadnjih letih.

Tako zaostrene demografske razmere v Sloveniji in v vse večjem številu evropskih držav vse bolj postavljajo demografsko problematiko v ospredje družbenega zanimanja in razprav o politikah, s katerimi bi vsaj omilili procese, ki smo jih okvirno opisali v prvem odstavku tega besedila. Ne glede na to, da med demografi vse bolj prevladuje mnenje, da rodnosti tako v Sloveniji kot drugod po Evropi v prihodnjih letih in desetletjih ne bo mogoče povečati na raven, ki bi dolgoročno zagotavljala enostavno obnavljanje prebivalstva in morda celo niti ne na raven, ki bi skupaj s pozitivnimi neto migracijami zagotovila ta cilj dolgoročne demografske stabilnosti, pa se tako v stroki kot v politiki iščejo tematike, kjer pa bi morda le bili možni določeni pozitivni premiki. Ena od takih tematik je del področja rodnosti, ki obravnava značilnosti in trende rojevanja po vrstnem redu rojstev. Pri tem je v ospredju upanje, da bi zasnovali, sprejeli in uresničevali politike, ki bi povečale rojevanje otrok drugega in še posebej tretjega reda. Da bi pa bilo možno to uresničiti, je potrebno proučevati področje rojevanja po redu rojstev,

V tem besedilu bo avtor analiziral novejše statistične podatke o rodnosti po redu rojstev v Sloveniji. Pri tem je treba povedati, da so slovenski podatki vitalne statistike dobri, večje težave pa se pojavijo pri podatkih, ki jih pridobivamo s popisi prebivalstva. V Sloveniji je bil zadnji klasični popis prebivalstva organiziran leta 2002, od leta 2011 naprej pa Statistični urad Republike Slovenije (SURS) opravlja registrske popise. Težave s popisi povzročajo raziskovalcem določene probleme, vendar so ti problemi pri raziskovanju rodnosti po redu rojstva še bolj izraziti in bodo prisotni tudi v analizi prikazani v tem besedilu.

Besedilo je razdeljeno na običajne točke, kot so uvod, sklep ter literatura in viri. Razen tega pa vsebuje še dve osrednji vsebinski točki. Prva med njima ima namen prikazati najbolj osnovne statistike in značilnosti rodnosti po redu rojstva v Sloveniji v zadnjih dveh do treh desetletjih. Prikazanih bo tudi nekaj starejših podatkov, ki bodo pokazali razsežnosti sprememb. Druga med njima pa je osrednja točka tega besedila in obravnava tablice rodnosti po redu rojstva v Sloveniji v letih 2011 in 2021.

2 RODNOST PO REDU ROJSTVA V SLOVENIJI V MODERNEM REŽIMU NIZKE RODNOSTI

Analiza rodnosti je tradicionalno namenjala veliko pozornosti zakonski rodnosti. V prebivalstvih z visoko ravnjo poročenosti je ta rodnost določala značilnosti celotne rodnosti, hkrati pa se je zelo razlikovala od zunaj zakonske rodnosti. V Sloveniji se je že pred več desetletji zelo znižalo absolutno in relativno število sklenjenih zakonskih zvez. Zakonodaja je z mnogih vidikov izenačila pravni položaj zakonskih in izven zakonskih skupnosti, število slednjih pa se je izrazito povečalo. Zaradi tega se je precej zmanjšala analitična vrednost študija zakonske rodnosti. To velja tudi za rodnost po vrstnem redu rojstva. V razmerah, ko se v Sloveniji rodi okrog 56 % živorojenih na leto izven zakonske zveze, nam značilnosti zakonskih rojstev ne dovoljujejo posploševanja na celotno rodnost. Po drugi strani pa pogosto slišimo, da se izven zakonske skupnosti obnašajo podobno kot poročeni pari, Ker pa imamo za njih veliko manj in slabše statistične podatke, jih je na osnovi običajne uradne statistike težje ali nemogoče analizirati. Zaradi vsega navedenega bomo vpliv trajanja zakonske zveze na rodnost in red rojstev v Sloveniji prikazali s podatki za leto 1991. Tega leta se je 30,0 % živorojenih v zakonski zvezi rodilo v prvem letu trajanja zakonske zveze, 51,8 % pa se jih je rodilo v prvih treh letih trajanja zakonske zveze. Za starostne razrede trajanja zakonske zveze 5-9, 10-14, 15-19 in 20+ so bili odstotki naslednji 21,5, 6,5, 1,8 in 0,4. Do velike večine rojstev in s tem tudi rojstev nižjih redov je prišlo v prvih desetih letih trajanja zakonske zveze. Le pri rojstvih višjih redov od tretjega in naprej so bili leta 1991 v Sloveniji deleži drugega desetletja trajanja zakonske zveze še tudi pomembni, vendar je bilo teh rojstev že takrat malo. (Malačič, 2000, str. 98-99) Navedeni podatki so transverzalni, saj nam longitudinalni niso na voljo. Zelo verjetno pa se osnovne značilnosti vpliva trajanja zakonske zveze na rodnost v naslednjih desetletjih niso bistveno spremenile.

Znižanje števila in deležev živorojenih višjih redov rojstva v Sloveniji se kaže tudi v obdelavi in objavljanju uradnih statističnih podatkov v statistični bazi SURS SISTAT. Več obdelav v tej bazi se preprosto konča pri redu rojstva 4+, čeprav so se obdelave še v zadnjih desetletjih prejšnjega stoletja končevale z odprtimi razredi 6+, 7+, 8+ ali celo 9+. Zaradi tega smo lahko vključili v tabelo 1 znatno manj podatkov po redu rojstva za Slovenijo, kot bi si želeli.

Tabela 1 prikazuje letne (transverzalne) podatke o številu živorojenih v Sloveniji po redu rojstva v izbranih letih obdobja 1991-2023. Red rojstva se konča z zgornjim odprtim razredom 4 in več (4+). Izbrana leta upoštevajo logiko desetletnih med popisnih intervalov, čeprav je SURS to logiko deloma porušil. Dodano pa je še leto 2023, za katero imamo zadnje objavljene podatke. Prikazani so absolutni podatki in relativna struktura v odstotkih.

Tabela 1: Absolutno in relativno število živorojenih v Sloveniji po redu rojstva v izbranih letih obdobja 1991-2023. Vir: SISTAT, dostop 7.9. 2024

Leto	1991		2001		2011		2021		2023	
Rojstva[1]	Št.	%	Št.	%	Št.	%	Št.	%	Št.	%
1	2	3	4	5	6	7	8	9	10	11
N	21.583	100,0	17.477	100,0	21.947	100,0	18.984	100,0	16.989	100,0
N_1	10.210	47,3	8.599	49,2	10.637	48,5	8.557	45,1	7.884	46,4
N_2	8.510	39,4	6.371	36,5	8.327	37,9	7.487	39,4	6.391	37,6
N_3	2.179	10,1	1.865	10,7	2.210	10,1	2.244	11,8	2.094	12,3
N_{4+}	684	3,2	642	3,7	773	3,5	696	3,7	620	3,6

[1] N je število živorojenih; N_1 , … , N_{4+} so zaporedoma števila rojstev od prvega reda do reda štiri in več.

Število živorojenih v Sloveniji v izbranih letih, ki so prikazana v tabeli 1 precej niha in je najnižje leta 2023, ki je zadnje leto, za katerega imamo podatke. Bolj presenetljivo pa je, da se struktura živorojenih v Sloveniji po redu rojstva v vseh teh letih zelo malo ali skoraj nič ne razlikuje. V vseh izbranih letih se je rodilo največ otrok prvega reda, delež se giblje med 45,1 in 49,2 odstotka. Velika večina rojstev je rojstev prvega in drugega reda, delež teh dveh redov se giblje med 84,0 in 86,7 odstotka. Delež živorojenih tretjega reda je le malo večji kot 10,0 odstotkov, delež četrtega reda in več pa je nizek in se giblje med 3,2 in 3,7 odstotka. Navedeni statistični podatki kažejo, da je prebivalstvo Slovenije v obdobju 1991-2023 tipično maltuzijansko prebivalstvo, ki načrtuje rojstva in rojeva le dokler ne doseže števila rojstev na družino oziroma partnersko skupnost, ki je bilo načrtovano. Pri načrtovanju še zmeraj pride do odstopanj, vendar so ta majhna. Majhne spremembe v strukturi živorojenih po redu rojstev pa kažejo še, da se je v Sloveniji v zadnjih desetletjih ustalila in verjetno utrdila ne samo nizka norma števila živorojenih otrok na eno žensko, ampak norma, ki je le eden do dva otroka na žensko.

Trditev v zadnjem stavku prejšnjega odstavka lahko podkrepimo tudi s podatki zadnjega na terenu izpeljanega popisa prebivalstva leta 2002. Popis je zbral podatke o številu žensk starih 15 in več let po tem, ali je ženska rodila ali ni rodila in po tem, koliko otrok je rodila. Navedenega popisnega leta je bilo v Sloveniji med 15 in več let starim ženskim prebivalstvom 26,5 odstotka žensk, ki niso ali še niso rodile. Deleži med njimi, ki so rodile zaporedoma enega, dva, …., do 6 in več živorojenih otrok pa so bili 19,5, 37,2, 11,1, 3,5, 1,3, in 1,1 odstotka. Iz teh podatkov izračunano povprečno število živorojenih otrok na eno žensko je bilo 1,55, kar je blizu stopnji totalne (celotne) rodnosti v zadnjih letih. (SISTAT, dostop 7. 9. 2024)

Podatki o številu živorojenih po redu rojstev nam omogočajo izračunati različne vrste stopenj rodnosti po redu rojstva. Med njimi so še posebej zanimive stopnje, pri katerih primerjamo število živorojenih danega reda rojstva s številom žensk, ki lahko rodijo otroke tega reda. Takšne stopnje bomo podrobneje obravnavali v naslednji točki tega besedila.

Stopnje rodnosti po redu rojstva glede na ženske, pri katerih lahko pride do teh rojstev, pa je povezano s kazalci verjetnosti povečanja družine. Tak kazalec nam pove, kakšna je verjetnost, da se družina z danim številom otrok poveča za dodatnega otroka. Verjetnosti povečanja družine lahko računamo na longitudinalni (kohortni) in transverzalni osnovi. Prvi način se uporablja za kohorte, ki so končale svojo rodno obdobje. Pri njem uporabljamo popisne podatke. Težava pa je v tem, da imajo kazalci bolj zgodovinsko kot praktično vrednost, saj nam kažejo, kaj se je dogajalo v kohorti, ki je že končala svoje rodno obdobje. Tega načina tukaj ne bomo obravnavali.

Praktično bolj uporaben je transverzalni način izračunavanja verjetnosti povečanja družine. V literaturi je na voljo več načinov izračunavanja takšnih verjetnosti. (Malačič, 2006, str. 97-100) Prvi način uporablja podatke o zakonski rodnosti po redu rojstev in modelske porazdelitve rojstev reda i glede na trajanje razmaka do reda i-1. Tudi tega načina tukaj ne bomo obravnavali. Namesto tega bomo v naslednji točki prikazali izračun verjetnosti povečanja družine na osnovi transverzalnih podatkov po redu rojstva za vsa rojstva.

3 TABLICE RODNOSTI PO REDU ROJSTVA V SLOVENIJI V LETIH 2011 IN 2021

Za sestavo oziroma izračun tablic rodnosti po redu rojstva na osnovi letnih oziroma transverzalnih podatkov potrebujemo podatke o številu živorojenih po redu rojstva za izbrano leto, o srednji starosti matere ob rojstvu otroka i-tega reda ter podatke o specifičnih stopnjah rodnosti po redu rojstva r_i, ki jih izračunamo tako, da število rojstev i-tega reda delimo s številom žensk, ki se jim ti otroki lahko rodijo. Če vzamemo za primer stopnjo rodnosti drugega reda, potem število rojstev drugega reda delimo s številom žensk rodne starosti, ki so rodile enega otroka. Za rodno starost lahko vzamemo starostni razred 15-49 ali pa 15-44. V

našem primeru smo vzeli slednjega, ker uporabljamo pri izračunu verjetnosti povečanja družine predpostavko, da ženske rojevajo do 45. leta. Dejansko število rojstev starejšim materam od 45 let pa je zelo nizko. Na ta način smo stopnje r_i izračunali po naslednjem obrazcu: $r_i = N_i/_{30}V_{f,i-1,15}$, pri čemer je i enak 1, 2, …, n+. V preteklosti smo lahko dobili podatke za imenovalec specifičnih stopenj rodnosti r_i le za popisna leta. V Sloveniji, kjer imamo register prebivalstva in registrsko statistiko, pa nam statistična baza SISTAT omogoča izračun tudi za druga leta za katera v bazi objavijo podatke. Med štirimi leti, za katera so na voljo podatki o ženskah starih 15 in več let po enoletnih in petletnih starostnih razredih po številu živorojenih otrok (brez, z enim, z dvema otrokoma itd.) smo za našo analizo izbrali leti 2011 in 2021.

Ko smo izračunali stopnje r_i , lahko v nadaljevanju izračunamo verjetnost povečanja družine po obrazcu, ki sta ga utemeljila Chiang, C.L. in van den Berg, B.J. (Chiang, C.L. and van den Berg, B.J., 1982). Obrazec za verjetnost a_i je: $a_i = (x_w – x_i) * r_i / 1 + ((x_w – x_{i+1}) * r_i)$. Pri tem je x_w enak 45,0, poševnica / je znak za deljenje, zvezdica * pa znak za množenje. Ko imamo na tak način vse potrebne podatke za sestavo tablic rodnosti po redu rojstva, jih moramo še izračunati in zaključiti. Za stolpec 5 v tabeli 2 uporabimo izhodiščno (modelsko) število 100.000 živih žensk, na katere apliciramo izračunane verjetnosti povečanja družine. Stolpec nam kaže število žensk brez otrok, z najmanj enim otrokom in tako dalje. Stolpec 6 dobimo kot razliko zaporednih vrednosti stolpca 5 deljeno s 100.000.

Tabela 2: Tablice rodnosti na osnovi reda rojstev za Slovenijo za leti 2011 in 2021. Vir: Chiang, C.L. and van den Berg, B.J., 1982; Malačič, J., 2006 in SISTAT, dostop 9. 9. 2024.

Red rojstva	Srednja starost ob rojstvu	Specifične stopnje rodnosti	Verjetnost povečanja družine	Število žensk z i in več živorojenih	Končna razdelitev po redu (v %)
i	x_i	r_i	a_i	l_i	d_i/l_0
1	2	3	4	5	6
Slovenija 2011					
0	15,0	0,05527	0,87480	100.000	12,6
1	28,8	0,10785	0,70520	87.480	25,8
2	31,3	0,02211	0,24065	61.691	46,8
3	33,3	0,03203	0,28315	14.846	10,6
4+	34,9			4.204	4,2
Slovenija 2021					
0	15,0	0,04966	0,84419	100,000	15,6
1	29,6	0,11511	0,70360	84.419	25,0
2	31,8	0,02501	0,15589	59.397	44,2
3	33,4	0,03159	0,27914	15.199	11,0
4+	35,1			4.243	4,2

V tabeli 2 smo prikazali tablice rodnosti na osnovi reda rojstva za Slovenijo za leti 2011 in 2021. Najbolj zanimiv kazalec v tablicah je verjetnost povečanja družine v četrtem stolpcu. Vrednosti tega kazalca sta dokaj visoki za verjetnost, da družina brez otrok dobi prvega otroka in da družina z enim otrokom dobi drugega otroka. Vendar sta tudi ti dve vrednosti med letoma 2011 in 2021 padli. Le malo več kot dve tretjini družin z enim otrokom se odloči za drugega otroka. Naslednja verjetnost, da družina z dvema otrokoma dobi tretjega otroka, pa drastično pade. V Sloveniji je še nadalje padla med letoma 2011 in 2021. Leta 2021 se je le 15,6% družin z dvema otrokoma odločilo še za tretjega otroka. Po podatkih SISTAT-a je bilo v Sloveniji v starostnem razredu žensk 50-54 let leta 2011 6,4 % in leta 2021 10,1 % žensk, ki

niso rodile. (SISTAT, dostop 9. 9. 2024) Razlika med tema podatkoma je presenetljivo velika in očitno precej niha med petletnimi starostnimi razredi, ki so dokončali rojevanje in rodno starost.

Za primerjavo z zgornjima dvema letoma navedimo, da so bile vrednosti verjetnosti povečanja družine, prav tako izračunane po prikazani metodologiji, za Slovenijo za leto 1961 v primeru zaporedja a_0 ,a_1 , … , a_5 naslednje 0,93142, 0,80099, 0,57079, 0,46080, 0,466523 in 0,48388, za leto 1981 pa zaporedoma 0,93811, 0,81473, 0,30978, 0,25493, 0,28310 in 0,32492. (Malačič, 2006, str. 99) Leta 1961 je bilo v Sloveniji 28.955 in leta 1981 29.220 živorojenih. (SL-2013, str. 77-78) To število vpliva na velikost r_i in tudi na dolžino vrste, ki smo jo lahko izračunali. Vrednosti a_i so bile v obeh letih občutno večje kot tiste v tabeli 2, čeprav so se tudi že v teh dveh letih znižale. Leta 1961 so bile še deloma pod vplivom končevanja demografskega prehoda.

4 SKLEP

Podatki o rodnosti po redu rojstva ter na njihovi osnovi izračunane tablice rodnosti po redu rojstva in še posebej verjetnosti povečanja družine za Slovenijo, ki so prikazani in analizirani v tem besedilu se praviloma nanašajo na posamezna izbrana leta in so po naravi transverzalni. Raziskovalci smo jih največkrat prisiljeni uporabljati zaradi tega, ker tako kohortni oziroma longitudinalni pa tudi transverzalni podatki za mnoga druga leta niso na voljo. Pogosto si pomagamo tudi z ocenami in približki pa tudi s posebnimi metodami analize za nepopolne in specifične podatke.

Ne glede na vse to, pa je naša analiza v tem besedilu pokazala presenetljivo enotno in dosledno sliko na področju, ki smo ga analizirali. V razmerah prenizke rodnosti prevladujejo rojstva nizkih redov rojstva. To sta največkrat prva dva reda rojstva. Verjetnost povečanja družine, ki kaže, koliko družin z dvema otrokoma se odloči za rojstvo tretjega otroka se po vseh naših tablicah drastično zniža v primerjavi z verjetnostjo, da družina z enim otrokom dobi drugega otroka. Hkrati pa nekaj večje verjetnosti povečanja družine za rojstva višjih redov ne morejo kompenzirati tega ključnega padca, ker je rojstev višjih redov v razmerah prenizke rodnosti zelo malo. Vse to pa je skupaj s trdno uveljavljeno normo rojevanja le enega do dveh otrok v povprečju na družino v Sloveniji zelo slaba popotnica za učinkovitost prebivalstvene politike, ki bi želela dvigniti normo na povprečno dva do tri otroke na družino. Vsi matematični demografski modeli kažejo, da samo slednja norma zagotavlja dolgoročno nemoteno obnavljanje prebivalstva.

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The aggregate loss of GDP resulting from premature mortality: a methodological approach based on GDP decomposition at occupational level

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Abstract

This paper proposes a novel method for estimating the economic burden of premature mortality in the working population. The method is based on GDP (value added) decomposition at the occupational level. The approach estimates the loss of value added due to premature deaths in Slovenia by considering the productivity of individuals in different occupations. By integrating data on employed individuals, causes of death, and company balance sheets, the results provide a decomposition of GDP losses by occupational groups. The results show significant differences in the value added lost between occupational groups, with professionals and technicians contributing the most to the total loss. This approach provides an alternative estimate of economic losses compared to traditional methods by taking into account the contribution of each occupational group to GDP. However, the study also acknowledges limitations, such as uncertainties regarding future retirement ages and a relatively small sample size for certain occupations. This methodology provides valuable insights for policymakers about the importance of addressing the economic burden of premature mortality in the labour force.

Keywords

Premature mortality, productivity loss, economic burden, value added decomposition, occupational level

1 Introduction

Between 2009 and 2022, an average of just over one thousand people of working-age died in Slovenia, which corresponds to around 0.11 % of the 900 thousand people in employment on average. During this period, the average age of death was 49.4 years and the individuals retired at an average age of 59 years [1]. Not reaching the average retirement age means that each individual lost an average of 8 working years.

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Premature death (dying before the age of 65) represents not only represents a personal and family loss, but also a significant loss of human capital and consequently a loss of productivity and GDP, amounting to the cumulative loss of value added reflecting the burden of premature mortality. The economic burden of premature mortality can be estimated at the microeconomic or macroeconomic level [2]. This paper proposes an alternative approach to estimate the economic burden of premature mortality at the macroeconomic level.

Health economics assesses the economic costs of disease using different methods [2]. At the macroeconomic (societal) level, the losses are both market losses (non-health consumption) and economic welfare losses (which consider not only the market, but also non-market losses). While market losses are usually estimated using general or partial equilibrium models (both simulation and regression based), the economic welfare losses are estimated using full-income models. The WHO [2] systematically summarizes the approaches proposed and used in the literature to estimate the macroeconomic consequences of diseases.

The **Cost of Illness (CoI)** approach focuses on estimating the total economic burden of a particular disease by combining both direct and indirect costs [3], [4], [5]. Direct costs include medical expenses, treatment, and travel costs, while indirect costs consider the loss of productivity due to illness, absenteeism, or premature death. This method quantifies the overall economic burden of a disease on society, often expressed as a percentage of GDP. Despite its usefulness in providing a broad estimate of the financial burden, the CoI approach has limitations. It tends to oversimplify the broader economic effects by focusing primarily on medical expenditures and labor productivity losses, without fully capturing long-term effects such as capital depletion or changes in labor supply. In addition, non-market impacts may not be considered [2].

Regression-based models estimate the impact of health indicators, such as life expectancy or mortality, on economic output, usually GDP. The method uses econometric models to identify statistical relationships between health and economic outcomes, relying on historical or cross-country panel data. The main advantage of regression models is their simplicity and relatively low data requirements. However, endogeneity issues—when health and income influence each other—can affect the results, and the models are sensitive to the specification of the production function [2].

Calibration models combine micro-level estimates of health impacts on income with macro-level data, such as GDP, demographic data, and labour force statistics, to simulate how

health changes affect national economic output. The calibration approach allows for the decomposition of health impacts across different countries or regions, providing flexibility in scenarios where data is limited. However, the calibration models are primarily sensitive to mortality impacts, while morbidity (illness) effects is more challenging to capture accurately.

The full-income model approach goes beyond traditional market-based valuations by estimating both the monetary value of lost production and the value of lives lost to illness. It uses techniques such as the Value of Statistical Life (VSL) or Willingness to Pay (WTP) to quantify social welfare losses [6], [7]. Although full-income models capture the broader societal costs of illness, including non-market impacts, they involve contentious assumptions, such as discount rates and VSL, which can lead to extreme or difficult-to-interpret results [2].

We extend existing methods by building on the **National Transfer Accounts (NTA) approach to the decomposition of value added** [8], which measures the economic impact of premature death by assessing the reduction in GDP, that is, by estimating the loss of productivity. This implies calculating the contribution that individuals would have made to GDP is calculated, based on their specific sector and productivity level. This productivity loss is then multiplied by the number of years the individual would have continued to work. The total losses are then aggregated to determine the overall impact on the economy [9].

2 Methodology and data

The methodology builds on the production loss approach due to premature mortality and the resulting loss of GDP. However, instead of estimating productivity loss using (sectoral) averages, we recognise that the actual productivity of firms is highly dependent on their human capital structure, which is the core of their intangible capital [10]. Intangible capital generates a large part of the value added in a knowledge-based economy [11], [12]. Therefore, we assess the loss of value added by assessing the contribution of individuals through their occupation, which more accurately captures the actual loss of value added due to premature death.

The methodological analysis is based on several steps and originates from the production function of a company, focusing on the contribution of the individual occupations or occupational groups to value creation. First, the employees were categorized into ten broad occupational groups according to the Standard Classification of Occupations, which aligns with the International Classification of Occupations. These broad occupational groups are: (0) military professions, (1) legislators, senior officials, managers, (2) professionals, (3) technicians and associate professionals, (4) clerks, (5) service workers, sales people, (6) agricultural, forestry, fishery, and hunting occupations, (7) non-industrial labor, (8) machine operators, industrial producers and assemblers, (9) elementary occupations. Analyses show that the contributions of different occupational groups to value added vary [10], [13], [14], [15], making it sensible to account for the actual structure of employees and their real contribution when calculating the loss of added value.

The productivity of employees, measured by value added per employee, is calculated by decomposing real value added at company level for the period between 2009 and 2022 to the level of different occupations. The decomposition of value added follows the NTA methodology [8], which uses regression without a constant to allocate aggregate variable values (e.g., household consumption) to individuals. Similarly, we regress firm's value added on the share of broad occupational groups. The beta coefficients are provided in the appendix (Table A1). The beta coefficients are then used to calculate the weights for each occupational group according to the following formula:

$$weight_i = \frac{\beta_i \cdot \sum x_i}{\sum_i^{10} \beta_i \cdot \sum x_i}$$

Where i represents each occupational group i∈(1,10), β is the calculated regression coefficient for each occupational group, and x is the number of employees in each occupational group. The added value per employee (VAEreal,i) according to the occupational profile is calculated using the following formula, where TOT_ VAEreal,i is the total real value added of the company:

$$\mathrm{VAE}_{\mathrm{real},i} = \mathrm{TOT_VAE}_{real} * weight_i$$

In the next step, we calculate the number and average age of individuals by occupational groups who died prematurely. Based on the actual retirement age during the observed period (on average only 59 years), the number of lost productive years was calculated (by subtracting the retirement age and the age of death by occupational group) and multiplied by the estimated value added of each occupational profile (VAEreal,i). By summing the lost value added due to lost productive years we estimate the economic burden of premature mortality.

The analysis was prepared using micro-data from registries covering the period between 2009 and 2022 [1]. The database integrates several different population data sources: (1) the Statistical registry of active population database from 2009 to 2022, which contains annual data on 838,000 to 998,000 individuals, with data on age, occupation, and employment sector; (2) cause-of-death data for the period 2009 to 2022, which contains the 4-digit code of the cause of death and death date; (3) company balance sheet data for again for 2009 to 2022. The merged database of employed individuals and companies was used for the decomposition of value added by occupational group, while the data on the number of deaths was used to estimate the loss of value added. Due to a small number of observations, military occupations were excluded.

3 Results

The analysis is based on a population of 12.7 million people in employment in Slovenia, averaging around 900,000 annually from 2009 to 2022. During this period, approximately 14,000 individuals from this group died, about 1,000 per year, representing 0.11% of all observed individuals [1].

Table 1 presents the data on the cumulative number of premature deaths among the employed population in Slovenia between 2009 and 2022. On average, the individuals died at the age of 49.4. Individuals generally retired at 59 years, but with some differences among occupational groups. For example, managers and professionals retired at an older age, whereas the employees in elementary occupations retired younger.

The loss of productive years, calculated as the difference between the average age at retirement and the average age at death, was highest in the group of professionals, who lost an average of 9 years, and was lowest among skilled agricultural,

fishery and forestry workers, where the average loss was only 1 year.

Occupational decomposition of aggregate value added at firm level allowed us to estimate the average contribution of each occupation group to the value added, considering also their relative size. Using these estimates, and the data on the average number of premature deaths, average age at death and average retirement age by occupational groups, the estimated loss of productive years was calculated (Table 1).

Table 1: The number of employed individuals' premature deaths, average age at death and retirement, loss of productive years of life, 2009-2022

	Number of deaths	Average age at death	Average age at retirement	Loss of productive years of life
0 Armed Forces Occupations	71	44.2	55.8	11.6
1 Managers	698	53.4	61.2	7.8
2 Professionals	1,678	52.3	61.3	9.0
3Technicians and Associate Professionals	1,828	51.2	59.2	8.0
4 Clerical Support Workers	966	50.2	58.3	8.1
5 Service and Sales Workers	1,476	49.8	57.9	8.1
6 Skilled Agricultural, Forestry, Fishery Workers	836	57.1	58.2	1.0
7 Craft and Related Trades Workers	2,573	49.9	58.7	8.8
8 Plant, Machine Operators, Assemblers	1,571	50.0	58.0	8.0
9 Elementary Occupations	1,562	49.8	57.8	8.0
Total	13,259	49.4	59.0	9.6

Data: [1], own calculations.

The occupational group of professionals contributed the most to the total number of lost productive years (28%), as the number of premature deaths was highest in this occupational group. This was followed by technicians and associate professionals, for whom the average number of years lost was also high and the relative group size was even larger. This group contributed about one fifth of years lost.

Figure 1 presents data on the contribution of each occupational group to the total value added lost due to premature deaths. Professionals contributed the most, around a fifth of thetotal value added lost. Followed by technicians and plant and machine operators.

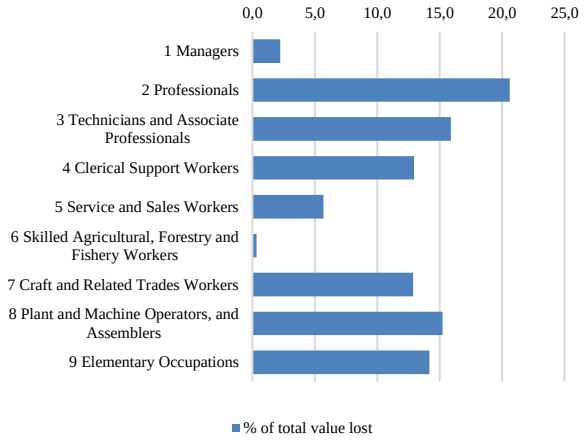

Figure 2: The contribution of occupations to total value added lost (in % of all value added lost)

4 Discussion and conclusion

This study offers a novel approach to estimating the economic burden of premature mortality in Slovenia by focusing on the loss of added value and consequently the potential loss of GDP. In contrast to traditional approaches that might rely on aggregate data or income loss models, this study employs a more detailed decomposition method based on the added value generated by companies, the occupational structure, and the premature mortality rates. This approach allows for a more precise estimate of the economic burden by considering the specific contributions to value added of the different occupational groups, which differ significantly in their productivity and value added in the economy.

One of the key strengths of this methodology is the use of microdata, which provides a detailed overview of the economic burden of premature mortality at the level of individual occupational groups. By using data from multiple sources, including the Statistical registry of the active workforce, mortality data, and company financial statements, the study achieves a high level of specificity. This level of detail is crucial, as it acknowledges the differential impact of premature deaths across different sectors and occupations, which is often overlooked in broader, less nuanced analyses.

However, the study also has limitations that need to be considered. One important limitation is the inability to accurately predict future retirement ages, especially given the trend towards increasing retirement ages in Slovenia and elsewhere. This introduces a potential underestimation of economic loss, as individuals might work longer in the future than currently assumed in the model. In addition, the relatively small sample size of premature deaths within certain occupational groups may affect the robustness of the results, and the lack of control for other risk factors may also bias the results. This also means that the actual numbers could be larger. Furthermore, while the study introduces an alternative methodology, the approach could benefit from further refinement, particularly in the decomposition method, which would take greater account of worker heterogeneity.

While the proposed methodology provides a detailed and occupation-specific approach to assessing the economic burden

of premature death, its applicability may be limited by certain assumptions and data limitations. Future research could enhance this model by incorporating more dynamic elements, such as evolving retirement patterns, changing productivity levels and broader demographic trends, to provide a more comprehensive picture of the economic impact of premature mortality. Despite these limitations, the study contributes significantly to the literature by providing a more nuanced understanding of the economic costs associated with premature mortality that could inform both policy decisions and future research directions.

Acknowledgments

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Mitigating Adverse Health Effects of Chronic Illnesses on Work Outcomes: A Conceptual Framework

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Abstract

The paper offers a comprehensive framework for linking health outcomes and their determinants to work outcomes through understanding how health, workplace and institutional environment affect work outcomes. Its goal is to identify the complex determinants of work ability and both favourable and adverse work outcomes. Work ability is determined by health and quality of life outcomes, which are influenced by both modifiable and non-modifiable health factors as well as macro, mezzo and micro-level incentives to improve health outcomes including job demands, and workplace support. Work outcomes-oriented improvement strategies also support work retention and return to work.

Keywords

health determinants, health outcomes, work ability, work outcomes, health and work outcomes-oriented improvement incentives

1 Introduction

The ability to retain employment or achieve faster return to work (RTW), particularly for individuals with chronic illnesses or disabilities, is an increasingly important topic in an aging society, requiring prolonged labour market participation. The increasing prevalence of long-term health conditions, an aging workforce, and fluctuating job demands have highlighted the importance of maintaining work ability.

The goal of this paper is to develop a conceptual framework that shows the links between health determinants, health outcomes, work ability and work outcomes, and their interplay with incentives aimed at improving work outcomes that are essential for extending productive working lives. This framework is useful for designing research on how individuals, organizations and policy makers can improve long-term employability and productivity in the face of health challenges.

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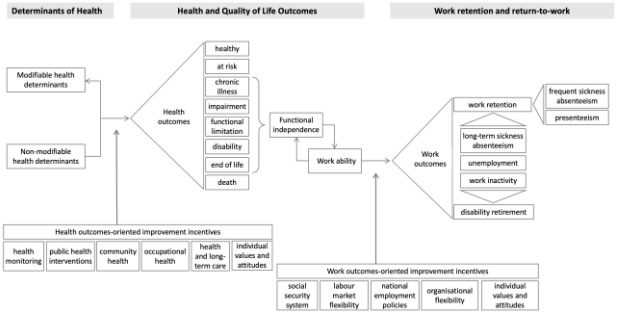

Figure 1: Mitigating adverse health effects of chronic illnesses on work outcomes: a conceptual framework

2 Determinants of Health, Adverse Health and Work Ability Effects, and Work Outcomes

2.1 Determinants of Health

Health status is fundamentally determined by the conditions in which we are born, grow, live, and age [1]. These conditions, known as health determinants, factors, or drivers, operate at various levels and in different contexts. In examining health determinants, we follow the WHO [2] framework, distinguishing between individual, socioeconomic, sociocultural, and environmental factors.

Individual factors include personal attributes that impact health, such as attitudes, knowledge, genetics, etc. Knowledge about healthy food choices, recommended physical activity levels, and the correct interpretation of food labels also plays a critical role [3]. This knowledge is often associated with health literacy that is an independent factor of self-assessed health, and low health literacy contributes to health disparities [1], [4].

Attitudes can also positively or negatively influence health, as argued by the theory of reasoned action [5], showing that attitudes and subjective norms predict behavioural intentions, which, in turn, predict actual behaviours. The value individuals place on health is pivotal; those who prioritize health are more likely to make it a priority over other demands, such as time, money, and competing life priorities [3], [6], [7].

Genetics is another key individual factor affecting health. Family history is recognized as one of the strongest risk factors for common diseases, including cancer, cardiovascular disease, diabetes, autoimmune disorders, and psychiatric illnesses [8].

Social factors are sociocultural and socioeconomic. Sociocultural factors include influences from family, peer pressure, media, religion, and culture. Family heavily influences choices related to religion, friendships, and media exposure, particularly in childhood. Family also plays a crucial role in shaping attitudes towards health and decisions on protective and risky behaviours. Peer influence operates similarly; social support and integration are highly protective against mortality, with their impact on health comparable to or exceeding that of traditional behavioural risk factors such as smoking, high alcohol consumption, lack of exercise, and obesity. Traditional and social media is increasingly recognized as a commercial determinant of health [9], influencing health through public relations, advertising, and economic pressures [10].

Socioeconomic factors include employment, education, and income. Employment status and occupation significantly impact health by influencing living and working conditions, levels of physical activity, and stress [3]. People at work may face hazards owing to chemicals, biological agents, physical factors, adverse ergonomic conditions, allergens, safety risks, and psychosocial factors. More than 100 occupational diseases are classified [11]. Working conditions are linked to an increased risk of developing work-related illness [12] and depressive disorders [13]. New psychosocial and physical stressors contribute to health disparities. Evidence suggests that better job quality provides protective effects against musculoskeletal disorders, mental health issues, and general health problems [14], and enhances labour productivity, notably when employees are healthy [15].

Income is also strongly associated with health outcomes [16]. Low income can restrict access to health services, whereas higher income allows for better living conditions and access to healthcare. Higher income often sets expectations for subsequent generations regarding education, employment, and income although positive association between income and health may flatten or even reverse at the highest income levels [17].

Environmental factors encompass both geographical location and access to health services and technology. Natural and built environments play significant roles in health, with some environmental characteristics contributing to chronic diseases [3]. A review of 133 diseases by Prüss-Ustün [18] established that nearly a quarter of the global disease burden could be prevented by reducing environmental risks.

Individual, social, and environmental factors interact in influencing health outcomes. Education—a key socioeconomic factor—directly influences individual factors like knowledge and skills. Additionally, a person's environment is often shaped by their employment and income, which are linked to the number of hours spent at work. In some cases, the living environment can restrict educational and employment opportunities, further impacting health. People living in rural or remote areas are more likely to experience poorer health outcomes, due to limited access to health services and education and employment opportunities. Sociocultural factors also play a significant role; for instance, not speaking the native language can hinder educational success and makes it more challenging to navigate the healthcare system. This interconnectedness underscores the importance of considering the combined effects of individual, social, and environmental factors in shaping health outcomes [3].

2.2 Modifiable and Non-modifiable Risk Factors

To improve health outcomes, it is crucial to understand which of the above explained health determinants are in or out of an individual's control. Modifiable factors can be changed and controlled to a certain extent, such as skills (individual), peers and religion (sociocultural), employment, education, income (socioeconomic) and geographic location and related access to health services (environmental). Some factors are more easily changed than others. Also, the degree to which a person is able to change them varies from person to person [3]. Non-modifiable health determinants include genetics (individual), and family, media and culture (sociocultural). While you can't change these factors, it's important to be aware of them.

The degree of control individuals can exert over their health varies across our lifespan [3]. Control increases until adulthood and decreases in older adulthood. The changing influence of determinants through life stages varies from person to person [19]. Further, modifiable factors often require support, such as access to healthcare or financial resources, to be effectively managed. When individuals lack such support, the potential to modify their health outcomes diminishes, contributing to the feeling of powerlessness in improving their health [20].

2.3 Health Outcomes-oriented Improvement Incentives

The term "morbidity" is commonly used to describe the burden of suffering, in terms of impairment or disability, caused by an illness or health condition. Addressing chronic illness morbidity aims at the best achievable state of health that encompasses all dimensions of physical, mental, and social well-being [21].

Strategies designed to help individuals live well should include a broad array of activities targeting primary, secondary, and tertiary prevention for all persons, with or without a chronic illness. Accordingly, public health mechanisms aimed at preventing undesired health outcomes (primary prevention such as vaccination, tobacco cessation, physical activity promotion, healthful eating, injury prevention) can also help people with a chronic illness or disability to live more healthfully. Health monitoring using real-time data plays a significant role in influencing health outcomes, by enabling early detection of health conditions, facilitating continuous management of chronic diseases, and improving overall patient care [22].

Health and long-term care mechanisms that prevent or delay complications, build coping skills, improve function, or alleviate pain and suffering may serve a dual purpose: (i) reducing the magnitude of illness burden over an individual's remaining years of life; (ii) reducing and/or delaying the development of additional complications or comorbidities in a way that serves to compress the period of morbidity until later in life [21]. Further, occupational health services improve health outcomes of the active population. Progress in the field of occupational and environmental medicine has led to a better understanding of the most efficient strategies for recognizing a wide variety of work-related ailments [23].

2.4 Impact of Health Outcomes on Functional Independence and Work Ability

All above-mentioned incentives are aimed at improving adverse health outcomes and thereby maintaining functional independence and, consequently, work ability. Functional independence can be viewed narrowly as the ability to perform basic activities of daily living (eating, dressing, hygiene, transferring) [24]; or more broadly as the ability to perform instrumental activities of daily living (performing chores, managing finances, taking medication, using transportation) [25] that enable an independent life. Research shows that functional independence has a strong impact on work outcomes [26], [27].

Functional independence is strongly linked to an individual's work ability defined as a holistic concept encompassing both personal health and the work environment's role in enabling or hindering an individual's ability to work [28]. The concept refers to an individual's capacity to remain employed and perform work-related activities, especially in the context of chronic diseases, aging, or disabilities [29].

Work ability is influenced by a range of factors including health status, workplace accommodations, and social support systems [30]. Physical health (mobility, endurance) and mental well-being (cognitive functioning, emotional resilience) are the most important factors to maintain work ability [31]. In addition, job demands, its physical and psychosocial (cognitive, emotional) demands, significantly influence an individual's ability to work effectively and productivity [32]. Workplace factors (organisational support, ergonomics, flexibility) play a crucial role in enhancing or diminishing work ability, especially for those with chronic conditions or disabilities [33]. Social and occupational factors (age, training opportunities, work-life balance) also impact work ability [34].

2.5 Work Outcomes and Work Outcomes-oriented Improvement Incentives

Work ability has a notable impact on work outcomes. If chronic illnesses result in an individual's prolonged sickness absenteeism, unemployment or work inactivity, work retention and RTW are favourable work outcomes. RTW refers to the process of reintegrating employees back into the workplace after an absence due to illness or injury. Besides work ability, RTW also depends on several patient's pull and push factors, from meaningfulness of work to being offered an adjusted work environment [35]. Successful RTW initiatives focus on assessing and improving work ability, ensuring that the work environment and job demands align with the employee's current health status. RTW outcomes are enhanced by flexible work arrangements, gradual reintegration programs, and workplace accommodations that mitigate the impact of health conditions [36], [37]. By addressing both organisational factors and individual health needs, RTW programs can prevent adverse work outcomes such as long-term absenteeism, presentism, unemployment and disability retirement [28], [29], [33], [36]. They can also mitigate short-term adverse effects of chronic illnesses such as frequent shorter sick leaves and presenteeism [26].

While employer organisations and their support of occupational health programs play an important role in improving work outcomes, other factors also mitigate adverse effect of reduced work ability on work outcomes. Flexibility is not important just in employer organizations, but also on the labour market at large, which involves labour code, industrial relations and active labour market policies (ALMPs) that include various measures, from training to job search assistance, subsidies, supported employment opportunities and programs to support entrepreneurial activities. Such measures enable occupational horizontal and vertical mobility [39], [40]. Other national employment policies, besides ALMP, may be important to facilitate (via regulation) and promote inclusive workplace practices and ensure that individuals are not excluded from job opportunities [41]. Lastly, passive supports as well as social security at large are relevant. Social security systems, including sick leave policies and disability insurance, provide essential financial support to individuals who are temporarily or permanently unable to work due to illness [41].

3 Conclusion

The paper proposes a conceptual framework that shows complex links between health determinants, health outcomes, work ability and work outcomes and their interplay with various incentives aimed at improving both health and work outcomes. It highlights the significance of modifiable and non-modifiable health factors that influence adverse health effects of chronic illnesses and the resulting functional independence, work ability and work outcomes. It emphasises the role of supportive work environments, health-oriented policies, and mechanisms that facilitate retention and RTW. The research highlights that improving work outcomes requires a complex approach involving individual, social, and environmental interventions, as well as policies that promote inclusive employment practices. This framework serves as a valuable tool for understanding how health and workplace factors interplay to improve long-term employability, particularly in aging populations or individuals with chronic conditions. It can serve as a foundation for future empirical research, literature review and policy preparation.

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Ko tempo sestavina v stopnji celotne rodnosti izzveni

When tempo component in the total fertility rate fades away

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Povzetek

Sredi 1980-ih let je začela povprečna starost matere ob rojstvu otroka hitro naraščati. To znižuje stopnjo celotne rodnosti, ki kaže, koliko otrok bi rodila ena ženska, če bi dočakala konec svoje rodne dobe in bi bila rodnost v posameznem njenem letu starosti takšna, kot je v izbranem letu pri drugih ženskah v posamezni starosti rodne dobe. Stopnja celotne rodnosti v takih razmerah sicer ustrezno odraža raven rodnosti v izbranem letu, vendar pa ne kaže ustrezno preferenc ljudi o številu otrok (omejenih s stvarnostjo). Število otrok, ki jih bodo ženske imele tekom svoje rodne dobe oziroma življenja, je v takih razmerah višje, le da ljudje odložijo rodnost v višjo starost in jih stopnja celotne rodnosti v tekočem letu ne zajame. V članku izračunamo prilagojeno stopnjo celotne rodnosti s pomočjo Bongaarts-Feeney metode in jo na ta način očistimo tempo učinka (angl. *tempo effect*), da vidimo ločeno učinek ravni (angl. *quantum effect*). Izkaže se, da tudi v letih okrog leta 2023, ko je bila stopnja celotne rodnosti zgolj okrog 1,2, prilagojena stopnja celotne rodnosti praktično ni upadla pod raven 1,6 otroka na žensko. V zadnjih petih letih pa se je naraščanje povprečne starosti mater ob rojstvu otroka povsem ustalilo na vrednosti 31,1 leta [1]. To pomeni, da negativnega »tempo« učinka na stopnjo celotne rodnosti ni več, temveč je samo še »quantum« učinek. Ker je stopnja celotne rodnosti (in s tem hkrati tudi prilagojena stopnja celotne rodnosti) upadla z 1,64 v letu 2021 na 1,55 v letu 2022 in nadalje na zgolj 1,51 v letu 2023, to pomeni najnižjo rodnost v zgodovini Slovenije, kar se tiče števila otrok, ki jih ljudje imajo v svojem življenju. Samo upamo lahko, da se rodnost ne bo na tej nizki ravni ustalila ali da bi se celo nadaljeval omenjeni trend upadanja iz zadnjih treh let.

Ključne besede

Rodnost, demografija, stopnja celotne rodnosti, obnavljanje prebivalstva, Slovenija

Abstract

In the mid-1980s, the average age of mothers at childbirth began to rise rapidly. This lowers the “total fertility rate” indicator, which shows how many children a woman would have if she reached the end of her reproductive age and if fertility in each of her years of age was the same as in the selected year for other women of the same age. The total fertility rate in such circumstances appropriately reflects the level of fertility in the selected year but does not show people’s preferences for the number of children, which are higher, only that people postpone childbirth to an older age, and the total fertility rate in the current year does not capture them. In the article, we calculate the adjusted total fertility rate using the Bongaarts-Feeney method by removing the ‘tempo effect’ from the total fertility rate to see the separate level effect (‘quantum effect’). It turns out that even in the years around 2023, when the total fertility rate was only around 1.2, the adjusted total fertility rate practically did not fall below the level of 1.6 children per woman. In the last five years, however, the increase in the average age of mothers at childbirth has completely stabilized at 31.1 years [1]. This means that the negative “tempo” effect on the total fertility rate is no longer present, but only the “quantum” effect remains. Since the total fertility rate (and thus also the adjusted total fertility rate) fell from 1.64 in 2021 to 1.55 in 2022 and further to only 1.51 in 2023, this means the lowest fertility in the history of Slovenia in terms of the number of children people have in their lifetime. We can only hope that fertility will not stabilize at this low level or that the mentioned declining trend of the recent three years will not even continue.

Keywords

Fertility, demography, total fertility rate, population replacement, Slovenia

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1 Uvod

Leta 1998 sta Bongaarts in Feeney [2] objavila članek, v katerem sta želela ponuditi splošno sprejeto metodo za izločanje tempo učinka iz kazalnika stopnje celotne rodnosti. Pred tem so se že pol stoletja demografi zavedali, da je stopnja celotne rodnosti kot ustaljen demografski kazalnik popačena, če se starost žensk ob porodu spreminja, vendar so čakali na ustrezno metodo za izločitev tega dejavnika.

Da bi lahko raven rodnosti primerjali med državami in skozi čas, je potrebno oblikovati ustrezen kazalnik. Primerjava absolutnega števila živorojenih med posameznimi državami in v času ne bi imela smisla, saj je število živorojenih močno odvisno od števila prebivalcev. Če delimo število živorojenih s številom prebivalcev, dobimo splošno stopnjo natalitete:

$$n = \frac{N}{P} * 1000\ , \qquad (1)$$

pri čemer je N število živorojenih v nekem obdobju (po navadi v enem letu), P pa je število prebivalcev v sredini tega obdobja (ali povprečje v tem obdobju). Problem tega kazalnika je dvojen.

Prvič, primerjava tega kazalnika med različnimi državami nima smisla, ker je pod vplivom različne starostne strukture dveh prebivalstev. To je še posebej problematično, če primerjamo razvite in manj razvite države. Manj razvite države imajo mnogo večji delež mladih oseb, starih npr. 3 leta, 7 let, 10 let itd. Ti prebivalci znižujejo vrednost kazalnika n, čeprav ne morejo vplivati na velikost števca (torej na število živorojenih, N), saj niso sposobni rojevati. Po drugi strani je v razvitih državah mnogo večji delež starih oseb v starosti npr. 60 let, 70 let, 80 let itd. Tudi ti prebivalci niso sposobni rojevati, kar pomeni, da ne morejo vplivati na velikost števca v enačbi (1), torej na število živorojenih. Se pravi, da neupravičeno znižujejo vrednost kazalniku splošna stopnja natalitete (n) v razvitih državah z vidika ravni rodnosti, za katero ugotavljamo, ali je dovolj visoka za obnavljanje prebivalstva ali ne. Drugič, konkretna vrednost tega kazalnika sama po sebi ni zgovorna glede tega, ali dobljeni rezultat predstavlja dovolj visoko ali nizko raven rodnosti, ki bo zagotavljala obnavljanje prebivalstva na dolgi rok ali ne.

Naslednji kazalnik pri iskanju ustreznega kazalnika je stopnja celotne rodnosti:

$$f = \frac{N}{\sum_{35} V_{f,15}} \cdot 1000, \qquad (2)$$

pri čemer je V_f oznaka za število žensk, 15 je začetek starostnega razreda, 35 pa širina starostnega razreda, ki je v tem primeru celotna rodna doba. V števcu so torej namesto vseh prebivalcev tokrat samo ženske v starosti 15–49 let (tj. ženske v rodni dobi). Gre torej za del prebivalstva, ki je v splošnem sposoben rojevati, kar pomeni, da lahko vpliva na velikost števca (tj. na število živorojenih). Še vedno pa deloma ostane prisoten problem različne starostne strukture – tokrat starostne porazdelitve žensk znotraj starostnega razreda 15–49 let. Ostane tudi problem (ne)zgovornosti samega kazalnika glede ravni rodnosti, ali ta zagotavlja obnavljanje prebivalstva ali ne.

Naslednji korak pri iskanju našega zgovornega kazalnika rodnosti, ki bi kazal, ali je rodnost dovolj visoka za obnavljanje prebivalstva ali ne, so starostno specifične stopnje rodnosti. Enačba je praktično enaka kot enačba (2), le da izračunamo stopnjo rodnosti posebej za vsako starost med 15. in 49. letom starosti:

$$f_x = \frac{N_x}{\sum_{} V_{f,x}} \cdot 1000\ , \qquad (3)$$

Te vrednosti so zanimive same po sebi, saj kažejo, 1) koliko posamezni starostni razredi žensk prispevajo k reprodukciji prebivalstva, 2) so osnova za izračun tablic rodnosti, saj približno izražajo verjetnost rojstva otroka v odvisnosti od starosti žensk in 3) iz njih lahko izračunamo stopnjo celotne rodnosti, kar bomo izvedli v nadaljevanju.

2 Stopnja celotne rodnosti

Stopnjo celotne rodnosti izračunamo kot vsoto vseh 35 starostno specifičnih stopenj rodnosti:

$$T_f = \frac{\sum f_x}{1000}, \qquad (4)$$

pri čemer T_f označuje stopnjo celotne rodnosti, f_x pa označuje starostno specifične stopnje rodnosti (pri čemer x predstavlja vrednosti od 15. do 49. leta starosti), ki kažejo raven rodnosti v posamezni starosti. Deljenje s konstanto 1000 povrne kazalnik v osnovno obliko, ki kaže število otrok, medtem ko so vrednosti f_x izražene na 1000 žensk – glej enačbo (3).

Ideja torej je, da seštejemo stopnje rodnosti v posamezni starosti skozi celotno rodno dobo. To pomeni, da dobimo število otrok, ki bi jih rodila ena ženska v svoji rodni dobi, če bi imela v svoji posamezni starosti takšno rodnost, kot so jo imele druge ženske v posameznih starostih med 15. in 49. letom v analiziranem koledarskem letu. Hkrati je implicitno prisotna predpostavka, da ta ženska dočaka konec rodne dobe – torej, da ne bo umrla do konca svoje rodne dobe. Žensk, ki so že umrle v preteklosti, namreč pri izračunu starostno specifičnih stopenj rodnosti v imenovalcu ne upoštevamo.

Kazalnik stopnja celotne rodnosti nam tako kaže število otrok, ki bi jih rodila ena ženska v svoji rodni dobi, če bi dočakala konec rodne dobe in bi v njeni posamezni starosti vladale take zakonitosti rojevanja, kot so veljale pri drugih ženskah v posameznih starostih rodne dobe v koledarskem letu, za katero stopnjo celotne rodnosti računamo. Ta kazalnik je končno zelo zgovoren sam po sebi, ki ima tudi jasno mejo, ali se bo ob taki rodnosti (v odsotnosti selitev) število prebivalstva na dolgi rok obnavljalo ali ne. Ta vrednost je za razvite države, kamor spada tudi Slovenija, 2,1 otroka na žensko.

Zakaj mora znašati rodnost nekoliko več kot 2 otroka na žensko, da bi se zagotavljala enostavna reprodukcija prebivalstva, kar pomeni, da bi se prebivalstvo na dolgi rok ravno obnavljalo (ne pa naraščalo ali upadalo)? Če imamo pred očmi tipičen par moškega in ženske, ki ima dečka in deklico: zakaj ta dva otroka nista dovolj za obnavljanje prebivalstva na dolgi rok? Fantek nadomesti očeta, deklica nadomesti mater in obnovitev prebivalstva za naslednji rod bi morala biti zagotovljena, a ne? Prvi razlog, da dva otroka nista dovolj, je to, da se med vsemi živorojenimi otroci rodi več fantkov kot deklic. Delež fantkov je okrog 51,5 %, medtem ko je delež deklic zgolj preostalih okrog

48,5 %. Ta deleža sta tako stabilna, da se razmerju med dečki in deklicami ob rojstvu pravi celo demografska konstanta [3], str. 15. Ženska mora torej v povprečju roditi nekoliko več kot dva otroka, da v povprečju rodi eno deklico in s tem nadomesti samo sebe.

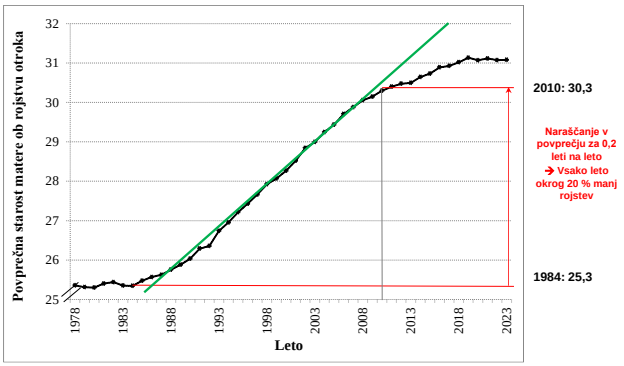
Drugi razlog, da stopnja celotne rodnosti 2,1 ni dovolj za obnavljanje prebivalstva, pa je že prej omenjena umrljivost žensk, preden dočakajo konec rodne dobe. Čeprav bi ena ženska rodila v povprečju eno deklico, to še ne bi bilo dovolj, saj ta deklica žal lahko umre v starosti npr. 0 let, 3 leta, 10 let itd., še preden se uspe reproducirati za naslednji rod. Večja kot je umrljivost žensk pred koncem rodne dobe, večja mora biti stopnja celotne rodnosti, da bo dovolj za obnavljanje prebivalstva na dolgi rok. Zgolj iz podatkov o številu živorojenih in številu žensk v posamezni starosti tega ne moremo ugotoviti, saj podatki vsebujejo samo ženske, ki so še žive, ne vidimo pa tistih žensk, ki so medtem že umrle. Ustrezen kazalnik, ki nam poda to informacijo, je število živih v začetku posamezne starosti (l_x) iz tablic umrljivosti. Ta kazalnik prikazuje, kolikšen delež žensk bi bil še živ v posamezni starosti, če bi bile tekom celotnega življenja žensk prisotne take razmere glede umrljivosti kot so bile prisotne v času oblikovanja tablic umrljivosti. Tablice umrljivosti so namreč model, ki na (običajno) sto tisoč v danem trenutku živorojenih otrok s posameznimi kazalniki tablic umrljivosti prikazujejo proces njihovega umiranja v odvisnosti od starosti [3], str. 120. Najnovejše tablice umrljivosti za Slovenijo kažejo, da bi ob razmerah iz leta 2022 več kot 99 % žensk dočakalo starost 41 let [4], to je starost, v kateri je velika večina rodnosti pri ženskah že zaključena. V letu 2023 se je namreč materam po tej starosti rodilo samo še 2,9 % vseh živorojenih otrok [5]. Vidimo, da je umrljivost žensk v Sloveniji, zelo nizka in zato iz tega naslova ni treba, da bi bila vrednost stopnje celotne rodnosti višja od 2,1. V kaki afriški državi pa celo stopnja celotne rodnosti 2,3 ne bi bila dovolj, saj je umrljivost žensk oz. deklic tam žal še vedno zelo visoka.

Stopnja celotne rodnosti naj bi torej v Sloveniji in drugih razvitih državah kazala raven rodnosti in obnavljanje prebivalstva na dolgi rok v odsotnosti selitev, pri čemer je potrebna vrednost za obnavljanje prebivalstva 2,1 otroka na žensko. Za številne demografske analize je to kljub vsemu povsem ustrezen demografski kazalnik, ki se odraža tudi v številu rojstev v posameznem koledarskem letu, iz tako izražene rodnosti potem tudi izhaja starostna porazdelitev prebivalcev v prihodnje itd.

Problem pa nastane, če tako izračunano stopnjo celotne rodnosti razlagamo v smislu dokončne stopnje celotne rodnosti [3], str. 42 (angl. *completed fertility*), torej v smislu števila otrok, jih bodo posamezne kohorte žensk rodile tekom svoje rodne dobe oz. svojega življenja.

Najbolj natančno sliko o tem, koliko otrok je posamezna kohorta žensk imela tekom svoje rodne dobe, dobimo, če kohorto žensk spremljamo od začetka do konca njihove rodne dobe. Ta »vzdolžni« kazalnik rodnosti, ki ga, kot omenjeno, imenujemo dokončna stopnja celotne rodnosti, ima vsekakor svoje mesto v analizah, vendar pa je velika pomanjkljivost tega kazalnika njegova ažurnost. Čakati moramo namreč do 50. leta starosti žensk neke kohorte, da lahko zaključimo, koliko otrok so te ženske rodile v svoji rodni dobi. To pomeni, da ne bomo videli neke ažurne slike rodnosti v državi, temveč bomo videli rodnost za ženske, ki so se rodile pred 50 leti in so imele vrhunec svoje rodne dobe pred približno 20 leti. Tako lahko npr. za Slovenijo odčitamo, da so ženske, ki so bile v letu 2021 stare 50 let, tekom svoje rodne dobe rodile v povprečju 1,77 otroka [6].

Če pa želimo čim bolj ažurne vrednosti, kaj se dogaja z rodnostjo, moramo namesto na »vzdolžni« kazalnik pristati na »prečni« kazalnik, ki smo ga predstavili v enačbi (4). Problem pa nastane, če se ob tem povprečna starost mater spreminja. Kot vidimo, je bilo temu v preteklosti dejansko tako. Slika 1 prikazuje, da se je povprečna starost matere ob rojstvu otroka od leta 1984 do leta 2010 povišala s 25,3 let na 30,3 let. To pomeni, da je naraščala približno 0,2 leta na leto.



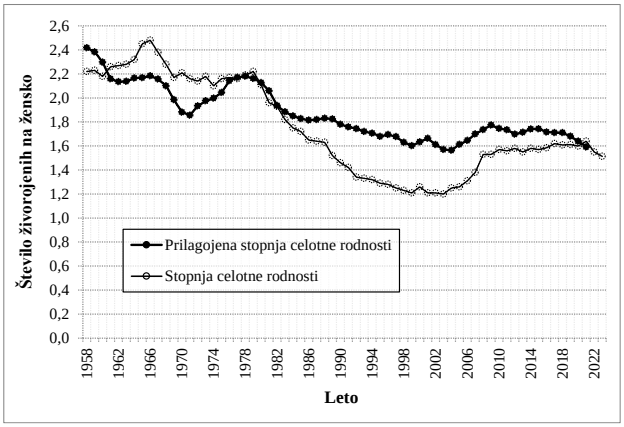
Slika 1: Gibanje povprečne starosti matere ob rojstvu otroka v Sloveniji v obdobju 1978–2023. Vir: [5].

Iz tega sledi, da se je v tekočem letu realiziralo samo 80 % vseh rojstev, medtem ko so preostala rojstva preložena v prihodnje koledarsko leto. Vendar pa z vidika »vzdolžne« oz. dokončne rodnosti, ki jo bomo lahko ugotavljali šele čez vrsto let, to ne pomeni, da bo ženska imela v svoji celotni rodni dobi število otrok na ravni 80 %, temveč na ravni 100 % – le da bo imela otroke v nekoliko višji starosti. Zaradi analize celotne rodnosti na osnovi »prečne« analize in interpretaciji v smislu »vzdolžne« analize torej močno podcenimo število otrok, ki jih bo ženska imela v svoji rodni dobi.

3 (Tempo) prilagojena stopnja celotne rodnosti

Bongaarts-Feeneyeva metoda je preprosta in razumljiva metoda za razmejitev učinka odlaganja rodnosti (»tempo« učinka) od učinka ravni (»quantum« učinka). V tem našem primeru metoda postavi omenjenih 80 % kot novo osnovo, za večjo natančnost to izvede ločeno po redih rojstva, hkrati pa za izločitev slučajnega dejavnika uporabi drseče povprečje. Za podrobnejšo razlago glej Bongaarts in Feeney [2].

Na sliki 2 sta prikazani obe stopnji celotne rodnosti: običajna stopnja celotne rodnosti in (tempo) prilagojeno stopnja celotne rodnosti (angl. *tempo adjusted total fertility rate*), ki smo jo izračunali na osnovi podatkov o številu žensk v posamezni starosti in števila živorojenih otrok materam v posamezni starosti, ki so hkrati razčlenjeni po redu rojstva (1, 2, 3, in 4+). Pri tem smo uporabili podatke Statističnega urada RS (tudi interne podatke, saj vseh potrebnih podatkov na domači strani Statistični urad RS več ne objavlja).



Slika 2: Gibanje stopnje celotne rodnosti in (tempo) prilagojene stopnje celotne rodnosti v Sloveniji v obdobju 1958–2023. Vir: [5] (različna leta); lastni izračuni.

Razlika med obema prikazanima stopnjama je začela vredno bolj naraščati od sredine 1980-ih let, ko je začela povprečna starost matere ob rojstvu otroka hitro naraščati (slika 1). Ko se je začela rast upočasnjevati (med letoma 2005 in 2010), se je začela izračunana tempo prilagojena stopnja celotne rodnosti približevati stopnji celotne rodnosti in se je v zadnjih letih povsem izenačila z njo. Naraščanje povprečne starosti matere ob rojstvu otroka se je namreč povsem ustavilo – v zadnjih petih letih (od 2019 do 2023) namreč že ves čas znaša 31,1 let [1].Tempo sestavina v stopnji celotne rodnosti je torej izzvenela.

Kaj to pomeni za vsebinsko analizo rodnosti? Glede števila živorojenih v posameznem koledarskem letu in posledično za strukturo prebivalstva v prihodnje ipd. ostane vse enako. Gre za prečni kazalnik, ki kaže trenutno raven rodnosti. Moramo pa biti previdni pri njegovi interpretaciji v duhu vzdolžnega kazalnika – torej, koliko otrok bi ena ženska dejansko rodila tekom svoje rodne dobe ob trenutnih vzorcih rodnosti. V tem primeru bi npr. v letu 2003 napačno sklepali, da bo ženska tekom svoje rodne dobe imela v povprečju zgolj 1,2 otroka.

Po eni strani je ta naša ugotovitev dobra novica. To namreč pomeni, da si ženske (skupaj z njihovimi partnerji) nikoli niso želele (skupaj z omejitvami glede realizacije svojih želja) tako zelo nizkega števila otrok, kot je to kazala stopnja celotne rodnosti – npr. zgolj 1,2 otroka v letu 2003. Tudi v teh letih, ko je bila stopnja celotne rodnosti tako zelo nizka, so preference glede števila otrok (skupaj z omejitvami glede njihove realizacije) bile še vedno okrog 1,6 otroka (glej sliko 2).

Slabi novici pa sta ob tem dve. Prva slaba novica je, da so te zelo nizke vrednosti stopnje celotne rodnosti (v primerjavi s tempo prilagojenimi vrednostmi stopnje celotne rodnosti) vseeno vodile do nizkega absolutnega števila živorojenih v obdobju razkoraka med tema dvema kazalnikoma. V omenjenega četrt stoletja, ko je povprečna starost mater ob rojstvu otroka naraščala najhitreje (približno za 0,2 leti na leto), se je namesto okrog 25 tisoč živorojenih letno rojevalo samo okrog 20 tisoč živorojenih. Teh izgubljenih 125 tisoč živorojenih v samo teh 25 letih je trajno izgubljenih in se ne pričakuje, da bi se ta rojstva kdaj naknadno realizirala, saj se ne pričakuje, da bi se povprečna starost mater ob rojstvu otroka v prihodnje začela nazaj zniževati.

Druga negativna novica pa je odločen upad stopnje celotne rodnosti v zadnjih dveh letih. Iz ravni 1,64 otroka v letu 2021 se je namreč v letu 2022 znižala na 1,55 otroka, v letu 2023 pa celo na samo 1,51 otroka. Ker je povprečna starost mater ob rojstvu otroka že zadnjih pet let nespremenjena (31,1 let), to pomeni, da gre za dejanski upad v ravni rodnosti (quantum učinek), kar se tiče preferenc ljudi (skupaj z omejitvami glede njihove realizacije).

4 Diskusija

V analizi smo ugotovili, da smo v zadnjih dveh letih (2022 in 2023) priča najnižji rodnosti v zgodovini Slovenije z vidika preferenc žensk in moških (skupaj z omejitvami glede njihove realizacije) o številu otrok. Ta najnižja tempo prilagojena stopnja celotne rodnosti ima nadalje še celo negativen trend, če si dovolimo razmišljati o trendu na osnovi zgolj treh vrednosti (2021–2023). Upajmo, da sta vrednosti za leti 2022 in 2023 zgolj naključni nihljaj navzdol, ne pa raven, ki bi se v prihodnje ohranjala ali da bi celo šlo za začetek trenda nadaljnjega upadanja. V letih okrog leta 2003 so sicer bile vrednosti stopnje celotne rodnosti bistveno nižje (zgolj okrog 1,2), ampak predvsem zaradi hitrega odlaganja rodnosti v višjo starost. Z upoštevanjem tega popravka rodnost takrat praktično nikoli ni upadla pod raven 1,6 otroka. V zadnjih petih letih (2019 do 2023) je tempo učinek izzvenel in te tolažbe ni več. Priča smo najnižji prilagojeni stopnji celotne rodnosti v zgodovini Slovenije, ki se je medtem zaradi neugodne starostne strukture žensk v rodni dobi tudi že odrazila v najnižjem absolutnem številu živorojenih v zgodovini Slovenije. V letu 2023 je število živorojenih namreč prvič upadlo pod 17 tisoč [1].

Zahvala

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Zbornik 27. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2024

Zvezek G

Proceedings of the 27th International Multiconference

INFORMATION SOCIETY – IS 2024

Volume G

Vzgoja in izobraževanje v informacijski družbi
Education in Information Society

Urednika / Editors

Uroš Rajkovič, Borut Batagelj

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Ljubljana, Slovenia

PREDGOVOR

Pred vami je zbornik 27. konference Vzgoja in izobraževanje v informacijski družbi – VIVID 2024, ki se je odvijala 11. oktobra 2024 na Institutu Jožef Stefan v Ljubljani. Letos je bilo sprejetih preko 60 prispevkov, ki pokrivajo širok spekter aktualnih tem s področja vzgoje in izobraževanja v informacijski družbi.

S hitro napredujočo digitalno preobrazbo, ki vpliva na vsakdanje pedagoške procese, je rdeča nit letošnje konference raziskovanje novih pristopov pri uporabi informacijsko-komunikacijskih tehnologij, vključno s hibridnimi modeli izobraževanja, personalizacijo učnih vsebin ter vključevanjem umetne inteligence v izobraževalne procese.

Skozi leta smo si prizadevali ustvariti okolje, kjer se prepletajo ideje, izkušnje in spoznanja z različnih stopenj izobraževanja – od predšolske vzgoje do univerzitetnega in vseživljenjskega učenja. Letos ni izjema. Še naprej razvijamo rešitve, ki ne le sledijo trenutnim trendom, ampak postavljajo temelje za izobraževalno prihodnost, v kateri bo tehnologija podpirala inovativne pristope k poučevanju in učenju.

Ta konferenca ni le prostor za izmenjavo najnovejših dognanj in praks, temveč tudi priložnost za oblikovanje novih povezav, izmenjavo izkušenj in razvoj svežih zamisli, ki bodo krojile prihodnost izobraževanja. Prispevki, predstavljeni na konferenci, so dragocen doprinos k razvoju informacijske družbe in k premisleku o prihodnosti izobraževanja.

Naj vam ta zbornik služi kot vir navdiha in strokovnega znanja, ki bo spodbudil nadaljnje raziskovanje ter inovacije na področju vzgoje in izobraževanja v digitalni dobi.

Uredniški odbor

FOREWORD

Here are the proceedings of the 27th conference Education in the Information Society – VIVID 2024, which took place on October 11, 2024, at the Jožef Stefan Institute in Ljubljana. This year, over 60 papers have been accepted, covering a wide range of current topics in the field of education in the information society.

With the rapidly advancing digital transformation impacting everyday pedagogical processes, the main theme of this year's conference is the exploration of new approaches to the use of information and communication technologies, including hybrid education models, personalized learning content, and the integration of artificial intelligence into educational processes.

Over the years, we have strived to create an environment where ideas, experiences, and knowledge from various levels of education—ranging from preschool to university and lifelong learning—intertwine. This year is no exception. We continue to develop solutions that not only follow current trends but also lay the foundation for an educational future where technology supports innovative approaches to teaching and learning.

This conference is not only a platform for sharing the latest findings and practices but also an opportunity to forge new connections, exchange experiences, and develop fresh ideas that will shape the future of education. The papers presented at the conference are a valuable contribution to the development of the information society and to the reflection on the future of education.

May this proceedings serve as a source of inspiration and expertise, encouraging further research and innovation in the field of education in the digital age.

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Optimizacija praktičnega pouka digitalne tehnike z avtomatskim testiranjem integriranih vezij

Optimization of Practical Lessons at Digital Electronics Using Automated Integrated Circuit Testing

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POVZETEK

V članku je predstavljen problem porabe časa pri testiranju integriranih vezij med praktičnim poukom digitalne tehnike. Učitelj mora ročno preveriti vse možne vhodne kombinacije na vseh logičnih vratih znotraj integriranega vezja, kar je lahko precej zamudno. Z namenom rešitve tega problema je bil izdelan sistem za avtomatsko testiranje integriranih vezij. Le-ta nam omogoča, da v uporabniškem vmesniku izberemo oznako vezja, ki ga želimo testirati. Integrirano vezje namestimo na ustrezno mesto na testni plošči, nato pa program sam preveri vse možne kombinacije in nam preko virtualnih barvnih indikatorjev javi pravilnost delovanja posameznih logičnih vrat znotraj integriranega vezja. Na ta način smo čas testiranja skrajšali za približno 20-krat.

KLJUČNE BESEDE

Integrirano vezje, avtomatsko testiranje, digitalna tehnika, praktični pouk, Arduino, Labview, optimizacija

ABSTRACT

The article presents the problem of time consumption in the testing of integrated circuits during the practical lessons of digital electronics. The teacher must manually check all possible input combinations on all logic gates within the IC, which can be quite time-consuming. This allows us to select the label of the circuit we want to test in the user interface. We place the integrated circuit in the appropriate place on the test board, and then the program itself checks all possible combinations and informs us via virtual color indicators of the correct operation of the individual logic gates inside the integrated circuit. In this way, we reduced the testing time by about 20 times.

KEYWORDS

Integrated circuit, automated testing, digital electronics, practical lessons, Arduino, Labview, optimization

1 UVOD

Pri praktičnem pouku strokovnega modula Digitalna tehnika dijaki izdelujejo vezja, ki so sestavljena iz integriranih vezij oz. čipov [1]. Pomembno je zagotoviti nemoten proces praktičnega pouka. Dijaki običajno v primeru težav pokličejo učitelja. Le-ta preveri delovanje in identificira kje je napaka. Pri tem mora biti hiter in učinkovit, saj lahko na njegovo pomoč že čakajo drugi dijaki. S tem namenom je smiselno določene postopke avtomatizirati in s tem izboljšati učinkovitost in hitrost učnega procesa. V nadaljevanju je prikazan potek praktičnega pouka in težave s katerimi se soočamo. Predstavljen je sistem za avtomatsko testiranje integriranih vezij, ki je bil razvit z namenom izboljšanja in pohitritve procesa praktičnega pouka digitalne tehnike.

2 POTEK PRAKTIČNEGA POUKA

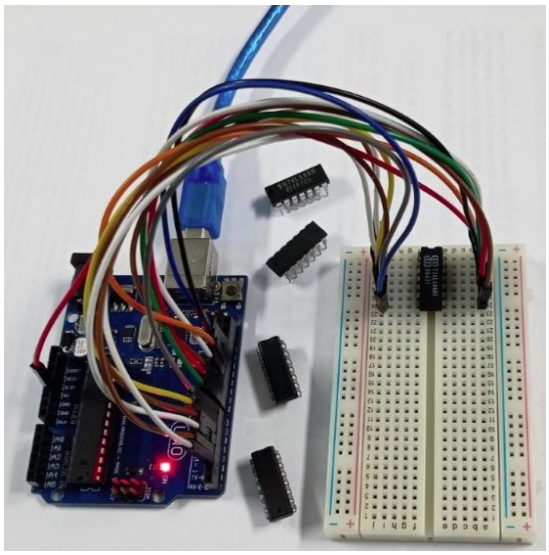
Vsebina praktičnega pouka digitalne tehnike je razdeljena na tri dele. V prvem delu dijaki spoznavajo integrirana vezja, ki vsebujejo logična vrata. Naučijo se kako poiskati dokumentacijo integriranih vezij in iz nje razbrati pomembne podatke. Najprej na testni plošči preizkušajo delovanje posameznih čipov, kasneje pa izdelujejo tudi logična vezja, ki so sestavljena iz več čipov. Glede na to, da se dijaki prvič srečajo z uporabo čipov, se verjetnost napak precej poveča. Napake, s katerimi se pogosto soočajo so: oznaka na čipu ni bila preverjena, odlomljen ali ukrivljen pin, nedelujoča vrata ali celoten čip, previsoka napajalna napetost, zamenjana polariteta napajalne napetosti, uničena svetleča dioda (LED), narobe obrnjena LED, slab stik …

Med učnim procesom dijak v primeru težav pokliče učitelja. Učitelj preveri ali so čipi pravilno povezani. Če kljub temu vezje ne deluje, se ugotavlja kateri čip oz. vrata znotraj čipa ne delujejo. Slednje je lahko zamudno, sploh, če vezje vsebuje večje število čipov oz. logičnih vrat. Učitelj mora ročno preveriti vse možne vhodne kombinacije na posameznih logičnih vratih. Z namenom rešitve tega problema, smo prišli na idejo, da bi postopek preverjanja delovanja posameznih logičnih vrat avtomatizirali. Za primerjavo vzemimo čas, ki ga učitelj porabi, da ročno preveri ali čip deluje in čas, ki se ga porabi z uporabo sistema za avtomatsko testiranje čipov. V prvem primeru je potrebno na posameznih vratih izvesti štiri vhodne kombinacije (00, 01, 10, 11) in opazovati izhod preko LED. Nato je potrebno postopek ponoviti tolikokrat, kolikor je vrat v čipu. Običajno uporabljamo čipe s štirimi 2-vhodnimi vrati. V drugem primeru pa namestimo čip na ustrezno mesto na testni plošči, v aplikaciji preko spustnega seznama izberemo kateri čip bomo testirali, kliknemo virtualni gumb “testiraj” in

čez manj kot sekundo dobimo rezultate. Vse skupaj nam vzame največ 10 sekund časa na posamezen čip. V primeru ročnega testiranja bi porabili približno tri minute. Torej smo čas, ki je potreben za ugotavljanje napake, skrajšali za približno 20-krat.

3 SISTEM ZA TESTIRANJE VEZIJ

Sistem sestavlja mikrokrmilniška razvojna plošča Arduino [2], ki je z žičkami povezana s testno ploščo, kamor namestimo integrirano vezje (Slika 1). Sistem je povezan na računalnik z USB-kablom, ki služi za napajanje in komunikacijo. Uporabniški vmesnik je bil razvit v programskem okolju Labview [3].

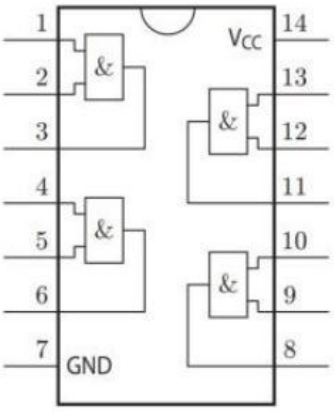


Slika 1: Sistem za testiranje vezij

Aplikacija nam omogoča izbiro čipa, ki ga želimo testirati. Z virtualnim gumbom "testiraj" sprožimo proces testiranja. V primeru pravilnega delovanja posameznih logičnih vrat se indikator obarva zeleno, sicer pa rdeče. Izbirati je možno med petimi različnimi čipi (7400, 7402, 7432, 7486, 7408), ki vsebujejo različna logična vrata (Slika 2).

Slika 2: Izbira čipov v okolju Labview

Oglejmo si primer testiranja čipa z oznako 7408, ki vsebuje štiri 2-vhodna IN (AND) vrata (Slika 3).



Slika 3: Integrirano vezje 7408 z logičnimi vrati IN (AND)

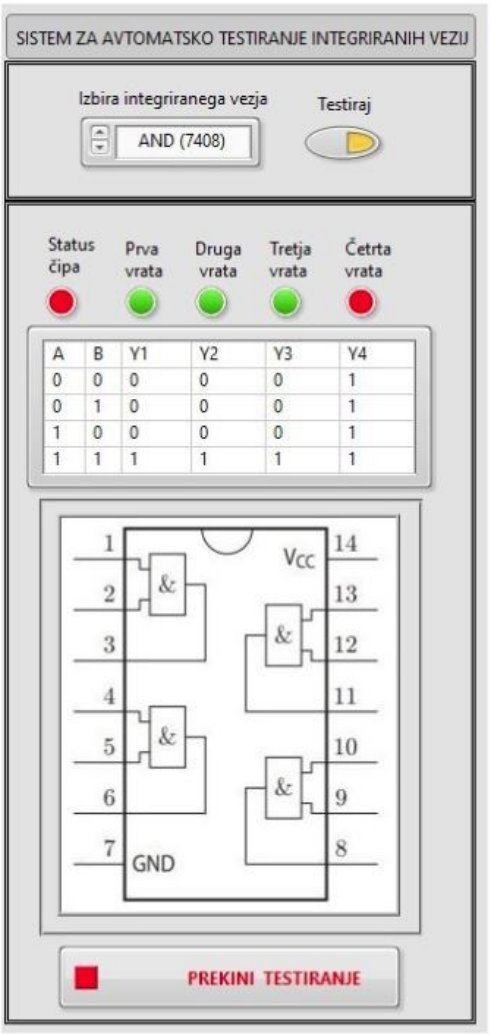
Logična funkcija AND (IN) na svojem izhodu vrne logično 1, če so vsi vhodi enaki 1. V našem primeru bo logično 1 predstavljala napetost 5 V, logično 0 pa napetost 0 V. Glede na to, da imamo dva vhoda, bomo imeli štiri vhodne kombinacije ničel in enic. Pravilnostna tabela prikazuje vse možne vhodne kombinacije in pripadajoč izhod (Tabela 1) .

Tabela 1: Pravilnostna tabela funkcije AND (IN)

Vhod A	Vhod B	Izhod Y
0	0	0
0	1	0
1	0	0
1	1	1

Pri testiranju logičnih vrat moramo na vhodih generirati vse štiri možne kombinacije in opazovati izhodno vrednost. Izhod bo 1, če bosta oba vhoda enaka 1. V ostalih primerih mora biti izhod 0.

Program, ki se izvaja na mikrokrmilniški plošči Arduino, na svojih digitalnih izhodih generira vse možne kombinacije ničel in enic. Nato preko digitalnih vhodov prebere izhodne vrednosti posameznih logičnih vrat čipa. Rezultati se preko USB-povezave posredujejo računalniku, kjer je nameščeno okolje Labview. Le-to nam služi za prikaz rezultatov testiranja. Dejanske izhodne vrednosti logičnih vrat se primerjajo z želenimi in v primeru odstopanj se indikator obarva rdeče, kar označuje nepravilno delovanje vrat. V našem primeru opazimo, da četrta vrata ne delujejo pravilno, saj dobimo na izhodu same enice (Slika 4). Pri vsakem izbranem čipu se prikaže tudi ustrezna shema. Testiranje pa se prekine s klikom na gumb "prekini testiranje".



Slika 4: Testiranje čipa 7408

4 MOŽNOSTI NADGRADNJE

Sistem bi lahko nadgradili tako, da bi razširili nabor čipov. Zanimivo bi bilo narediti samodejno razpoznavanje logičnih vrat, brez, da bi vnaprej preko spustnega seznama izbrali čip. Rezultati testiranja bi se lahko shranjevali v posebno tabelo ali tekstovno datoteko. Alternativo uporabniškemu vmesniku bi lahko predstavljalo vezje na testni plošči, kjer bi s tipkami izbrali ustrezna vrata in LED, ki bi signalizirale pravilnost delovanja. V tem primeru ne bi potrebovali računalnika s programskim okoljem.

5 ZAKLJUČEK

Dijaki so pozitivno sprejeli sistem za testiranje. V primeru, da se jim zdi, da je s čipom kaj narobe, ga prinesejo učitelju, ki izvede avtomatsko testiranje. Na ta način hitro dobijo povratno informacijo, kje je vzrok nepravilno delujočega vezja. Dostikrat pa samo iščejo potrditev svojih opažanj. Npr. “Se mi je zdelo, da četrta vrata ne delujejo.” oz. “Sedaj vem, da čip deluje. Verjetno sem nekaj narobe povezal.”

Uspelo nam je torej izdelati avtomatski sistem, ki je pohitril proces iskanja napak, izboljšal potek izvajanja praktičnih vaj in razbremenil učitelja.

VIRI

[1] Integrirano vezje. Dostopno na naslovu https://sl.wikipedia.org/wiki/Integrirano vezje (17. 8. 2024)
[2] Arduino. Dostopno na naslovu www.arduino.cc (17. 8. 2024)
[3] Labview. Dostopno na naslovu www.ni.com (17. 8. 2024)

Codeium kot podporni asistent v poučevanju programiranja

Codeium as a Support Assistant in Teaching Programming

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POVZETEK

V prispevku predstavljamo orodje za programiranje v oblaku, ki temelji na vodilnih odprtokodnih modelih, podprto z generativno umetno inteligenco, imenovano Codeium, za podporo učiteljem in dijakom pri poučevanju in učenju osnov programiranja. Codeium v osnovi ponuja funkcije klepeta in poziva h kodi za generiranje programske kode. Ta funkcionalnost se osredotoča na generiranje kode iz besedilnih vnosov, kar omogoča generiranje besedila v kodo znotraj ustreznega integriranega razvojnega okolja (IDE), v našem primeru Visual Studio Code. Z vključitvijo teh naprednih zmožnosti generiranja kode orodje izboljšuje učne tokove poučevanja osnov programiranja, zaradi česar je učni proces bolj učinkovit in intuitiven. Poleg omogočanja znanih interakcij, kot so tiste s ChatGPT-jem, lahko dijaki uporabljajo pametne predloge za izvajanje običajnih dejanj, kot je dodajanje dokumentacije funkcijam ali preoblikovanje programske kode. Funkcija predlaganja kode ponuja izvedljivo možnost za dokončanje in generiranje kode v različnih scenarijih uporabe in ponuja dodatne izboljšave za interaktivno izkušnjo kodiranja. Dokončanje kode, običajno imenovano samodokončanje, je neprecenljiva funkcija tako pri učenju kot pri razvoju programske opreme, ki pomaga pri dokončanju nedokončanih segmentov kode. Po drugi strani pa generiranje kode vključuje samodejno generiranje izvorne kode iz vnosa naravnega jezika, ki ga vodijo uporabniško določene omejitve. Ta zmožnost povečuje učinkovitost razvojnega procesa z avtomatizacijo ustvarjanja kode na podlagi jezikovnih specifikacij, ki jih zagotovi uporabnik. Prispevek opisuje uporabo teh funkcij v učnem procesu in njihov vpliv na učinkovitost učenja programiranja. Raziskava je pokazala, da uporaba Codeiuma bistveno izboljša učinkovitost učenja in spodbuja globlje razumevanje programiranja. Na koncu predstavljamo ugotovitve o vplivu Codeiuma na uspešnost dijakov in predlagamo smernice za nadaljnje raziskave.

KLJUČNE BESEDE

Programiranje, Codeium, umetna inteligenca, poučevanje, učni proces

ABSTRACT

In this paper, we present a cloud-based programming tool based on leading open source models supported by generative artificial intelligence, called Codeium, to support teachers and students in teaching and learning the basics of programming. Codeium basically provides chat features and calls to code to generate software code. This functionality focuses on generating code from text inputs, allowing text-to-code generation within the appropriate integrated development environment (IDE), in our case Visual Studio Code. By incorporating these advanced code generation capabilities, the tool enhances learning streams for teaching programming fundamentals, making the learning process more efficient and intuitive. In addition to enabling familiar interactions like those with ChatGPT, students can use smart templates to perform common actions such as adding documentation to functions or refactoring program code. The code suggestion feature provides a viable option to complete and generate code in various usage scenarios and offers additional enhancements for an interactive coding experience. Code completion, commonly referred to as autocompletion, is an invaluable feature in both learning and software development that helps complete unfinished code segments. Code generation, on the other hand, involves the automatic generation of source code from natural language input guided by user-defined constraints. This capability increases the efficiency of the development process by automating the generation of code based on user-supplied language specifications. The paper describes the use of these functions in the learning process and their impact on the effectiveness of learning programming. Research has shown that using Codeium significantly improves learning efficiency and promotes a deeper understanding of programming. Finally, we present findings on the impact of Codeium on student performance and suggest directions for further research.

KEYWORDS

Programming, Codeium, artificial intelligence, teaching, learning process

1 UVOD

Programiranje je ustvarjalna dejavnost in kot ena ključnih sestavin računalniškega mišljenja podpira kognitivne procese in

dokazuje računalniško usposobljenost učečih se deležnikov, hkrati pa ponuja platformo za prakso in izboljšanje reševanja problemov, kritično mišljenje, sodelovanje, in spretnosti aktivnega učenja. Vendar se programiranja ni enostavno naučiti. Preobremenjenost zaradi nezadostnega predznanja in zapletenosti nalog kodiranja pri dijakih začetnikih povzroči nepričakovano veliko porabo časa za njihovo uspešno razumevanje in reševanje [1]. Frustrirajoča izkušnja in ponavljajoči se neuspehi, zlasti na začetku, lahko pri dijakih zmanjšajo samoučinkovitost glede programiranja.

Za izboljšanje učne izkušnje v učni proces na začetku vpeljemo pomožna programska okolja, ki pomagajo blažiti napačne predstave v sintaksi izbranega programskega jezika in konceptualnem znanju. Poučevanje osnov programiranja v programskih okoljih, ki temeljijo na slikovnih delčkih, odpravi sintaksne napake in dijakom omogoči delo na zasnovanih projektnih nalogah. Uporaba teh okolij znižuje oviro za vstop v programiranje in dijakom omogoča, da se osredotočijo na učenje, kako oblikovati rešitev, ki jo z računalnikom lahko izvedejo. Vendar se kmalu pojavi potreba po prehodu na besedilne programske jezike, kar pa prinaša svoje izzive, hkrati pa odpira vprašanja, s katerimi orodji ali tehnologijami v procesu poučevanja ta prehod čimbolj učinkovito izvesti.

Poučevanja in učenje osnov programiranja izboljša veščine programiranja v ustvarjalne namene, dijake pa seznani z osnovnimi koncepti programiranja in programskimi jeziki, kot so Python, JavaScript in podobni. Dijaki pridobijo sposobnost pisanja preprostih programov z uporabo besedilnih programskih orodij in se naučijo korakov v procesu reševanja problemov s programiranjem. Ko poučevanje programiranja napreduje, se dijaki premikajo k bolj zapletenim programskim konceptom, kot so algoritmi, podatkovne strukture in programske paradigme. To dijakom zagotavlja trdne temelje v načelih programiranja in tehnikah reševanja problemov ter poveča njihovo sposobnost za razvoj programske opreme za reševanje problemov iz resničnega sveta [2]. Dijaki pridobijo tudi veščine testiranja, odpravljanja napak in vzdrževanja programske opreme, hkrati pa jim pomaga razumeti procese razvoja programske opreme za različna področja uporabe in jih pripravi na uspešno kariero v tehnologiji.

V zadnjem času je prišlo do porasta priljubljenosti orodij za ustvarjanje ali dokončanje programske kode, ki temeljijo na umetni inteligenci: Github Copilot, Codeium, Tabnine, če naštejemo le nekatere. Za razliko od tradicionalnih orodij za samodejno dokončanje lahko ta nova generacija orodij za ustvarjanje ali dokončanje kode ponudi poljubne izrezke kode kot predloge, pri čemer upošteva kontekst kode, vključno s komentarji, napisanimi v naravnem jezik. Čeprav vedno ne zagotavljajo pravilnosti predlogov, so lahko zelo koristni pri pospešitvi razvojnega procesa v razumevanju osnov programiranja.

Za izboljšanje učinkovitosti poučevanja osnov programiranja smo v učni proces pri kreativnem kodiranju vključili Codeium-a, že omenjeni uporabniški vmesnik klepetalnega robota, ki ga je razvilo tehnološko podjetje Exafunction. Codeium je napredno orodje za ustvarjanje in dokončanje programske kode, izboljšano z umetno inteligenco, ki na novo definira tradicionalne prakse kodiranja, saj je bolj iterativen in razčlenjuje rešitve vnešenih poizvedb korak za korakom. To ga naredi bolj didaktičnega in razumljivejšega, hkrati pa omogoča večjo stopnjo globine odgovorov. Uspešno se vključuje v različne urejevalnike programske kode in integrirana razvojna okolja (IDE), zaradi česar so učni in delovni tokovi preprostejši in udobnejši. Na osnovi integriranega klepeta je njegova uporabniška izkušnja podobna tisti, ki jo ponuja ChatGPT, vendar je integrirana v urejevalnike ali razvojna okolja, ki jih učitelji in dijaki uporabljajo, tako da lahko pogovorno komunicirajo z generativno umetno inteligenco znotraj teh istih orodij. To sofisticirano orodje podpira zanimivo paleto več kot 70 programskih jezikov in zlasti zmanjša breme učenja osnov programiranja na osnovi kodiranja. Codeium je pokazal izjemne sposobnosti pri ustvarjanju človeških odzivov in zagotavljanju prilagojenih povratnih informacij, kar ga uvršča med potencialno orodje za preoblikovanje učne izkušnje v poučevanju in učenju osnov programiranja. Transformativni potencial Codeium-a z ustreznim načrtovanjem nudi učiteljem priložnost ustvarjati interaktivna in prilagodljiva učna okolja, ki lahko pritegnejo in motivirajo dijake za učenje. Tak pristop dijakom omogoča, da se bolj povežejo z učnim gradivom, kar posledično vodi do globljega razumevanja konceptov programiranja, jezikov in postopkov, ki so bili abstrahirani skozi številne nivoje abstrakcij. Pogovorni slog Codeium-a lahko ustvari bolj zanimivo in prijetno učno izkušnjo, hkrati pa zmanjšuje dolgočasje in nezainteresiranost, ki se včasih pojavita pri tradicionalnem poučevanju v obliki predavanj. To sodelovanje prispeva k bolj angažiranemu in motiviranemu učenju, kar lahko pozitivno vpliva na uspeh dijakov v izobraževanju na področju medijske produkcije.

Učitelji z usklajevanjem zastavljenih učnih ciljev z odprto uporabo umetne inteligence v ustrezno zasnovanem učnem okolju dijake usmerjajo k uporabi umetne inteligence za opolnomočenje njihovega učenja, ne pa za njegovo nadomestitev. Vključevanje umetne inteligence v sodelovalni učni proces lahko spremeni miselnost dijakov od zgolj uporabe umetne inteligence za hitre odgovore k uporabi umetne inteligence kot močnega zaveznika za nenehne izboljšave in razvoj učnih spretnosti. Pri podpori orodij umetne inteligence pri poučevanju je še vedno ključna vloga učitelja, ki se od poučevalca spreminja v usmerjevalca učnega procesa. Učitelj mora zagotoviti pravilno uporabo orodij umetne inteligence, interpretirati rezultate in nuditi nadaljnjo razlago ter voditi dijake skozi učno snov. Prav tako je odgovoren za ustvarjanje ustrezne učne okolice, ki spodbuja sodelovanje in interakcijo med dijaki. Najpomembneje je, da mora učitelj poudariti veščine reševanja problemov in kritičnega mišljenja, ki jih kodiranje zahteva. Zato je potrebno dijake spodbujati, da poglobljeno razmišljajo o problemih, ki jih poskušajo rešiti, in da se jim približajo na kreativen in inovativen način. Prav tako je dijake potrebno poučiti tudi o etičnih posledicah generativne umetne inteligence in strojnega učenja.

Uvajanje inovativnih učnih tehnologij v pouk je vedno eksperimentalno in zahteva določeno zavedanje o potrebah učitelja in dijakov. Umetna inteligenca je začela iskati svojo pot v učilnice, šole in načine, na katere določene učne dejavnosti dijakom pripeljemo domov preko projektnih nalog ali izvenšolskih dejavnosti. Čeprav te tehnologije ponujajo nove možnosti za poučevanje in učenje, prinašajo tudi nove izzive in zahtevajo kritičen razmislek o osnovnih učnih strategijah in smernicah, ki oblikujejo njihovo uporabo. Pri poučevanju in učenju kodiranja v takšnem učnem okolju morajo učitelji spremljati aktivnosti, s katerimi se dijaki osredotočajo predvsem na inovativno reševanje problemov/izzivov in oblikovanje

elegantnih rešitev s pomočjo generativne umetne intelligence, kar je prikazano v Tabeli 1.

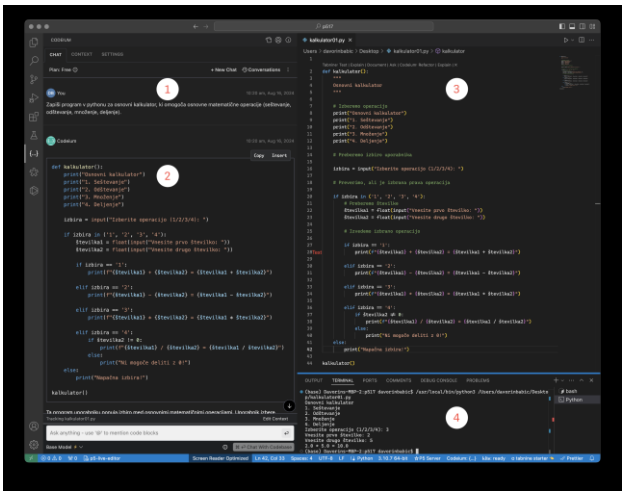
Tabela 1: Aktivnosti dijakov in njihova spremljava

Aktivnosti	**Spremljava aktivnosti**
Reševanje problemov	Spodbujanje dijakov, da k izzivom kodiranja pristopijo sistematično in da kreativno razmišljajo o možnih rešitvah.
Računalniško mišljenje	Pomagati dijakom pri razvijanju razumevanja delovanja računalnikov in algoritmov.
Logično mišljenje	Dijake naučiti uporabljati logičnega mišljenja za razdelitev kompleksnih problemov na manjše, bolj obvladljive dele.
Algoritmično mišljenje	Dijaki bi morali vedeti, kako ustvariti postopke za reševanje problemov po korakih.
Ustvarjalnost	Spodbujanje dijakov k razmišljanju “out of the box” in ustvarjanju projektov za zabavo in užitek.
Sodelovalnost	Razvijanje sodelovalnega pristopa učenja pri reševanju izzivov kodiranja in medsebojnega deljenja pridobljenih znanj in izkušenj.
Razhroščevanje in odpravljanje težav	Dijake naučiti, kako prepoznati in odpraviti napake na sistematičen način.
Etični vidiki	Nudenje priložnosti dijakom, da razpravljajo o etičnih posledicah umetne inteligence in strojnega učenja ter o tem, kako lahko njihova koda vpliva na družbo in svet okoli njih.

2 METODA DELA

Poučevanje in učenje programiranja s pomočjo generativne umetne inteligence je vključevanje tehnik in orodij strojnega učenja v proces razvoja programske opreme [3] za izboljšanje nalog računalniškega programiranja. Ta pristop v poučevanju z interakcijo dijakov z generativno umetno inteligenco kaže podobnosti z modernejšo obliko sodelovalnega dela, s programiranjem v paru. Programiranje v paru opisuje aktivno prakso dveh dijakov v vlogi programerjev, ki skupaj izmenično sodelujeta v neprekinjenem procesu do dokončanja naloge z uporabo enega računalnika, tipkovnice in miške. En programer v paru, voznik, izvaja kodiranje (tipkanje) in izvaja nalogo, medtem ko drugi programer, krmar, pomaga pri načrtovanju, pregledovanju, odpravljanju napak in predlaganju izboljšav in alternativ. Programiranje s pomočjo umetne inteligence v osnovi nadomešča enega od dveh programerjev s podpornim asistentom generativne umetne inteligence. Učitelji s podpornim asistentom ‘avtomatiziramo’ nabor vaj, ki jih je mogoče na splošno razvrstiti v dve zahtevnostni kategoriji: ustvarjanje in razumevanje. Vaje ustvarjanja zajemajo dejavnosti, povezane z generiranjem programske kode, dokončanjem kode, prevodom kode, izboljšanjem kode in povzemanjem kode. Vaje razumevanja primarno zajemajo dejavnosti, kot je odkrivanje napak v ustvarjeni programski kodi.

Pred raziskavo vpliva uporabe podpornega asistenta generativne umetne inteligence za programiranje pri učenju programiranja so se dijaki že učili o osnovnih konceptih programiranja: spremenljivkah, operatorjih, izrazih, pogojih, zaporedjih, vejitvah, zankah, funkcijah in seznamih znotraj slikovnega programiranja z delčki. Metodološki okvir so predstavljale praktično usmerjene vaje in so vključevale dejanske primere uporabe. Da bi raziskali učinek uporabe Codeiuma pri učenju osnov programiranja v python (Slika 1), smo učni proces uvedli hitro generiranja vsebin z relativno enostavnimi problem, vezanimi za strokovno zahtevnost. Sistem omogoča dijakom, da delajo na vrsti programskih nalog, ki so bile zasnovane za postopno uvajanje novih konceptov.



Slika 1: Uporabniški vmesnik Visual Studio Code: 1) besedilni vnos (poziv) problema v vdelanem oknu Codeiuma; 2) generator kode za vstavljanje kode, ki jo ustvari umetna inteligenca glede na dijakov vnos, v urejevalnik kode; 3) vnesena koda v pythonovski urejevalnik z možnostjo dokončanja; 4) rezultat delovanja kode v terminalu urejevalnika. Vir: lastno delo

2.1 Učni proces z uporabo Codeiuma

Codeium kot napredno orodje za generiranje in dokončanje programske kode, integriran v različne urejevalnike programske kode in razvojna okolja (IDE), s svojimi funkcionalnostmi omogoča prilagoditev učnega procesa na dijake osredotočenega poučevanja z naslednjimi možnostmi [4]:

- samodokončanje kode: Codeium samodejno predlaga dokončanje delov kode na osnovi konteksta nalog, kar dijakom omogoča hitro in učinkovito pisanje kode;
- generiranje kode iz naravnega jezika: dijaki lahko vnesejo opis naloge v naravnem jeziku, orodje pa samodejno generira ustrezno kodo;
- interaktivna podpora: Codeium omogoča pogovorno interakcijo, podobno kot ChatGPT, vendar znotraj razvojnih okolij, kar omogoča enostavno integracijo v učni proces (v obliki ustreznih razlag in pomoči, npr. dijaki lahko uporabijo Codeium za vprašanja, kot so

"Kako lahko izračunam povprečje števil iz nekega številskega seznama?" ali " Kateri je najboljši način za ocenjevanje uspešnosti dijakov?" in podobno, lahko predlaga optimizacije, kot so izboljšanje besedilnega vnosa, obravnavanje napak pri vnosu podatkov ali dodajanje funkcionalnosti za večjo robustnost programa).

2.2 Eksperimentalna zasnova

Za statistično analizo prispevka smo uporabili t-test, da smo preverjali vpliv uporabe orodja Codeium na uspešnost učenja programiranja pri dijakih. Raziskava je bila izvedena na skupini 53 dijakov v programu medijski tehnik ob koncu drugega ocenjevalnega obdobja, razdeljenih v dve skupini: eksperimentalno skupino (26 dijakov), ki je uporabljala Codeium, in kontrolno skupino (27 dijakov), ki tega orodja ni uporabljala. Analizirali smo dve glavni spremenljivki: čas dokončanja nalog in število napak v kodi.

Dijaki so imeli nalogo razviti enostavne aplikacije v programskem jeziku python. Med izvajanjem nalog so uporabljali funkcije samodokončanja in generiranja kode ter pametne predloge za izboljšanje svoje kode. Opazovali smo njihovo interakcijo z orodjem in spremljali uspešnost pri reševanju nalog, ob upoštevanju aktivnosti iz Tabele 1. Naloge so vključevale primere iz resničnega sveta, kar je omogočilo dijakom, da so se soočili s praktičnimi izzivi, ki jih srečujejo programerji v vsakdanjem delu. Primeri so bili skrbno izbrani, da so se navezovali na osnovne koncepte, ki so jih dijaki že poznali, a so hkrati vključevali tudi nekoliko zahtevnejše elemente, ki so zahtevali dodatno razmišljanje in uporabo podpornega asistenta.

2.3 Zahtevnostne kategorije nalog

Osnovna zahtevnost

Naloge so se osredotočale na osnovne programske koncepte, kot so deklaracija spremenljivk, matematični izrazi in pisanje pogojnih stavkov. Na primer, dijaki so morali napisati program v obliki preproste aplikacije za izračun obsega in površine kroga ter program za preverjanje, ali je vnešeno število pozitivno ali negativno.

Srednja zahtevnost

Naloge so vključevale delo z nizi, seznami, zankami in slovarji. Ena naloga je zahtevala, da dijaki napišejo program, ki preveri, ali je dani niz palindrom, druga pa je vključevala izračun povprečne vrednosti elementov seznama in prikaz elementov, ki so večji od povprečja.

Naprednejše naloge

Naloge so zahtevale uporabo regularnih izrazov, obdelavo podatkov z uporabo knjižnice pandas in vizualizacijo podatkov s pomočjo knjižnice matplotlib. Na primer, dijaki so morali napisati program za preverjanje veljavnosti e-poštnih naslovov in ustvariti stolpčni diagram, ki prikazuje razporeditev ocen dijakov.

2.4 Analiza učinkovitosti

Analiza učinkovitosti Codeiuma kot podpornega asistenta v poučevanju programiranja je temeljila na dveh metodah:

1. Kvantitativna analiza: Merili smo čas, ki so ga dijaki porabili za dokončanje nalog, in število napak v kodi.
2. Kvalitativna analiza: Izvedli smo anketo med dijaki, kjer so ocenili uporabnost orodja, enostavnost uporabe ter njihovo zadovoljstvo z rezultati.

2.5 Cilji raziskave

Med osnovne cilje raziskave smo uvrstili naslednje:

1) Oceniti vpliv uporabe podpornega asistenta v poučevanju na učinkovitost učenja programiranja.
2) Raziskati, ali uporaba Codeiuma pripomore k boljšemu razumevanju in utrjevanju osnovnih programskih konceptov in konstruktov.
3) Preveriti, kako se dijaki odzivajo na uporabo orodij generativne umetne inteligence pri reševanju problemov/izzivov z določenega strokovnega področja s programiranjem.

2.6 Hipoteze

Na podlagi ciljev raziskave oblikujemo naslednje hipoteze:

- Hipoteza 1 (H1): Povprečni čas dokončanja nalog bo krajši pri dijakih, ki uporabljajo Codeium (eksperimentalna skupina), v primerjavi s tistimi, ki tega orodja ne uporabljajo (kontrolna skupina).
- Hipoteza 2 (H2): Povprečno število napak v kodi bo manjše pri dijakih, ki uporabljajo Codeium, v primerjavi s kontrolno skupino.

3 REZULTATI

3.1 Statistična analiza

1. Analiza časa dokončanja nalog (v minutah):
- Neodvisna spremenljivka: skupina (eksperimentalna, kontrolna)
- Odvisna spremenljivka: čas dokončanja nalog (v minutah)
- Test: neodvisni t-test (za primerjavo povprečij dveh neodvisnih skupin)

2. Analiza števila napak v kodi:
- Neodvisna spremenljivka: skupina (eksperimentalna, kontrolna)
- Odvisna spremenljivka: število napak v kodi
- Test: neodvisni t-test

3.2 Izvedba t-testa

Izvedli smo t-test za obe hipotezi. Na osnovi predhodno obdelanih rezultatov smo za izvedbo t-testa uporabili sledeče podatke:

- Eksperimentalna skupina (Codeium):
  - Povprečni čas dokončanja nalog: 45 minut, standardni odklon: 5 minut.
  - Povprečno število napak: 2, standardni odklon: 1.
- Kontrolna skupina (brez Codeiuma):
  - Povprečni čas dokončanja nalog: 55 minut, standardni odklon: 7 minut.
  - Povprečno število napak: 5, standardni odklon: 2.

Rezultati t-testa so bili naslednji (Tabela 2).

Tabela 2: Prikaz rezultatov t-testa

Čas dokončanja nalog	Število napak
t-vrednost: −5.96	*t*-vrednost: −6.87
p-vrednost: 2.33×10^{-7}	p-vrednost: 8.89×10^{-9}

3.3 Kvantitativni rezultati

Čas dokončanja nalog: p-vrednost je bistveno manjša od običajnega praga statistične značilnosti (0,05), kar pomeni, da obstaja statistično značilna razlika med eksperimentalno in kontrolno skupino. Povprečni čas dokončanja nalog je bil bistveno krajši v eksperimentalni skupini, kar podpira Hipotezo 1 (H1).

Število napak: p-vrednost je prav tako bistveno manjša od 0,05, kar kaže na statistično značilno razliko med skupinama. Eksperimentalna skupina je imela bistveno manj napak v primerjavi s kontrolno skupino, kar podpira Hipotezo 2 (H2).

Rezultati so pokazali, da je eksperimentalna skupina naloge zaključila v povprečju 23% hitreje kot kontrolna skupina. Poleg tega so dijaki v eksperimentalni skupini naredili 28% manj napak v primerjavi s kontrolno skupino. To kaže, da je uporaba Codeiuma prispevala k učinkovitejšemu in natančnejšemu pisanju programske kode.

3.4 Kvalitativni rezultati

Anketa med dijaki je pokazala, da so podporni asistent ocenili kot zelo uporabnega. 85% dijakov v eksperimentalni skupini je izrazilo zadovoljstvo z orodjem in menilo, da jim je omogočilo boljše razumevanje osnovnih konceptov programiranja. Dijaki so izpostavili tudi, da je interaktivna narava orodja izboljšala njihovo izkušnjo učenja in zmanjšala stres, povezan z učenjem programiranja.

4 RAZPRAVA

Naši rezultati potrjujejo, da je uporaba orodij, kot je Codeium, lahko zelo koristna pri učenju osnov programiranja. Codeium omogoča, da se dijaki osredotočijo na reševanje problemov, medtem ko sintaktične in strukturne podrobnosti prepustijo orodju, kar zmanjša frustracije in poveča motivacijo za učenje. Pri nalogah osnovne zahtevnosti so dijaki naloge opravili hitreje in z manj napakami, kar kaže na to, da Codeium učinkovito podpira razumevanje osnovnih konceptov. Pri nalogah srednje zahtevnosti je Codeium pomagal dijakom pri reševanju kompleksnejših problemov, kar je privedlo do boljših rezultatov v primerjavi s tradicionalnimi metodami učenja. Pri naprednejših nalogah, kjer so se dijaki soočali z najzahtevnejšimi nalogami, je Codeium olajšal uporabo sofisticiranih tehnik in omogočil hitrejše dokončanje nalog z višjo kakovostjo kode.

Poleg tega, da je uporaba Codeiuma pozitivno vplivala na uspešnost dijakov pri reševanju nalog, je hkrati učiteljem omogočala, da so se osredotočili na mentorstvo in usmerjanje dijakov pri razvoju kreativnih in inovativnih rešitev.

Kljub pozitivnim rezultatom ima naša raziskava nekaj omejitev. Izvedena je bila na relativno majhnem vzorcu dijakov, kar omejuje možnost posploševanja rezultatov. Poleg tega dolgoročni učinki uporabe Codeiuma na razvoj programskih veščin niso bili ocenjeni, saj so bili spremljani ob koncu drugega ocenjevalnega obdobja. Poleg tega bi bilo koristno raziskati, kako vključitev Codeiuma vpliva na učenje naprednejših konceptov programiranja, kot so algoritmi in podatkovne strukture, ter na razvoj projektov v skupinskem okolju.

Vendar pa je pomembno upoštevati, da lahko prekomerna uporaba AI asistentov vodi do prekomerne odvisnosti, kar lahko negativno vpliva na sposobnost dijakov, da samostojno rešujejo probleme. Nadaljnje raziskave bi morale preučiti, kako uskladiti uporabo podpornih asistentov s tradicionalnimi metodami poučevanja, da bi zagotovili optimalne rezultate pri učenju programiranja. Dijaki dojemajo Codeium kot dragocen učni vir programiranja in so od njega odvisni pri vodenju svojega učnega procesa. Poleg tega dijaki izkazujejo določeno stopnjo zaupanja v hiter odziv in natančnost Codeiuma, tako da se odločijo za njegovo uporabo po neposrednem odpravljanju napak v kodi ali branju sporočil o napakah s konzole. Zato menimo, da je treba upoštevati naslednje vidike, ko dijaki uporabljajo podporne asistente za učenje programiranja. Prvič, v začetnih fazah programiranja lahko dijaki v celoti izkoristijo pomoč podpornih asistentov, da poglobijo svoje razumevanje težav pri programiranju in najdejo ustrezne rešitve. Drugič, dijaki bi morali postopoma povečevati pogostost neodvisnega urejanja kode, da izboljšajo svoje sposobnosti programiranja in strokovnosti, ko učenje napreduje. Nazadnje, pomembna je previdnost, da ne postanejo preveč odvisni od podpornih asistentov. Dijaki začetniki bi morali posvetiti več časa osvajanju osnovnih konceptov programiranja, preden začnejo uporabljati orodja umetne inteligence, ne glede na njihovo splošno raven uspešnosti. Podporne asistente je treba pravilno uporabljati kot pomožno orodje za učenje in reševanje problemov programiranja.

5 ZAKLJUČEK

Vpeljava pomoči orodij generativne umetne inteligence v poučevanje osnov programiranja učinkoviteje razjasni nesporazume kot statični učbeniki ali različni podporni videi. Codeium je odličen pri zagotavljanju prilagojenih in potrpežljivih razlag programskih konceptov, ponujanju primerov kode in rešitev, prilagojenih individualnim potrebam dijakov. Njegov interaktivni pogovorni vmesnik spodbuja dijake k dialogu, utrjuje njihovo razumevanje z aktivnim sodelovanjem in povratnimi informacijami. Dijaki lahko težave, ki nastanejo pri kodiranju, predstavijo na preprost način, hkrati pa strani Codeiuma prejmejo izčrpno razlago po korakih, ki razjasni temeljna načela skozi celoten učni proces. Takšna dinamična pomoč ponuja ključno podporo in premošča vrzeli, ko učetelj ni na voljo. Uporaba Codeiuma lahko okrepi sposobnosti dijakov za oblikovanje preprostih algoritmov in pisanje kode, kar zmanjša stres, ki pogosto spremlja seznanjanje z uvodnimi pristopi reševanja izzivov z besedilnim programiranjem. Nenazadnje se je opazilo povečano navdušenje nad učenjem osnov programiranja med številnimi dijaki po izpostavitvi poučevanju s Codeiumum. Kot učitelji moramo biti na tekočem z najnovejšim tehnološkim razvojem in še naprej prilagajati svoje metode poučevanja, da bi naše dijake čim bolje pripravili na svet, ki je pred nami.

Ne glede na opisano je vključevanje generativne umetne inteligence v učni proces programiranja s pomočjo orodja Codeium pokazala pozitivne učinke na uspešnost in motivacijo

dijakov. Z uporabo naprednih funkcionalnosti, kot so samodokončanje in generiranje kode, Codeium zmanjšuje obremenitve, povezane z učenjem programiranja, ter omogoča bolj osredotočeno in ustvarjalno učenje. Prihodnje raziskave bi morale raziskati dolgoročni vpliv takšnih orodij na razvoj programskih veščin in njihovo učinkovitost v različnih izobraževalnih okoljih.

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Uporaba spletnega orodja H5P za formativno spremljanje poučevanja računalniškega mišljenja

Using the H5P Online Tool for Formative Assessment of Computational Thinking Learning

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POVZETEK

Izhodišča: Vključevanje digitalnih orodij v izobraževanje je spremenilo učni proces, zlasti na področjih, povezanih z računalništvom, kjer je računalniško mišljenje temeljna veščina. Pogosto uporabljen programski jezik, python, je izbran za uvajanje dijakov v računalniško mišljenje zaradi svoje preprostosti in vsestranskosti. Vendar pa učinkovito poučevanje računalniškega mišljenja zahteva ne le poučne vsebine, temveč tudi aktivno vključevanje in neprekinjeno spremljanje razumevanja dijakov.

Namen: Namen raziskave je ugotoviti, kako uporaba spletnih orodij za formativno spremljanje učnega procesa, zlasti platforme H5P, vpliva na poučevanje računalniškega mišljenja pri programiranju v pythonu. Raziskava ocenjuje učinkovitost H5P kot orodja za ustvarjanje interaktivnih in formativnih spremljevalnih dejavnosti, ki vključujejo dijake in izboljšujejo njihovo razumevanje računalniškega mišljenja.

Metode: V raziskavo je bilo vključenih 140 dijakov tretjega letnika medijske produkcije iz programa medijski tehnik, ki so sodelovali pri ocenjevanju vpliva formativnih dokazov z orodjem H5P na njihove učne rezultate. Uporabljen je bil anketni vprašalnik, s katerim smo želeli ugotoviti, v kolikšni meri orodja H5P prispevajo k izboljšanju razumevanja in ohranjanja veščin računalniškega mišljenja pri dijakih pri soočanju s praktičnimi problemi. Dijaki so z vprašalnikom ocenjevali povratne informacije o svojih izkušnjah in zaznavah glede formativnih dokazov, ki temeljijo na virih orodja H5P. Podatke smo obdelali s pomočjo spletne programske oprema za statistiko DATAtab, ki se izvaja v oknu brskalnika, s pomočjo standardnih statističnih metod smo izračunali povprečne vrednosti in standardni odklon.

Rezultati in diskusija: Rezultati so pokazali, da je H5P učinkovito orodje za formativno spremljanje veščin računalniškega mišljenja pri programiranju v pythonu. Pomembno izboljšanje dokazov o znanju dijakov po ocenah poudarja vrednost interaktivnih in takojšnjih mehanizmov povratnih informacij, ki jih zagotavlja H5P. Hkrati pa rezultati ankete kažejo tudi na visoko zadovoljstvo dijakov z nalogami H5P, kar podpira njegovo nadaljnjo uporabo v izobraževalnih okoljih. Vse to dokazuje, da z vzpodbujanjem in poučevanjem veščin računalniškega mišljenja učitelji lahko vplivajo na dijakov razvoj in na sistematičen razvoj znanja in veščin na njegovem profesionalnem področju.

KLJUČNE BESEDE

H5P, formativno spremljanje, računalniško mišljenje, digitalne kompetence, spletna učna orodja

ABSTRACT

Background: The integration of digital tools into education has changed the learning process, especially in fields related to computer science, where computational thinking is a fundamental skill. A commonly used programming language, python, is chosen to introduce students to computational thinking because of its simplicity and versatility. However, effective teaching of computational thinking requires not only instructional content, but also active involvement and continuous assessment of students' understanding.

Purpose: The purpose of the research is to determine how the use of online tools for formative assessment of the learning process, especially the H5P platform, affects the teaching of computational thinking in python programming. The research evaluates the effectiveness of H5P as a tool for creating interactive and formative follow-up activities that engage students and improve their understanding of computational thinking.

Methods: 140 third-year media production students from the media technician program were included in the research, who participated in evaluating the impact of formative evidence using the H5P tool on their learning outcomes. A survey questionnaire was used, with which we wanted to determine to what extent the H5P tools contribute to improving students' understanding and retention of computational thinking skills when dealing with practical problems. Students used a questionnaire to assess feedback on their experiences and perceptions of formative evidence based on H5P resources. We processed the data with the help of the DATAtab online statistics software, which is run in a browser window, and with the help of standard statistical methods, we calculated the average values and the standard deviation.

Results and discussion: The results showed that H5P is an effective tool for formative assessment of computational thinking skills in python programming. The significant

improvement in evidence of student knowledge across assessments highlights the value of the interactive and immediate feedback mechanisms provided by H5P. At the same time, the results of the survey also show high student satisfaction with the H5P tasks, which supports its further use in educational environments. All this proves that by encouraging and teaching computational thinking skills, teachers can influence the student's development and the systematic development of knowledge and skills in his professional field.

KEYWORDS

H5P, formative assessment, computational thinking, digital competences, online learning tools

1 UVOD

1.1 Formativno spremljanje učnega procesa

Formativno spremljanje je bistvenega pomena za izboljšanje poučevanja in učenja, sodobni izobraževalni digitalni viri (različna digitalna učna okolja, aplikacije in platforme ter orodja vizualizacij) pa zagotavljajo velik potencial za njegovo zasnovo in izvajanje. Sodobni digitalni izobraževalni viri so večinoma interaktivni, kar omogoča viru, da se odzove na dejanja dijakov bodisi z izbiro pravilne učne poti, zagotavljanjem povratnih informacij dijakom ali izvajanjem dejanj, ki jih običajno izvaja učitelj. Poleg tega, da so interaktivni, izobraževalni viri pogosto vključujejo različne vrste elementov z namenom, da dijakom zagotovijo optimalno učno izkušnjo. Vključiti je mogoče videoposnetke, zvočne posnetke, kvize (ki dijakom omogočijo, da vnesejo svoje odgovore) – vendar izobraževalni vir lahko vključuje tudi veliko različnih vrst elementov hkrati. Z omenjenimi viri zagotavljamo dragocene povratne informacije ne samo učiteljem, ampak tudi dijakom, predvsem v usmerjanju izboljšav pri poučevanju in učenju za optimizacijo učnih rezultatov dijakov. Praksa v razredu je formativna do te mere, da dokaze o dosežkih dijakov pridobijo, interpretirajo in uporabljajo učitelji, dijaki in njihovi vrstniki. Ti deležniki kasneje sprejemajo odločitve o svojih naslednjih korakih pri poučevanju in učenju, ki bodo verjetno boljše ali bolje utemeljene od odločitev, ki bi jih sprejeli, če ne bi bilo pridobljenih dokazov. Povratne informacije so ključna sestavina v procesu učenja dijakov. Ker je napredek v tehnologiji omogočil sprejetje digitalnih učnih okolij z možnostmi ocenjevanja, so se postopoma spremenili tudi pogostost, oblika dostave in pravočasnost povratnih informacij, ki izhajajo iz pridobljenih informacij o (pred)znanju. Povratna informacija je eden najvplivnejših delov učnega procesa [1] in je opredeljena kot: informacije, ki jih zagotovi posrednik (npr. učitelj, vrstnik, knjiga, starš, jaz, izkušnje) v zvezi z vidiki posameznikove uspešnosti ali razumevanja. Po [1] je računalniško podprta povratna informacija učinkovita. V primerjalni študiji primera [2] so sodelujoči dijaki računalniško podprto povratno informacijo ocenili višje kot tradicionalno pisno povratno informacijo. Pomembni dejavniki pri tej ugotovitvi so: jasna struktura povratnih informacij, njihova čitljivost, informacije o vrzelih v razumevanju dijakov in prepoznavanje dobrih vidikov dijaških prispevkov. Poleg tega so bile računalniško podprte povratne informacije dijakom zagotovljene hitreje kot tradicionalne povratne informacije. Tudi raziskava [3] je pokazala podobne rezultate, pri čemer so dijaki poročali o višji motivaciji in boljši uspešnosti. Izobraževalne digitalne tehnologije lahko omogočijo neposredno spremljanje dijakovega napredka, izmenjavo povratnih informacij ter izobraževalcem zagotovijo načine za vrednotenje in prilagajanje njihovih strategij poučevanja. V množici digitalnih orodij, ki so na voljo učitelju, je pomembno, da se pred uporabo, med njo in po njej učitelj nasloni na kriterije za vrednotenje digitalnih orodij glede na njihovo funkcionalnost, prilagodljivost, praktičnost in uporabnost. Glede na izobraževalne koristi digitalne tehnologije lahko to organiziramo v tri skupine [4]:

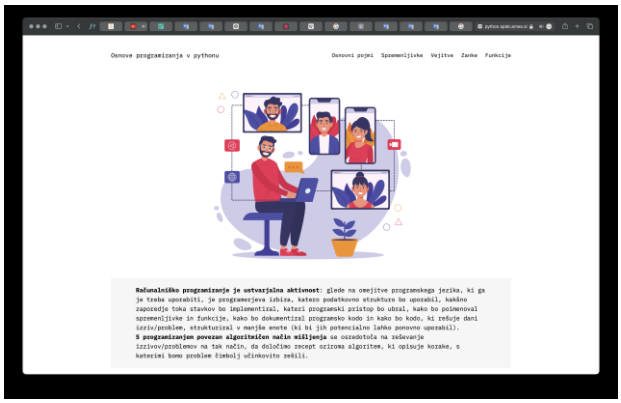
1) tehnologije kot učno orodje, kar vključuje pregled uporabe tehnologije v razredu – strojna oprema, programska oprema,
2) računalniško podprto poučevanje, prilagojeni učni programi, internet.
3) Tehnologije za zagotavljanje učenja, kar vključuje tehnologije izobraževanja na daljavo, kot so spletno učenje, mobilno učenje, kot tudi podporne tehnologije.
4) Tehnologije za podporo učenju, kar vključuje razvijajoče se podpore za tehnologijo kot učno orodje in za zagotavljanje učenja – odprti izobraževalni viri, veliki podatki, učna analitika in umetna inteligenca.

Nabor učnih strategij, ki jih uporabljamo učitelji za podporo vključevanja sodobnih izobraževalnih digitalnih virov v učni proces, je v veliki meri bolj osredotočen na dijake, ki uporabljajo računalnik kot učno orodje, učitelj je v vlogi moderatorja, ki podpira projektno učenje in neodvisno raziskovanje.

1.2 Spletno okolje H5P

Za ustvarjanje strokovnega izobraževalnega vira smo uporabili specializirano spletno platformo, ki nam je zagotovila vsa potrebna orodja za ustvarjanje, upravljanje in skupno rabo lastnih izobraževalnih virov. H5P (HTML5 Package) [5] je brezplačno in odprtokodno ogrodje za sodelovanje pri vsebinah, katerega namen je vsem olajšati ustvarjanje, skupno rabo in ponovno uporabo interaktivnih vsebin. Še posebej je dragoceno za formativno spremljanje, saj zagotavlja takojšnje povratne informacije, ki dijakom omogočajo, da razmislijo o svojem učenju in prepoznajo področja za izboljšave [6]. Lahko ga implementirano v WordPress in premore veliko zanimivih funkcij, vključno z interaktivnimi videoposnetki (Interactive Videos), predstavitvami tečajev (Course Presentations), scenarijem razvejanja (Branching Scenario), povleci in spusti (Drag and Drop), pogovornimi karticami (Dialog Cards), navideznim ogledom (Virtual Tour 360), slikovnimi vročimi točkami (Hotspots), bliskovnimi karticami (Flashcards), povleci besede (Drag the Words), razvrsti odstavke (Sort the Paragraphs), časovnico (Timeline), nizom vprašanj (Question Set), vprašanji z več izbirami (Multiple Choice Questions), izpolnjevanjem praznin (Fill the Blanks), True or False, zaporedje slik (Image Sequencing), aritmetični kviz (Arithmetic Quiz), označevanje besed (Mark the Words), narek (Dictation) in esej (Essay). Nastale interaktivne in adaptivne vsebine so vizualno privlačne in dodatno motivirajo dijake za njihovo učenje. Spletišče Wordpres pa omogoča delo na različnih napravah, od namiznih računalnikov preko tabličnih računalnikov do pametnih telefonov. Izbrano orodje smo v pedagoški proces vključili za motivacijo za pripravo na utrjevanje znanja, za ponavljanja in

utrjevanje znanja pred ocenjevanjem znanja in za samopreverjanje (Slika 1).



Slika 1: Primerek spletišča v Wordpressu na Arnesovem strežniku splet.arnes.si, znotraj katerega so bili dijaki vpeti v formativno spremljanje učnega procesa

1.3 O računalniškem mišljenju

Bistveni del v poučevanju računalniškega mišljenja je osnovno razumevanje programiranja. Računalniško mišljenje pri poučevanju opisuje nabor orodij metod, ki jih je mogoče uporabiti za oblikovanje, analizo in obdelavo problemov/izzivov, tako da jih lahko reši algoritemska logika. Temelji na miselnih procesih in konceptih, kot so modeliranje problemov/izzivov z uporabo abstrakcije (pomaga razumeti in oceniti zahtevne in zapletene probleme), dekompozicije (razdelitev problemov na podprobleme), načrtovanje rešitev skozi zaporedne korake (logično in algoritmično mišljenje) in prepoznavanje vzorcev. V zadnjem obdobju je računalniško mišljenje postalo orodje za reševanje problemov na skoraj vseh strokovnih področjih srednješolskega izobraževanja. Poučevanje in učenje veščin računalniškega mišljenja tako postane ključnega pomena ne samo za inženirje in računalnikarje, temveč tudi za dijake na področjih zunaj pretežno naravoslovno-tehniških ved, med katere sodi tudi medijska produkcija, kjer je delovno-ustvarjalni tok močno odvisen od omenjenih veščin.

1.4 Raziskovalna vprašanja

V opravljeni raziskavi smo si prizadevali odgovoriti na naslednja raziskovalna vprašanja:

- Kako učinkovita so orodja H5P pri izboljšanju dijakovega razumevanja veščin računalniškega mišljenja pri programiranju v pythonu?
- Katera so najučinkovitejša orodja H5P za formativno spremljanje poznavanja veščin računalniškega mišljenja?
- Kako dijaki dojemajo uporabo formativnega spremljanja, ki temelji na H5P, v svojem učnem procesu?
- Kakšen vpliv imajo formativni dokazi uporabe H5P na angažiranost dijakov za učenje in dosežene učne rezultate?

2 METODA DELA

Poučevanja programiranja in z njim povezanimi veščinami računalniškega mišljenja postopoma postaja bistvena veščina na različnih strokovnih področjih medijske produkcije in je pomemben del v odprtem kurikulu, ki zajema temeljno znanje in sklepanje s praktičnim pristopom. Glede na omejen čas v učnem procesu je izziv, kako dijake učinkovito naučiti smiselnega nabora spretnosti, ki jim omogoča, da sami usmerjajo svoje prihodnje učenje. Poleg tega, ker strokovni modul vključuje sumativno ocenjevanje, potrebujemo druga sredstva za spremljanje in merjenje učenja dijakov ter usmerjanje razvoja samega modula. Te izzive obravnavamo tako, da združimo kratka predavanja s kratkimi kvizi za formativno spremljanje in učnemu procesu dodamo še eno učno dejavnost. Ugotavljamo, da so v odsotnosti sumativnega ocenjevanja kratki, pogosti kvizi s takojšnjimi povratnimi informacijami odlično orodje za spremljanje učenja razreda kot celote. Dijaki poročajo, da so kvizi, čeprav zahtevni, izboljšali njihovo razumevanje konceptov programiranja, jih osveščali o morebitnih napakah in bili zabavna učna izkušnja. Poleg tega rezultati iz tega prispevka ponazarjajo, kako je mogoče novega programskega jezika učiti dijake brez predhodnega znanja programiranja v kratkem času. V raziskavi je sodelovalo 140 dijakov, ki so imeli različne ravni predhodnih izkušenj s programiranjem in veščinami računalniškega mišljenja. Povzemamo naše izkušnje, pridobljene pri oblikovanju in vključevanju interaktivnih virov v spremljanje učnega procesa programiranja.

2.1 Oblikovanje nalog za formativno spremljanje učnega procesa

Da bi pridobili ustrezne dokaze o dijakovem razumevanju veščin računalniškega mišljenja, smo zasnovali nabor nalog s pomočjo interaktivnega ustvarjalca vsebine H5P v platformi WordPress. Te naloge vključujejo naslednje veščine računalniškega mišljenja: dekompozicija, prepoznavanje vzorcev, abstrakcija, algoritmi in odpravljanje napak. Naloge so bile oblikovane z uporabo različnih virov z različnimi značilnostmi in strukturami ter didaktičnimi priporočili, kot je podrobno opisano spodaj:

Prva naloga: Dekompozicija z interaktivnim videom

Orodje H5P: Interaktivni video vmesnik (Interactive Video)

Opis: Dijaki si ogledajo videoposnetek, ki razlaga kompleksen problem, in se morajo ustaviti na določenih točkah, da problem razdelijo na manjše dele.

Didaktično priporočilo: Dijake spodbujamo, da razpravljajo o razčlenjenih delih v parih, hkrati pa jih spodbujamo za sodelovalno reševanje problemov.

Druga naloga: Prepoznavanje vzorcev s funkcijo povleci in spusti

Orodje H5P: Povleci in spusti (Drag and Drop)

Opis: Dijakom je predstavljena vrsta izrezkov programske kode in morajo prepoznati vzorce tako, da povlečejo in spustijo podobne strukture kode v kategorizirana polja.

Didaktično priporočilo: S to nalogo utrjujemo pomen prepoznavanja vzorcev v kodi, ki je ključnega pomena za optimizacijo algoritmov.

Tretja naloga: Abstrakcija s kvizom z več možnimi odgovori

Orodje H5P: Kviz z možnimi izbirami (Multiple Choice Quiz)

Opis: Dijaki odgovarjajo na vprašanja z več možnimi odgovori, ki od njih zahtevajo, da prepoznajo temeljna načela za

kompleksnimi problemi, pri čemer učinkovito izvajajo abstrakcijo.

Didaktično priporočilo: Zagotavljamo podrobne povratne informacije za vsako možnost, da dijakom pomagamo razumeti, zakaj so določene abstrakcije ustrezne ali neustrezne.

Četrta naloga: Algoritmi z izzivom interaktivnega kodiranja

Orodje H5P: Razvrsti odstavke (Sort the Paragraphs)

Opis: Dijaki razvrstijo po ustreznem zaporedju premetane stavke pythonovskega programa za implementacijo algoritma za rešitev danega problema (Slika 2).

Didaktično priporočilo: Dovolimo večkratne poskuse in zagotovimo namige, ki bodo dijake vodili k pravilni rešitvi, kar bo okrepilo iterativno naravo kodiranja.

Slika 2: Primer naloge z orodjem H5P, razvrsti odstavke, ki od dijaka zahteva razvrstitev premešanega zaporedja stavkov v logično in algoritmično ustrezno zaporedje za pravilno izvedeno rešitev.

Naloga 5: Odpravljanje napak z vročimi točkami

Orodje H5P: Slikovne vroče točke (Hotspots)

Opis: Dijaki prepoznajo in popravijo napake v ponujenem delčku pythonove kode s klikom na napačne dele.

Didaktično priporočilo: S to nalogo poudarimo pomen odpravljanja napak kot kritičnega koraka v procesu razvoja programske opreme.

Pri izvajanju nalog z orodji H5P smo učitelji zagotovili jasna navodila (da dijaki razumejo cilje vsake naloge in kako ravnati z orodji H5P), spodbujali sodelovalno učenje (dijaki delajo v parih ali majhnih skupinah, s čimer spodbujamo spretnosti sodelovalnega reševanja problemov), ponudili takojšnje povratne informacije (uporaba funkcije povratnih informacij platforme H5P, da dijakom zagotovimo takojšnje odzive na njihova dejanja in jim pomagamo, da se učijo iz napak v realnem času) in poskrbeli za različnost nalog (prilagodimo kompleksnost nalog glede na raven znanja dijakov, da ohranimo angažiranost in izziv).

2.2 Izvedba in zbiranje podatkov

Naloge so bile izvedene znotraj strokovnega modula kreativno kodiranje s poudarkom na programiranju v pythonu. Po opravljenih nalogah so dijaki izpolnili anketo, da smo zbrali povratne informacije o njihovih učnih izkušnjah in dojemanju formativnega spremljanja, ki temelji na platformi H5P.

2.3 Oblikovanje ankete

Anketa je bila sestavljena iz kvantitativnih in kvalitativnih vprašanj. Namen raziskave je bil izmeriti zaznano učinkovitost orodij H5P, stopnjo angažiranosti in vpliv na njihove učne rezultate. Anketna vprašanja so vključevala naslednje kazalnike:

- Kako bi ocenili interaktivnost nalog spletnega okolja H5P, ki vam pomagajo razumeti veščine računalniškega mišljenja?
  Kazalniki: 1 (zelo nizko) do 5 (zelo visoko)
- Kateri vir H5P se vam je zdel najbolj učinkovit za učenje konceptov programiranja v pythonu?
  Kazalniki: več možnosti z možnostmi: interaktivni video, povleci in spusti, kviz z več možnimi izbirami, vrsta vsebine interaktivne kode, dostopna točka
- Kako so takojšnje povratne informacije, ki so jih zagotovile naloge, izdelane v H5P, vplivale na vaš učni proces?
  Kazalniki: 1 (sploh niso) do 5 (pomembno)
- Ali menite, da je uporaba orodij H5P izboljšala vaše sposobnosti reševanja problemov v Pythonu?
  Kazalnika: Da/Ne
- Kateri vidiki nalog, izdelanih v H5P, so se vam zdeli najbolj koristni ali zahtevni?
- Kazalnik: Odgovori esejskega tipa

2.4 Statistična analiza

Podatki, zbrani v raziskavi, so bili analizirani s statističnimi metodami z ustrezno programsko opremo DATAtab (https://datatab.net) [8, 9] za oceno učinkovitosti orodij H5P. Rezultati ankete so bili analizirani s t-testom, da bi ugotovili, ali obstaja statistično pomembna razlika v zaznavah dijakov pred in po uporabi orodij H5P za formativno spremljanje.

Glede na odgovore ankete so bile testirane naslednje hipoteze:

Ničelna hipoteza (H0): uporaba orodij H5P ne vpliva bistveno na angažiranost dijakov in razumevanje veščin računalniškega mišljenja.

Alternativna hipoteza (H1): uporaba orodij H5P bistveno izboljša sodelovanje dijakov in razumevanje veščin računalniškega mišljenja.

Uporabljena formula t-testa je bila:

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

kjer so so $\overline{X_1}$ in $\overline{X_2}$ aritmetični sredini obeh skupin (pred in po formativnem spremljanju), S_1^2 in S_2^2 varianci, n_1 in n_2 pa velikosti vzorcev (v našem primeru kar celotno število dijakov).

Opisna statistika je bila uporabljena za povzetek odgovorov na anketo, analiza s t-testom pa je bila izvedena za identifikacijo odnosov med stopnjami angažiranosti dijakov in njihovimi učnimi rezultati [7].

3 REZULTATI

3.1 Opisna statistika

Dobljeni rezultati so pokazali visoko stopnjo angažiranosti dijakov pri nalogah, izdelanih z orodji H5P. Večina dijakov je ocenila interaktivnost nalog kot "visoko" ali "zelo visoko", s povprečno oceno 4,3 na 5-stopenjski lestvici kazalnikov. Orodja Interactive Code Content Type in Drag and Drop so bila prepoznana kot najučinkovitejša za učenje konceptov programiranja v pythonu, pri čemer je 65 % dijakov dalo prednost tem orodjem.

3.2 Analiza s t-testom

t-test je pokazal znatno izboljšanje angažiranosti in razumevanja dijakov po uporabi orodij H5P za formativno spremljanje. Povprečne ocene za angažiranost so se povečale s 3,1 na 4,2 ($p < 0,05$), za razumevanje pa z 2,9 na 4,0 ($p < 0,05$). Ti rezultati kažejo, da so orodja H5P učinkovita pri izboljšanju učnih izkušenj dijakov pri računalniškem mišljenju.

3.3 Kakovostne povratne informacije

Kakovostne povratne informacije so pokazale, da so dijaki cenili takojšnje povratne informacije, ki jih zagotavljajo naloge z orodji H5P, kar jim je pomagalo hitro prepoznati in popraviti svoje napake (Tabela 1). Vendar se je nekaterim dijakom zdelo, da je naloga odpravljanja napak zahtevna zaradi zapletenosti predloženih delčkov programske kode.

Tabela 1: Ustreznost kakovostnih povratnih informacij

Anketno vprašanje	Povprečna ocena	Standardni odklon
Interaktivnost naloge	4,3	0,6
Učinkovitost povratne informacije	4,1	0,7
Izboljšanje učenja	4,2	0,5

4 RAZPRAVA

Ugotovitve kažejo, da so orodja spletne platforme H5P dragocena za formativno spremljanje učnega procesa in napčredka dijakov pri izobraževanju o računalniškem mišljenju. Zdi se, da interaktivna narava nalog H5P v kombinaciji s takojšnjo povratno informacijo spodbuja globlje razumevanje in večjo angažiranost dijakov. Vsestranskost orodij H5P omogoča učiteljem, da oblikujejo raznolike in prilagodljive naloge, ki lahko poskrbijo za različne učne stile in ravni znanja.

5 ZAKLJUČEK

Formativno ocenjevanje je bistvenega pomena pri izobraževanju programiranja za merjenje razumevanja dijakov in njihovo vodenje skozi učni proces. V prispevku smo raziskvali uporabo veščin računalniškega mišljenja skozi osnovne koncepte in konstrukte v programiranju – kot so zaporedja, spremenljivke, tipi podatkov, vejitve, zanke in funkcije – v pythonu za ustvarjanje učinkovitih formativnih dokazov. Z vključitvijo teh temeljnih elementov lahko učitelji spremljajo napredek v razumevanju posredovanega in naučenega ter oblikujejo smiselne povratne informacije, ki ne samo ocenjujejo znanja, ampak tudi krepijo sposobnosti reševanja problemov in logično mišljnje dijakov. Metodologije, obravnavane tukaj, zagotavljajo praktične primere in strategije platforme H5P kot učinkovitega orodja za vključevanje formativnega spremljanja v učni proces poučevanja osnov programiranja v pythonu. Pozitiven vpliv na sodelovanje in razumevanje dijakov poudarja pomen vključevanja takih interaktivnih orodij v kurikul za izboljšanje digitalne kompetence.

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Utrjevanje snovi preko interaktivne sobe pobega

Consolidating Knowledge through an Interactive Escape Room

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POVZETEK

V sodobni šolski situaciji se učitelji, učenci in drugi udeleženci učnega procesa srečujemo z vedno več ponudbami različnih aplikacij, ki spodbujajo vključevanje učencev v učni proces.

V kolikšni meri bomo kot učitelji aplikacije vključili v pouk, je odvisno od naše pripravljenosti raziskovanja in preizkušanja novosti. Velikokrat se pri uvajanju novih aplikacij pojavi, vsaj pri nas starejših učiteljih, strah pred neizkušenostjo, saj so učenci spretnejši pri uporabi le-teh.

Učenci imajo radi sobe pobega, pri katerih je treba ob pomoči različnih ugank in namigov najti izhod iz zaprtega prostora v omejenem času. Na takšen način namreč največkrat praznujejo rojstne dneve. Zato sem tudi sama razmišljala, da bi ustrezno zasnovano sobo pobega lahko uporabila kot učno metodo pri pouku.

V prispevku bom predstavila, kako je potekalo utrjevanje snovi o zgodovini domačega kraja preko interaktivne sobe pobega. Za učence sem v Google Forms in Deck Toys pripravila interaktivni sobi pobega. Iz sob so lahko pobegnili le tako, da so pokazali znanje iz zgodovine domačega kraja, ki so ga dobili na sprehodu po njem in s pomočjo pripravljene literature.

KLJUČNE BESEDE

Informacijsko-komunikacijska tehnologija, interaktivna soba pobega, Komenda, sodelovalno učenje, učenci

ABSTRACT

In today's educational environment, teachers, students, and other participants in the learning process are increasingly presented with various applications designed to engage students more deeply. The extent to which we, as teachers, incorporate these applications into our lessons depends largely on our willingness to explore and experiment with new technologies. For many older teachers, there may be some apprehension about adopting new applications due to a lack of experience, especially since students are often more adept at using them.

Students are particularly fond of escape rooms, where they solve puzzles and follow clues to find their way out of a confined space within a limited time. This activity is a popular way for them to celebrate birthdays. Inspired by this concept, I considered using a well-designed escape room as a teaching method in the classroom.

In this paper, I present how an interactive escape room was used to consolidate knowledge about the history of the students' hometown. I created these escape rooms using Google Forms and Deck Toys, where students could only "escape" by demonstrating their knowledge of the local history they had learned during a guided walk and through the use of provided literature.

KEYWORDS

Information and communication technology, interactive escape room, Komenda, collaborative learning, student engagement

1 UVOD

Sodobne tehnologije in mediji se odražajo na vseh področjih našega življenja. Razpoložljivost informacijskih in komunikacijskih tehnologij (IKT) je postala norma, ki kaže napredek in razvoj nekaterih družb. IKT se je iz udobja doma preselila tudi v šolske prostore, kjer spodbuja motivacijo učiteljev, olajša dostop do informacij in podpira sodobne pristope k poučevanju. IKT tudi olajša poučevanje otrok s posebnimi potrebami in učiteljem omogoča pristop k učencem z različnimi učnimi stili. [1]

Večji del svojega učiteljskega dela poučujem v petem razredu. Posebej se rada pripravljam na ure, ko pri predmetu družbe spoznavamo Slovenijo in domači kraj. Čeprav imajo učenci pred seboj zemljevid in pri urah ob razlagi uporabljam različne pripomočke, opažam, da jih še najbolj privlačijo virtualni.

2 INFORMACIJSKO-KOMUNIKACIJSKA TEHNOLOGIJA V ŠOLI

»Učiti se« pomeni spoznavati nekaj novega, pridobivati novo vedenje, nove izkušnje, razvijati nove spretnosti, odkrivati neznana področja, razumeti sebe in svet, v katerem živimo, ter se v njem čim bolje znajti. Učimo in izobražujemo se tudi mi učitelji, še posebej tisti, ki smo starejši in ki nismo odraščali z digitalno tehnologijo, s katero se srečujemo zadnja leta.

In čeprav smo pri svojem delu sicer avtonomni, iščemo različne metode in oblike dela, s katerimi bodo učenci prišli do znanja in osvojili cilje učnega načrta.

Ob različnih metodah in oblikah dela, ki jih vključujem v poučevanje, se trudim, da uporabljam tudi informacijsko-komunikacijsko tehnologijo (IKT). Dnevno uporabljam že

izdelano interaktivno gradivo založb, pripravljam preproste Power Point predstavitve, lotim pa se tudi kakšnega interaktivnega kviza.

Hiter napredek in razvoj tehnologije nam starejšim učiteljem večkrat prinaša nelagodje. Tehnologijo lahko na ustrezen in smiseln način vključim v pedagoški proces le, če poznam raznovrstno IKT in jo znam tudi učinkovito uporabljati. Znati moram torej izbrati primerno metodo v okviru IKT na podlagi vsebine, ki jo poučujem, in jo nato na ustrezen način vključim v pouk.

Zgodi se mi, da včasih dobim odpor do njene uporabe, saj mi le-ta predstavlja izziv, ki ga nisem vedno pripravljena sprejeti. A podpora s strani mlajših kolegic mi da dodatno motivacijo. Nove tehnologije v pouk tako uvajam postopoma, kot pripomoček za učenje.

V prispevku bom predstavila, kako sem pri utrjevanju snovi v razredu uporabila spletne obrazce Google Forms in program Deck Toy. Z obema sem ustvarila interaktivno sobo pobega.

Priprava na tak pouk je za učitelja bolj zahteven, pri uri s pripravljenim IKT gradivom pa je opazovalec in usmerjevalec dela, aktivni pa so učenci. Pomembno je tudi, da s takim delom spodbujamo, krepimo in ustvarjamo sodelovalno učenje

2.1 Ura družbe

Pri uri družbe z učenci raziskujemo tudi domači kraj in obravnavamo njegovo zgodovino. Vsako šolsko leto znova ugotavljam, da učenci svojega kraja in znamenitosti ne poznajo. Še dobro, da imamo kolesarja Tadeja Pogačarja, saj je učencem znan le roza oz. rumeno obarvan Pogačarjev rondo v Komendi. Tako si v razredu najprej preko Power Point predstavitve ogledamo glavne znamenitosti Komende. V zvezek si zapišemo miselni vzorec (izdelan v Canvi – oblikovale smo ga skupaj v aktivu).

Slika 1. Miselni vzorec o Komendi (VIR: lasten, zajem zaslonske slike)

Naslednjo uro gremo skupaj z učenci na sprehod po Komendi in raziskujemo njeno zgodovino. Že pred sprehodom jih spodbudim, naj pozorno poslušajo, mogoče tudi kaj zabeležijo v beležke, ki jih nesejo s seboj, saj jih bo na povratku v šoli čakalo razburljivo virtualno potovanje.

Predvidevala sem, da so bodo učenci zapomnili nekatere od znamenitosti, o katerih smo se pogovarjali predhodno uro, zato jih poskušam na sprehodu čim bolj vključiti. Žal ugotovim, da so le nekateri znali prepoznati in poimenovati posamezno znamenitost, več pa ne.

Po skupnem obhodu in ustavljanju ob pomembnih objektih, ob katerih povem o vsakem nekaj zanimivosti, spoznamo tudi pomembne može, ki so nekoč živeli v Komendi.

Seveda omenim tudi Tadeja Pogačarja, svetovno znanega kolesarja in pisatelja Ivana Sivca (ki sedaj sicer živi v Mengšu), a je še vedno med prvimi najbolj branimi avtorji, posebej mladinskih knjig.

Ustavimo se ob spomenikih, pomembnih zgradbah in kipih.

Učni sprehod po Komendi opravim vsako šolsko leto, a so si tokrat učenci še z večjim zanimanjem zapisovali podatke, kot leta poprej, saj sem jih predhodno spodbudila, da bomo po končanem poučnem sprehodu v razredu snov ponovili in utrdili preko zanimivega virtualnega popotovanja.

Prejšnja šolska leta smo namreč po prihodu v razred izvedli kviz, ki sem ga pripravila po vzoru oddaje oz. družabne igre Moja Slovenija.

2.2 Soba pobega

Večkrat sem že poslušala učence, ki so v šoli z zanimanjem pripovedovali, kako so praznovali svoj oz. rojstni dan prijatelja v sobi pobega.

Zakaj ne bi poskusili nekaj podobnega še v razredu?

Zavedam se, da tehnologijo lahko na ustrezen in smiseln način vključim v pedagoški proces le, če jo znam učinkovito uporabljati. Zato moram znati izbrati primerno metodo v okviru IKT na podlagi vsebine, ki jo poučujem, in jo nato na ustrezen način vključiti v pouk.

Za to je potrebna volja in seveda pomoč mlajših kolegic.

Prvo sobo pobega sem naredila v Google Forms. Za delo v tem okolju je potreben le Google račun, ki je za uporabnike brezplačen. Učenci za reševanje ne potrebujejo računa in se jim ni potrebno prijavljati. To orodje mi je všeč, ker lahko k vprašanjem dodamo slike, posnetke in tako naredimo reševanje preglednejše, nazornejše in zanimivejše.

V Google Forms sem sestavila vprašanja na temo zgodovine domačega kraja. Vsako vprašanje je na nek način zaklenjeno in učenci lahko z naslednjim nadaljujejo šele, ko pravilno odgovorijo na trenutno vprašanje. To se mi zdi koristno, saj so učenci tako primorani priti do pravega odgovora, sicer ne morejo nadaljevati.

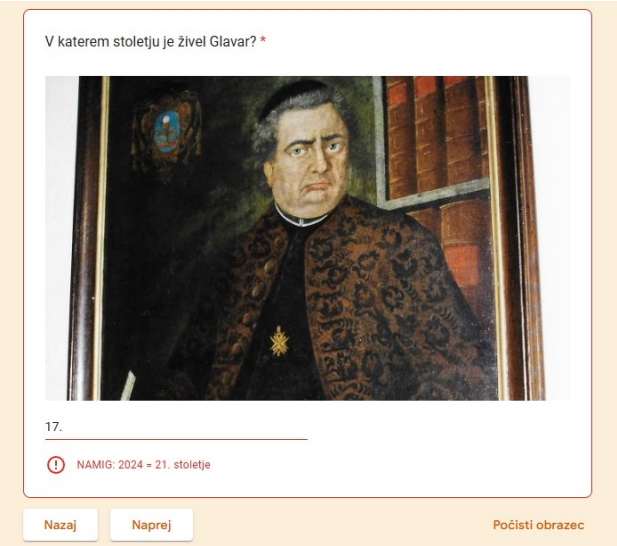
Stvar je še nekoliko otežena, saj morajo pri odgovorih paziti tudi na slovnični zapis besede, sicer program odgovora ne zazna kot pravilnega. Na to sem jih opozorila tudi na prvi strani, kjer sem jim napisala navodila za reševanje nalog.

Ta način mi je všeč tudi zato, ker lahko za učence napišem tudi namig, če napišejo napačen odgovor in jih tako usmerim na pravo pot. Nekatere skupine so imele težave z vprašanjem, v katerem stoletju se je rodil Glavar, saj so pozabili, kako se določa stoletje. V namigu sem jih spomnila na način določanja stoletja.

Drugo sobo pobega sem ustvarila s programom Deck Toys. Tudi pri tem reševanju učenci ne morejo nadaljevati z delom, dokler pravilno ne opravijo naloge. Program je deloma brezplačen, za dodatne možnosti pa je potrebno doplačilo. Menim, da je za učitelje osnovna verzija za popestritev pouka povsem zadostna.

Ta program je na začetku nekoliko težji in zamudnejši, ko pa ga enkrat usvojiš, ti pomaga ustvariti zanimive naloge za učence.

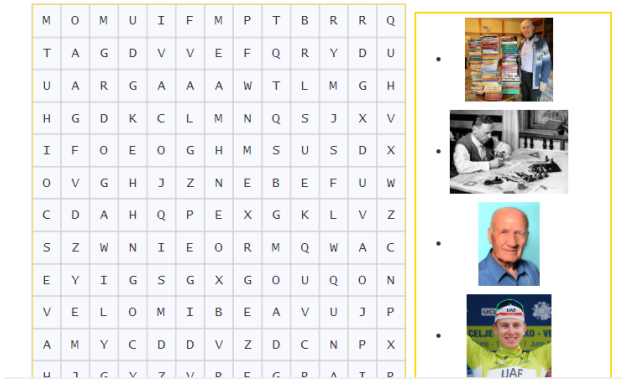
Slika 2. Primer navodil za učence (VIR: lasten, zajem zaslonske slike)



Slika 3. Namig pri enem izmed vprašanj (VIR: lasten, zajem zaslonske slike)

Omogoča ustvarjanje različnih tipov nalog: križanke, spomin, sestavljanke, naloge povezovanja … Z različnimi tipi nalog tako lahko približamo učenje različnim tipom učencev. Z reševanjem teh nalog so tako utrjevali snov in hkrati ugotavljali, koliko znanja so odnesli od pouka.

Slika 4. Začetna stran sobe pobega (VIR: lasten, zajem zaslonske slike)



Slika 5. Primer naloge (VIR: lasten, zajem zaslonske slike)

Ta program ima slabost, saj ne upošteva šumnikov, kar zna biti pri reševanju nekoliko moteče. Na to sem učence opozorila na začetni strani z navodili. Zdi se mi prav in koristno, da se učenci naučijo natančno brati navodila, kar opažam, da v zadnjih letih poučevanja to postaja vedno pogostejša težava.

2.3 Delo v razredu

Z učenci smo po prihodu v učilnico najprej pogovorili o sobi pobega. Veliko jih je sobo pobega že obiskalo in so navdušeno pripovedovali, kako so morali ob pomoči različnih ugank in namigov najti izhod iz zaprtega prostora v omejenem času.

Povem jim, da bomo v nadaljevanju ure preko virtualne sobe pobega ponovili, kar smo na učnem sprehodu po Komendi videli in slišali.

Učence sem razdelila v heterogene skupine. Upoštevala sem znanje učenca, sposobnosti in socialno spretnost ter jih spodbudila k sodelovalnemu učenju. Sodelovalno učenje je oblika učenja v majhnih skupinah, v katerih učenci skušajo doseči zastavljene učne cilje. Temelji na njihovi medsebojni

soodvisnosti in odgovornosti, pomembno pa je, da vsak doda svoj prispevek k skupni nalogi.

Učenci se tudi bolje spoznajo med seboj, razvijajo skupinsko identiteto, doživijo medsebojno podporo. Naučijo se spoštovati razlike med člani skupine in razvijajo sinergijo v skupini. [2]

Skupinam sem razdelila tablice. Povezavo do obeh virtualnih sob sem jim pripela v Microsoft Teams, kamor so vključeni vsi učenci. S klikom na povezavo so se jim odprla vrata do virtualne sobe, iz katere so poskušali čim prej pobegniti. Najprej so se lotili sobe pobega v MS Forms, nato še drugo, narejeno v Deck Toys.

S skupnimi močmi so učenci poskušali razvozlati vprašanje in se tako prebiti do naslednjega. Opazovala sem jih, kako so brskali po svojih zapiskih in pripravljeni literaturi. Ni jim bilo težko prebrati niti daljšega besedila, pomembno je bilo, da so našli pravi odgovor.

Ko je vsem skupinam uspelo pobegniti iz sob, smo skupaj opravili refleksijo njihovega dela. Učenci so svoje znanje označili za uspešno, prav tako zmožnost pridobivanja informacij iz pripravljenih gradiv.

3 PREDNOSTI IN SLABOSTI

Prednost je zagotovo sodelovalno učenje. V kvizu, ki sem ga izvajala prejšnja leta, je bil razred razdeljen v dve skupini in čeprav so bile naloge različnega tipa, vsi učenci v skupini niso sodelovali. Tokrat so bili bolj motivirani za delo, samostojno so raziskovali in brskali po pripravljeni literaturi.

Pozorno so morali prebrati vprašanja, sicer so bili zapisani odgovori prepoznani kot nepravilni in niso mogli nadaljevati z delom.

Učenci so bili motivirani za delo in številni so nalogo opravili tudi doma. Tako so snov še enkrat ponovili in poskrbeli, da si boljše zapomnijo podatke o zgodovini svojega domačega kraja.

Slabost je ta, da moram vnaprej pripraviti tablice, ki ne delujejo vedno , kot bi si želeli. Največkrat nas razočarajo tik pred uporabo. Da pričnejo pravilno delovati, je potreben dodaten čas in če še nisi strokovnjak na tem področju, potrebuješ dodatnega časa še več. Tudi tokrat je bilo tako. Dve tablici namreč nista delovali.

Prav tako je slabost tudi ta, da sem morala oblikovati vprašanja, na katera so učenci odgovarjali z eno besedo ali besedno zvezo. Zato sem potem učencem postavljala še dodatna ustna vprašanja, da kljub vsemu niso bili prikrajšani za kakšen podatek.

Paziti so morali tako na pravopisne kot na tipkarske napake, saj se je zgodilo, da so našli pravilni odgovor, a so se zatipkali in zato niso mogli naprej. Zato so si vtipkane odgovore zapisovali na list in če niso prišli do naslednjega vprašanja, so me poklicali, da sem preverila njihov zapisani odgovor. Če je bil zapisan pravi odgovor, sem jih opozorila na tipkarsko napako in spremljala njihov vnos, da je bil pralni odgovor tudi ustrezno vpisan.

4 ZAKLJUČEK

Čeprav učencem tokrat ni bilo potrebno najti izhoda iz zaprtega prostora v omejenem času, kot je to v fizični sobi pobega, ki so jo obiskali že kdaj prej, so tudi pri reševanju iz virtualne pokazali zanimanje in motivacijo za ponavljanje, kar pa je bistvo za uspešno delo in učenje.

Otroci, ki v teh časih hodijo v šolo, so ves čas vpeti v sodobno tehnologijo, zato jim vsekakor moramo priti naproti in posodobiti način poučevanja.

Kot učitelji moramo najti pravo ravnovesje med uporabo IKT in uporabo drugih metod, kar pa pogosto ni prav lahko delo.

IKT ne bo nadomestila učitelja, saj se ni sposobna vživeti in prilagoditi vzdušju v razredu, pa tudi odzivnosti na posamezne učne strategije ji manjka, lahko pa dinamično in všečno obogati učiteljevo razlago in ostale faze njegovega dela.

ZAHVALA

Hvaležna sem svoji sodelavki Marjeti Kuhar, ki prav tako kot jaz poučuje v 5. razredu. S svojim znanjem na računalniškem področju ter stalno pripravljenostjo pomagati, me spodbuja k preizkušanju in uporabi novih aplikacij.

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Pouk matematike z IKT

Mathematics Lessons with ICT

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POVZETEK

V današnjem svetu je poznavanje informacijsko-komunikacijske tehnologije (IKT) in povezovanje z ostalimi znanji nujno potrebno.

Učenje s pomočjo sodobne tehnologije dijake motivira in jim omogoča hitrejše in kakovostnejše doseganje učnih ciljev. Ko IKT povežemo še s sodelovalnim učenjem, dijaki pri tem razvijajo tudi druge pomembne kompetence 21. stoletja.

V srednji šoli ima risanje geometrijskih likov, teles in funkcij velik pomen pri poučevanju matematike. Pomembno je, da dijaki razumejo, kako liki, telesa in funkcije nastanejo in kako se spreminja njihova velikost in oblika pri različnih spremenljivkah.

V prispevku je predstavljen pomen in primeri uporabe IKT pri pouku matematike. Predstavljeno je delo dijakov, ki so samostojno ali v skupinah reševali problemsko strukturirane naloge, pri čemer so morali pridobljeno teoretično znanje uporabiti, da so naloge najprej rešili, nato pa jih kritično preverili in raziskovali s pomočjo uporabe različne IKT.

KLJUČNE BESEDE

IKT, matematika, skupinsko delo

ABSTRACT

In today's world, the knowledge of information and communication technology (ICT) and the connection with other skills is absolutely necessary.

Learning by means of modern technology motivates students and enables them to achieve learning goals faster and with better quality. When we connect ICT with collaborative learning, students also develop other important 21st century competences.

In high school, drawing geometric shapes, solid figures and functions is of great importance in teaching mathematics. It is important for students to understand how geometric shapes, solid figures and functions are created and how their size and shape change according to different variables.

The article presents the importance and the examples of the use of ICT in mathematics lessons. We presented the work of students who solved problem-structured tasks independently or in groups, where they had to use the acquired theoretical knowledge to first solve the tasks, and then critically check and research them, using various ICTs.

KEYWORDS

ICT, mathematics, group work

1 UVOD

Učitelji potrebujemo vedno več znanja in izkušenj, da bi bili sposobni razumeti in se prilagoditi vsakodnevnim situacijam, ki se pojavljajo v učnem procesu.

Pri predmetu matematika je učiteljeva IKT pismenost pomemben dejavnik. Prav tako kot razumevanja določene teme je treba dijake naučiti uporabljati tehnologijo pri reševanju matematičnih problemov. Pri vsakodnevnem delu v razredu opažamo, da so sicer digitalno pismeni, a je njihova sposobnost zbranosti in sprejemanja informacij zelo kratka, zato jih je treba ves čas motivirati.

V nadaljevanju bo predstavljeno, kateri IKT se uporablja pri pouku matematike. Natančneje bodo prikazane dejavnosti, ki so dijake spodbudile k sodelovalnemu delu, reševanju problemov, raziskovanju in obenem k aktivni rabi IKT v vseh fazah učenja.

Namen prispevka je prikazati, kako se lahko s tehnologijo izboljša poučevanje in razumevanje matematike.

2 IKT PRI POUKU MATEMATIKE

Kompetentnost učitelja je »sposobnost učinkovitega delovanja v številnih situacijah, ki sicer temelji na pridobljenem znanju, vendar ni omejeno s tem znanjem« [1].

Spoznanje, da strokovno znanje le delno zagotavlja uspešno delo v šolstvu, privede učitelja v nenehno skrb za osebnostni razvoj. In sicer tudi na področju poučevanja z uporabo sodobnega IKT.

Pri matematiki učitelji uporabljamo IKT z namenom izvajanja matematičnih postopkov in obravnave kompleksnejših matematičnih problemov, hkrati pa se na ta način omogoča tudi kompenzacijo primanjkljajev v znanju in sposobnostih dijakov. Z uporabo IKT učitelji s poudarkom na osmišljanju matematičnih pojmov matematiko približamo dijakom na zabavnejši način.

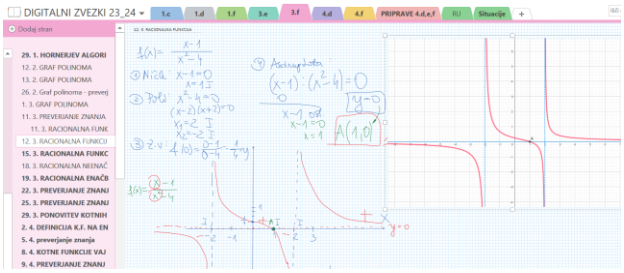
Pri pouku matematike IKT uporabljamo, da bi:

- razvijali matematične pojme;
- raziskovali in reševali probleme ter modelirali;
- avtomatizirali določene postopke;
- shranjevali, razvrščali, urejali, predstavljali rezultate dela;
- preverjali znanje. [2]

V nadaljevanju bodo predstavljeni primeri uporabe IKT pri pouku matematike.

2.1 Primer 1: MICROSOFTOVO ORODJE ONENOTE

Interaktivna tabla omogoča, da se med urami uporablja Microsoftovo orodje OneNote. V njem je za posamezen oddelek oblikovan digitalni zvezek (slika 1), namenjen sprotnemu sledenju pouka matematike. To orodje omogoča vnaprejšnjo pripravo določenih gradiv, kar pripomore k večji strukturiranosti pouka. Zapiske, ki nastajajo med poukom na koncu ure, je možno deliti z dijaki. Prav tako se lahko pogleda katerakoli pretekla snov oz. poljubna ura, s čimer se brez večjih težav ponovi snov, na kateri temelji nadaljnja razlaga. Tak način poučevanja omogoča, da je uporabljena tehnologija, ki je v danem trenutku najbolj primerna, da bi dijaki lažje usvojili snov. Prednost uporabe Onenote je tudi ta, da dijaki v enakem času rešijo več nalog ter da jim nudi boljšo prostorsko predstavljivost snovi. Vnaprej pripravljeno gradivo pomeni, da med poukom ostane več časa za nadzor dela, komunikacijo in sodelovanje z dijaki ter dodatno razlago, če česa niso razumeli. Vse, kar naredimo na tabli, lahko shranimo, delimo ali uporabimo ob ponavljanju ter pripravi na preizkuse znanja.

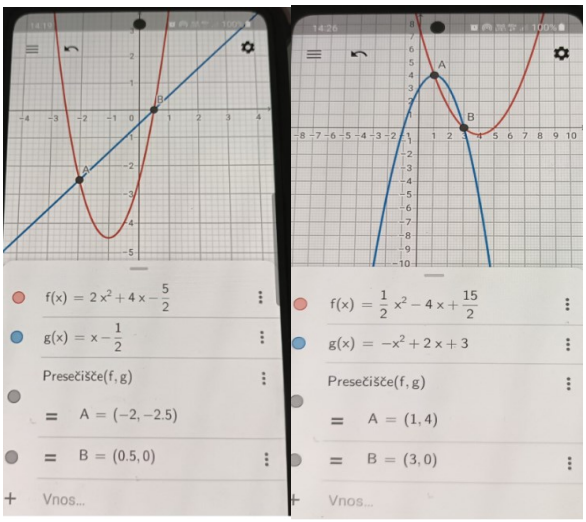


Slika 1: Prikaz tabelne slike v digitalnem zvezku

2.2 Primer 2: PROGRAM GEOGEBRA

Na poučevanje geometrijskih konceptov pozitivno vpliva uporaba programov za dinamično geometrijo. Eden takšnih je GeoGebra [3]. Gre za prosto dostopno aplikacijo, ki združuje komponente geometrije, algebre in analize. Možnosti uporabe GeoGebre zajemajo številne matematične vsebine. Med drugim lahko z njeno pomočjo ponazarjamo geometrijske elemente in obravnavamo njihove lastnosti, rišemo grafe funkcij in obravnavamo njihove lastnosti, statistično obdelujemo podatke ter ponazarjamo koncepte s področja verjetnosti. Program nam omogoča spreminjanje lastnosti objekta in opazovanje teh sprememb, s čimer pri dijakih spodbujamo vizualizacijo.

Prikazana je uporaba aplikacije GeoGebra pri pouku matematike v drugem letniku srednje šole pri temi kvadratna funkcija (slika 2). Aplikacija je brezplačna in dostopna tako na Androidu kot na sistemu iOS in ima več kot 10 milijonov prenosov.



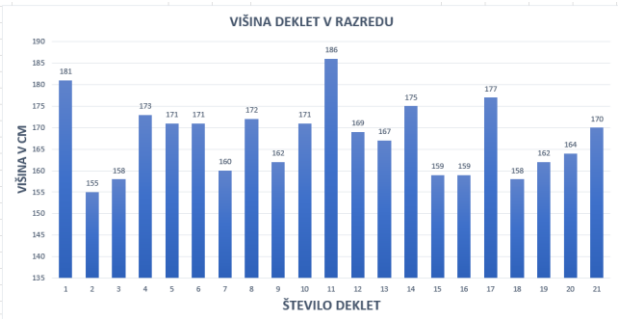
Slika 2: Prikaz rešenih nalog z aplikacijo Geogebra na telefonu

2.3 Primer 3: RAČUNALNIŠKE PREGLEDNICE IN GRAFI

Pri učni temi statistika dijaki uporabljajo program Excel za izračun mediane, modusa in povprečne vrednosti. Dijaki, ki na koncu opravljajo poklicno maturo, pa na ustnem delu uporabljajo tudi program Excel pri določenih matematičnih situacijah, s čimer pokažejo znanje prikazovanja podatkov s pomočjo tabele in grafov (tabela 1 in slika 3).

Tabela 1: statistika - primer uporabe

Podatki - višina deklet v razredu			Ukazi: = pred vsako formulo
181	Koliko je vseh podatkov?	21	COUNT(B3:B23
155	x_{min} =	155	MIN(B3:B23
158	x_{max} =	186	MAX(B3:B23
173			
171	Vsota =	3520	SUM(B3:B23
171			
160			
172			
162	aritmetična sredina	167,6	J7/J3
171	modus	171	MODE(B3:B23
186	mediana	169	MEDIAN(B3:B23
169			
167	Kolikokrat se modus ponovi?	3	COUNTIF(B3:B23;J12
175			
159			
159			
177			
158			
162			
164			
170			

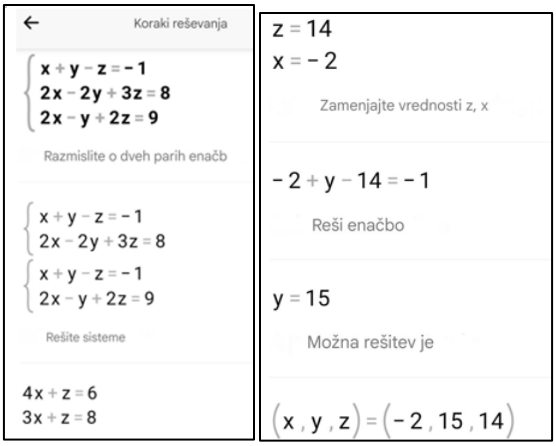


Slika 3: Uporaba Excela

2.4 Primer 4: PROGRAM PHOTOMATH

Photomath [4] je aplikacija, ki deluje tako na operacijskem sistemu Android kot tudi na iOS. Dijaki uporabljajo Photomath za preverjanje svojih rešitev. Za prikaz rešitve se nalogo fotografira, mobilna programska oprema PhotoMath prikaže rešitev ali pa omogoči prikaz vseh korakov, ki so bili uporabljeni za izračun.

Prikazan je primer (slika 4), ko so dijaki preverjanje znanja opravili v parih. Dijaka sta pred uporabo IKT izvedla najprej medvrstniško vrednotenje. Med seboj sta pregledata rešitve in ob tem razvijala še pozitivno komunikacijo, ki je nekonfliktna, spoštljiva, hkrati pa sta uspela odločno predstaviti napake in možnosti izboljšave.



Slika 4: Prikaz rešenih nalog z aplikacijo Photomath

2.5 Primer 5: ZRCALJENJE ZASLONA

Pri preverjanju znanja se uporablja zrcaljenje zaslona (ang. Screen mirroring). To je tehnologija, ki omogoča prenos in prikazovanje zaslona mobilne naprave na zaslon, v našem primeru na projektor (slika 5). Na ta način lahko vsem dijakom hkrati podamo kriterije uspešnosti. Prihranimo čas, ki ga namenimo komunikaciji z dijaki in preverjanju, da so dijaki snov res usvojili. Prikazan je primer, ko so dijaki najprej samostojno rešili nalogo, sama pa sem medtem z mobilnim telefonom slikala pravilno rešitev pri enem dijaku in jo projicirala na tablo.

2.6 Primer 6: MS TEAMS

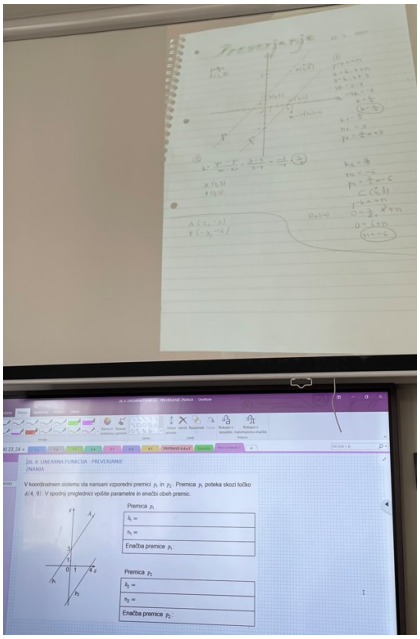
Za grajenje komunikacije z dijaki uporabljamo pri pouku tudi MS Teams. Ekipe, ki jih ustvarimo za vsak razred posebej, omogočajo prenos informacij in drugih gradiv vsem dijakom. Klepet pa dijaki uporabljajo za individualni pogovor z učiteljem. V MS Teams dijaki občasno oddajo tudi domačo nalogo in tako dobijo povratno informacijo.

2.7 Primer 7: UPORABA PROGRAMA DESMOS

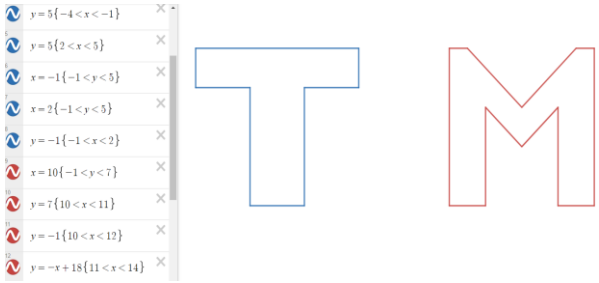
Program Desmos [5] je razvil Eli Luberoff, profesor matematike in fizike na Univerzi Yale. Uporablja se lahko kot spletna ali mobilna aplikacija. Uporabniki programa si lahko ustvarijo uporabniški račun, v katerega shranjujejo grafe, ki jih lahko kadar koli uporabijo. Desmos je interaktivno matematično orodje, ki omogoča uporabnikom ustvarjanje in raziskovanje grafov ter matematičnih funkcij. Uporablja se lahko za različne matematične naloge, kot so risanje grafov, reševanje enačb, analizo funkcij in drugo.

Desmos je zasnovan za enostavno uporabo in je dostopen na spletu ali v aplikaciji.

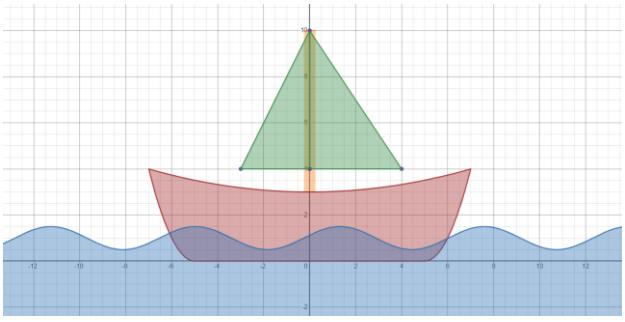
Dijaki so imeli za nalogo, da s pomočjo matematičnih funkcij v Desmosu izdelajo črki svojega imena in priimka (slika 6). V spodaj prikazanem primeru so potrebovali 20 različnih linearnih funkcij z intervali.



Slika 5: Zrcaljenje zaslona



Slika 6: Ustvarjanje v Desmosu



Slika 7: Igranje v Desmusu

Dijaki so poleg črk svojega imena, za zabavo, lahko pripravili karkoli. In tako je pri domačem delu nastala slika 7.

3 ZAKLJUČEK

Kljub časovni stiski pri matematiki je pri individualnem delu ali delu v skupinah in uporabi različnega IKT še bolj pomembno zavedanje učitelja, da ne poda prehitro povratne informacije in pusti, da dijaki sami popravijo svoje napake in imajo možnost za izboljšanje.

Pri vsaki uporabi IKT dijaki niso usvojili le določene snovi, temveč so se naučili tudi, kako preveriti in raziskati postopke reševanja. Predvsem pa so se s pomočjo uporabe IKT naučili, kako kritično analizirati svoje rezultate. Na ta način so bili bolj motivirani, večkrat so tudi ponovili postopke reševanja in se učili iz svojih in napak sošolcev.

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[4] Matematični program Photomath. Dostopno na naslovu: https://photomath.com/

[5] Matematični program Desmos. Dostopno na naslovu: https://www.desmos.com

Do boljšega razumevanja fizikalnih količin s pomočjo temeljnih znanj računalništva in informatike

Towards a Better Understanding of Physical Quantities through Fundamental Knowledge of Computer Science and Informatics

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POVZETEK

V prispevku je predstavljena izvedba laboratorijskih vaj iz fizike s pomočjo računalniške tehnologije na nekoliko drugačen način. Velika praznina v pouku postaja razdeljenost med področji znanja in znanosti, ki je mladostniki sami ne zmorejo zapolniti. Zato je bil projekt medpredmetne povezave zastavljen tako, da dijaki spoznajo tako fiziko kot informatiko kot dve enakovredni znanosti, ki ena drugo nadgrajujeta in se povezujeta. Opisana je ideja, ki je pripeljala pouk od pogovora in priprave gradiv do izvedbe vaj. Predstavljena je tudi izvedba v razredu in nekaj ključnih ugotovitev o izvedbi.

KLJUČNE BESEDE

Računalništvo in informatika, fizika, fizično računalništvo, micro:bit

ABSTRACT

The article presents the implementation of physics lab exercises using computer technology in a slightly different way. A significant gap in education is the division between fields of knowledge and science, which adolescents are unable to bridge on their own. Therefore, the project of interdisciplinary integration was designed so that students would understand both physics and computer science as two equal sciences that complement and connect with each other. The idea that led the teaching process from discussions and preparation of materials to the implementation of the exercises is described. The execution in the classroom and some key findings about the implementation are also presented.

The conclusion of the article outlines plans for future work and the use of this approach in addressing other topics in physics and computer science, with the possibility of transferring it to other subjects.

KEYWORDS

Computer science, physics, physical computing, micro:bit

1 Medpredmetno povezovanje malo drugače

Dijaki želijo delati praktično, kar dejansko pomeni, da moramo povezovati znanje različnih predmetov. Vendar kljub temu ostajamo pri pouku ločeni po predmetnih področjih. To se dogaja kljub medpredmetnemu povezovanju, kjer običajno en predmet prevzame vodilno vlogo, drugi pa ostane v vlogi podpornega predmeta.

Zaradi motivacijskega učinka je uporaba fizičnega računalništva dobrodošla, ker dijakom nudi učinek takojšnjega odgovora in možnosti takojšnje povratne informacije. S tem je poudarjena vloga povratne informacije, ki dijakom pomaga razumeti, kaj delajo, učitelju pa predstavlja "pomočnika" pri njegovem delu.

Fizika je v osnovi znanost, kjer lahko dijaki dobijo znanja iz zelo različnih področij, ker se s snovjo dotika praktično vsakega dela našega življenja. Ljudje to običajno začutimo, ko moramo kaj narediti s svojimi rokami, ne le z razmišljanjem. Zato je pomemben del pouka laboratorijsko delo, s katerim dijaki razvijajo ročne spretnosti in sposobnosti reševanja problemov. Pri tem spoznavajo povezanost različnih področij znanosti, ki se prepletajo tudi s pomočjo sodobne komunikacijske in informacijske tehnologije.

1.1 Enakost?

Med svojim delom učitelji, kakor tudi dijaki, spoznavamo, da se zaradi časovnih okvirjev in zaporedja snovi posameznega predmeta različni predmeti težko povezujejo med sabo. Tako se običajno zgodi, da en predmet prevzame vlogo prvega oz. učnega predmeta, drugi predmet pa je potem le vir podatkov ali metod dela. Na takšen način učitelj drugega predmeta pri pouku ne doseže vseh ciljev, čas pa teče ne glede na to, kaj je bilo doseženega. Zato pride do razhajanja, ker imajo predmeti na razpolago le določeno kvoto časa.

Zaradi dela v skupini projekta MINUT NAPOJ (http://naslokar.fmf.uni-lj.si/FMF/MINUT-NAPOJ/MINUT-NAPOJ-predstavitev.html#domov) sva se zavedala te pasti in sva v osnovi skušala zmanjšati to razliko ter obema predmetoma določila cilje kot izhodišče načrtovanja.

1.2 Povezovanje znanja

S stališča fizike so laboratorijske vaje lahko namenjene zgolj izvajanju meritev ali pa so namenjene merjenju in razumevanju poti do meritev. V času nenehne dostopnosti do podatkov postajajo poti do podatkov in znanja bolj pomembne kot podatki sami. Zato so laboratorijske vaje odlična priložnost spoznati pot. In ne samo pot, tudi način pridobivanja podatkov, prenos podatkov, smiselnost in uporabnost ter obseg podatkov in še kaj. Žal to prinese tudi več razmišljanja izven območja udobja, ki ga dijaki ne sprejmejo kar tako.

Da bi ugotovili uspešnost dela, je bilo treba spremembo tudi izmeriti. Z rezultati takih meritev je možno nadaljevati s primernim načrtovanjem, da se izognemo nesmotrni rabi časa in dela ter izboljšamo uspešnost. Zato so dijaki izpolnili anketni vprašalnik pred in po izvajanju aktivnosti. Z anketnim vprašalnikom sva želela izmeriti odnos do obeh predmetov, predznanje in predvsem spremembo, ki bi nastala med drugačnim načinom dela.

2 Vse že imamo, a ne uporabljamo

Med opravljanjem laboratorijskih vaj kakor tudi ostalih dejavnosti pri pouku fizike se pojavlja čedalje več stvari, ki nakazujejo, da bi morali v pouk vključevati uporabo informacijske in komunikacijske tehnologije. To je izraženo na različnih ravneh – od želja dijakov, vodstva, učnih načrtov in še česa. Težava pa se pojavi takoj, ko to v resnici želimo narediti, ker so med dijaki zelo velike razlike v znanju in spretnostih.

V nadaljevanju bo prikazan način dela pri povezovanju in spoznavanju osnovnih korakov fizičnega računalništva. Vsak dan imajo dijaki večino časa pri sebi naprave, ki so polne senzorjev, ki snemajo njihovo okolico, dogajanje in se na to, kar zaznavajo, tudi samostojno odzivajo. Ko smo se v uvodu aktivnosti pogovarjali o tem, so imeli dijaki ogromno idej, kako uporabiti svoje naprave. Imajo ideje, s katerimi bi radi rešili svet, a se zavedajo tudi, da ga ne morejo rešiti preko noči, ampak le z majhnimi koraki. Zato smo učitelji pozvani tudi k temu, da jim njihova vsakdanja orodja razsvetlimo v novi luči in jim približamo načine, s katerimi lahko sami opazujejo svet okoli sebe tudi s pomočjo teh naprav in orodij, ki jih že poznajo in uporabljajo. Tako so npr. v šoli pri računalniških dejavnostih dijaki že uporabljali micro:bite, ki pa so služili zgolj učenju programiranja.

Tako smo ugotovili, da lahko tudi micro:bit uporabimo za merjenje velikega števila parametrov, s katerimi bi lahko opisovali spremembe okolja, kakor tudi spremembe našega življenja, ki je od teh sprememb odvisno.

2.1 Povezovanje predmetov

Delo na povezovanju fizike in informatike se je pripravljalo kar nekaj časa, preden je bila aktivnost izvedena. Pred to izvedbo pouka sva se večkrat že dogovorila in izvedla kakšno dejavnost skupaj. Pri informatiki so dijaki pripravljali projektne naloge s tematiko drugih predmetnih področij, med katerimi je vsako leto bila prisotna fizika. Pri fiziki smo se z dijaki lotevali izvajanja poskusov z računalniškimi meritvami, kjer so potrebovali pomoč informatike, ker niso imeli dovolj znanja. Pri fiziki so dijaki velikokrat srečali programiranje. Tu je bilo programiranje v jeziku Python uporabljeno za vnos podatkov za različne naloge in preračun vrednosti izrazov. Ker so bile rešitve pridobljene bliskovito hitro, je veliko dijakov začelo iskati pot do programiranja, saj so videli, da je uporabno tudi za njihovo delo in učenje. Tako je nastal krožek programiranja, kjer so dijaki spoznavali osnove programiranja. A ne za dolgo, ker jim je običajno zmanjkalo zagona in idej. In tako sva praviloma vsake toliko časa ostala brez dijakov, ki bi jih zanimala uporaba informatike pri ostalih predmetih. V analiziranju svojega dela pa sva vseeno oba našla pogosto izraženo željo dijakov, ki so vedno znova izražali, da bi si želeli več uporabe računalnika oz. IKT pri ostalih predmetih.

V tem obdobju sva izvedela za seminar Izzivi poučevanja informatike v OŠ in SŠ na Fakulteti za matematiko in fiziko, ki se izvaja že več let in ki sva se ga oba udeležila in kmalu postala del večjega projekta skupine učiteljev pod vodstvom dr. Andreja Brodnika in mag. Matije Lokarja – MINUT NAPOJ. Ta projekt je bil nadaljevanje prvotnega projekta NAPOJ. Osnovni cilj slednjega je bil sestaviti skupnost učiteljev, ki bi se dobivali, izmenjevali svoje izkušnje, izmenjevali gradiva, se pogovarjali o svojem pouku in izvedbi istih stvari pri drugih učiteljih. Pri osnovnem projektu NAPOJ so sodelujoči spoznali, da je pomembna sestavina skupnosti skupna izdelava različnih učnih gradiv. Na ta način so uspeli doseči, da projekt ni doživel konca kot veliko drugih projektov. Večina projektov se namreč po uradnem zaključku konča in za njimi se običajno izgubijo sledi. Tokrat se to ni zgodilo in rodilo se je nadaljevanje – MINUT NAPOJ, kjer gre v bistvu za prenos idej mednarodnega gibanja STEM v izobraževanje in dopolnitev za naše šolsko delo.

Ravno v tem projektu smo se prvo leto posvetili razmišljanju o tem, kako bi lahko povezovali predmete na način, da bi dijaki dosegali cilje obeh (oziroma vseh) predmetov. Da ne bi bil eden zgolj vir podatkov, tabel, enačb in še česa za delo pri drugem. Ko smo v začetku sestavljali zapise načrtov in predstavljali projekte kolegom, smo bili kot osnovnošolci, saj je marsikdo skoraj obupal, ko je po tri- ali večkrat popravljal svojo dokumentacijo. A se je vseeno splačalo.

Na koncu smo dosegli, da smo jasno zapisali svoje ideje in cilje. To nam je pomagalo, da smo lahko ocenili in uravnovesili svoj pouk za oba predmeta.

Kaj je boljšega od tega, ko se lahko pri pouku tudi igramo? Tudi oba učitelja sva se igrala, ne le dijaki. Najprej sva morala sama najti smisel, način in smoter uporabe teh "igračk", ki jih danes nosimo v žepih čisto vsi.

3 Ideja

V osnovi je bil cilj pri fiziki zastavljen precej višje, saj je zvenelo zelo lepo, da imamo merilnik, ki ga lahko sami sprogramiramo in uporabimo za vse meritve. Ko smo začeli pregledovati tehnične karakteristike micro:bita, je kmalu fizik doživel prizemljitev. Micro:biti delujo preko termometra, ki je na procesorju in ima očitno nekaj izolacije, ki onemogoča hitre odzive, ne sme doživeti previsokih temperatur, ne sme se zmočiti in še kaj. Ima pa ta lastnost tudi stranski učinek – napako. V vsakem primeru kaže termometer temperaturo, ki je nekoliko drugačna od tiste v okolici. In to je bil namig, ki je rešil zagato. Poudarek ne bo na merjenju temperature, ampak na merjenju napake, pogovoru o napakah in o tem, kako napako odstraniti. To pomeni kalibrirati termometer.

Zelo priročno orodje je v tem primeru računalnik, kjer lahko izmerjene količine popravimo, preden jih uporabimo za kaj drugega. Torej imamo skoraj idealno orodje za delo, merjenje in učenje. Zdaj je treba le še najti prostor in čas, ko se lahko vse to izvede.

3.1 O projektu

Projekt povezovanja fizike in informatike se je začel z načrtovanjem ciljev in načina, kako izvesti meritve, s čim meriti, kako dolgo in kaj izmeriti. Načrtovala sva, da bodo laboratorijske vaje izvedene v dveh šolskih urah, a je bilo treba dodati še eno uro, da smo lahko (tako dijaki kot oba učitelja) rešili ankete pred izvedbo in po izvedbi pouka. Tako je celoten projekt trajal tri šolske ure. Vendar je bila dodatna ura koristno izrabljena. Ankete smo namreč izvedli, da izmerimo, kaj se bo spremenilo in na kaj bo vplivalo spremenjeno delo pri pouku.

Ker smo micro:bite imeli na šoli v zadostnem številu, sva se lotila programiranja in povezovanja ter celoten projekt, še preden so se ga lotili dijaki, izvedla sama. Oba sva pri tem bila prepričana, da bo časa premalo, a sva vseeno pustila časovno omejitev treh ur. Ob najinem izvajanju sva dobila še idejo, da bi dijaki na micro:bite povezali še zunanji senzor. Na spletu smo na pripravah projekta MINUT NAPOJ našli zunanji senzor z oznako BMP180, ki je meril temperaturo, tlak in vlažnost in je bil idealen za projekt. A se je v ustreznem času dalo dobiti le enega, pozneje pa več ni bil na voljo. Zato sva to idejo le zabeležila kot možnost nadgradnje projekta z boljšimi dijaki. Hkrati pa smo našli tudi komplet (Minode), ki omogoča povezovanje micro:bitov na enostavnejši način. A je za namene našega projekta komplet predrag, predvsem glede na to, da smo v šoli že imeli dovolj veliko število micro:bitov.

3.2 Operativni učni cilji

Za izvedbo sva si zastavila dokaj širok obseg operativnih ciljev, ki smo jih v veliki meri dosegli:

- Dijak je sposoben *uporabljati* IKT tehnologijo pri izvajanju fizikalnih poskusov in razvija sposobnosti za učinkovito in uspešno *pripravo, izvajanje in analizo* poskusov.
- Dijak spozna in zna *uporabljati* računalniško tehnologijo in programsko opremo ter s programiranjem rešiti preproste probleme.
- Dijak zna posamezne strokovne teme *obravnavati v luči problemov* ter se usposablja za učinkovito in *konstruktivno sodelovanje* v skupini/paru.
- Dijak pozna pomen in vlogo digitalne/računalniške tehnologije, jo spozna in zna uporabljati.
- Dijak razvija *ustvarjalno mišljenje in sposobnost reševanja problemov*.
- Dijaki znajo izmeriti izbrane fizikalne količine.
- Dijaki znajo izmerjene vrednosti prikazati v tabele in grafe.

Cilji so postali vodilo za delo, na katere sva dodala še vsebino, ki je omogočala, da so dijaki lahko samostojno ali z vodenjem posegli na novo področje dela in razmišljanja. Dijaki pred izvedbo teme niso imeli izkušenj s programiranjem, kakor tudi ne s samostojnimi laboratorijskimi vajami.

3.3 Izvedba

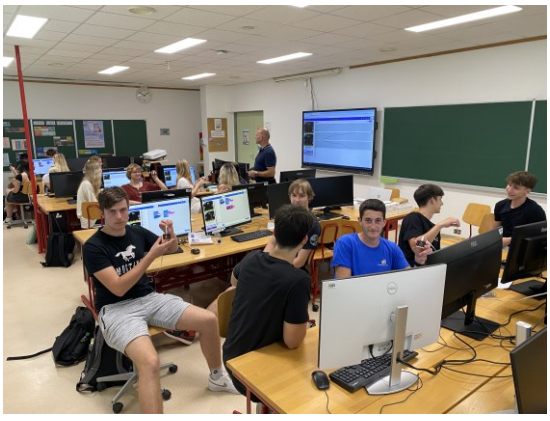
Izvedba pouka se je začela z načrtovanjem na srečanju učiteljev projekta MINUT NAPOJ, ko smo iskali primerne projekte za izvedbo v šoli in smo sestavljali načrte dela. Za tem je sledilo kar dolgo obdobje, ko sva oba učitelja pri svojih predmetih opazovala dijake, si zabeležila kakšno posebnost in jih že pred tem pripravljala na aktivnost, ki jo bodo izvedli. Pri fiziki smo izvajali laboratorijske vaje na klasičen način, saj je bil cilj tudi izvedeti razliko in stališče dijakov do tega, kako pri pouku poskuse izvajati.

Druga faza izvedbe pa se je začela nekaj dni pred izvedbo, ko sva oba dijake opozorila, da bomo tri ure skupaj izvajali laboratorijsko vajo s pomočjo IKT. Med dijaki je bilo zaznati pozitivno pričakovanje, saj so že kakšen dan prej bili precej radovedni in so spraševali o poskusih ter o tem, kako bo delo potekalo …

Manjša težava je bila v urniku dobiti dovolj ur za izvedbo takšne aktivnosti. Šola nama je v urniku omogočila premik predmetov, da je nastalo zaporedje treh ur fizike in informatike, ko sva lahko izvedla pouk v računalniški učilnici. Pri tem sva pred izvedbo preverila tudi, ali bodo mize v računalniški učilnici zadostovale in bo na njih dijakom uspelo zložiti, sestaviti in izvesti celoten poskus.

Izvedba se je začela z reševanjem anketnih vprašalnikov in s tem meritvijo začetnega stanja. Po tem delu smo izvedli skupni uvod, kjer sva tako fizik kot informatičarka vsak iz svojega zornega kota predstavila delo naslednjih treh šolskih ur. Dijake sva pozvala, naj premislijo in se odločijo, ali si želijo delati samostojno ali v parih.

Sledila je predstavitev delovanja micro:bita in njegove funkcije, ki so jih dijaki spoznavali na enostavnih primerih uporabe (npr. izpiši svoje ime na zaslon, ob pritisku na gumb A naj se zgodi …). Dijaki so potrebovali nekaj časa in poskusov, da so spoznali način prenašanja kode na micro:bite, a je postopek dovolj enostaven, da so se ga vsi naučili po že nekaj primerih programiranja (Slika 1).

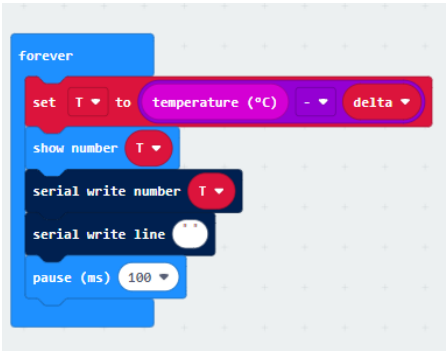


Slika 1: Preizkušanje osnovnih funkcij micro:bitov.

Naslednji korak je bilo spoznavanje merjenja fizikalne količine, ki se je izpisovala na zaslonu micro:bita. V tej fazi so dijaki med pogovorom spoznali, da dobivajo različne rezultate, čeprav se nahajajo v istem prostoru. Zato je takoj sledila razlaga učitelja fizike, ki je prevzel zgodbo in dijake pozval, naj poskušajo sami poiskati izvor teh napak. Ko smo s skupnimi

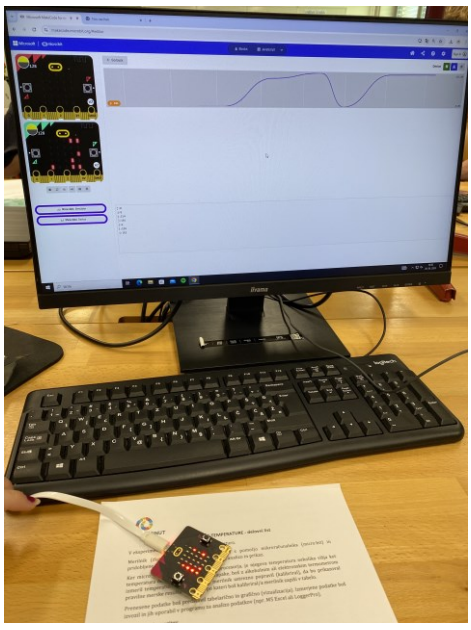
močmi ugotovili nekaj možnih virov napak, smo skupaj pogledali še v tehnične karakteristike micro:bitov in ugotovili, da imajo določena odstopanja. Ko je učiteljica informatike pojasnila še vpliv porabe energije v procesorju med delovanjem programov in toplote, ki se zato pri tem sprošča, smo imeli dovolj razlogov, da se lotimo umerjanja.

V naslednjem koraku so dijaki spoznali namen uporabe spremenljivk (Slika 2). Z njimi smo si pomagali izračunati razliko, ki so jo morali upoštevati v svojih meritvah.



Slika 2: Del programske kode

Na koncu smo raziskali še možnost prenosa podatkov v računalnik, kjer lahko z zabeleženimi podatki naredimo več kot le to, da jih prikažemo na prikazovalniku merilnih naprav (Slika 3). Iz njih lahko sestavimo tabele in grafikone, se ob podatkih lotimo drugačnih analiz. Morda celo primerjamo podatke različnih merilnih postaj med sabo in iščemo vzroke ter posledice. Odprtih je veliko možnosti.



Slika 3: Prikaz merjenja temperature.

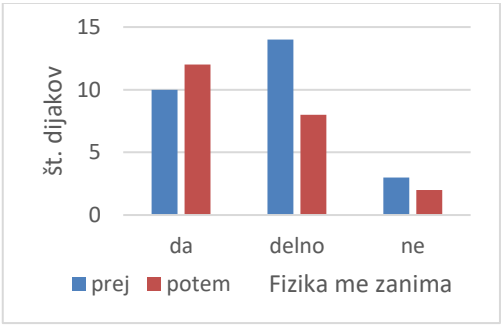
Za konec smo izvedli še evalvacijo s pomočjo ankete in pogovora. V obeh aktivnostih so dijaki izrazili veliko zanimanja za podobno delo še v prihodnje.

4 Refleksija

Po izvedbi določene učne teme na nov način se učitelju odpirajo številna vprašanja, ali je delo uspelo, kaj spremeniti in če bi se to splačalo ponoviti. Čeprav se učitelji trudimo biti objektivni, načrtovati, evalvirati ves čas in tudi ocenjevati, pa včasih pride tudi trenutek, ko se vmes postavi naš subjektivni pogled. Ravno zato, da se to ne zgodi, smo pod vodstvom projekta MINUT NAPOJ [2] vsi izpolnjevali anketo – dijaki in oba učitelja.

Ugotivila sva, da je šlo za zelo intenzivno izvedbo pouka, saj sva morala dijake naučiti ne le izmeriti nekaj številk, ampak jih tudi usmeriti na pot razmišljanja o globljih ciljih fizike in informatike.

Večina dijakov je izrazila spremembo v smeri večjega interesa za oba predmeta. Seveda to ni bil kvantni preskok, da bi lahko trdili, da so zdaj vsi dijaki usmerjeni samo v fiziko in informatiko, a se je opazil premik na celotni ocenjevalni lestvici v smer pozitivnih izkušenj za oba predmeta. Presenetljivo je bilo, da so dijaki izrazili, da jim je programiranje lažje, kot so pričakovali. V prihodnje bi radi več takšnih aktivnosti. A je bilo nekaj tudi sporočil, da ne smemo z IKT pretiravati.



Grafikon 1: Sprememba v odnosu do fizike

Ko sva svoje delo evalvirala tudi sama, sva ugotovila, da je najino mnenje precej podobno tistemu, ki so ga izrazili dijaki. Strinjala sva se, da je zelo dobra aktivnost, ki bi jo bilo treba še nadgraditi in tudi kdaj izvesti. V skupini sva opazila nekaj posameznikov, ki so se takega načina dela lotili zelo težko in jim ni ustrezalo. To sva predvidevala že pred začetkom dela. Zato sva načrtovala delo v parih in po izbiri samostojno. A za te posameznike bo treba najti še kakšen način dela, da se odprejo in pri pouku zaživijo tudi na ta način.

5 Zaključek

Po premisleku glede opravljenega dela in rezultatov ugotavljava, da je opisana aktivnost primerna za trajno vključitev v pouk obeh predmetov. Po pridobljeni izkušnji je bilo zaslediti, da podpira izvedbo ciljev obeh predmetov, ki jih logično povezuje in ustvarja nekakšen okvir, kjer eni omogočajo izvedbo drugih in obratno. Fizika namreč ni samo stvar laboratorijev, ampak stvar realnega življenja, informatika pa se prepleta v vse niti našega življenja s tehnologijo in razvojem novih načinov sprejemanja realnosti.

Glede na izvedbo, ki je bila pripravljena, dokumentirana in analizirana še s strani strokovnjakov s področja RIN na FRI in FMF ter drugih učiteljev projekta MINUT Napoj, bo ta aktivnost

ostala vključena v redno delo pri pouku še v naslednjih letih. Glede na spremembe, ki se trenutno dogajajo na področju posodabljanja učnih načrtov, dejavnost ustreza trendom na tem področju. Oba učitelja si želiva slediti spremembam pedagoške in didaktične prakse. Zato načrtujeva, da bo nastalo še več podobnih aktivnosti.

Zahvala

Zahvala za izvedbo celotnega projekta gre v prvi meri dijakom, ki so vztrajali in nama dovolili pri pouku eksperimentirati z njihovim časom in znanjem. Hkrati bi se zahvalila tudi vsem sodelavcem, ki so nama priskočili v pomoč z nasveti, in vodstvu šole, ki je imelo dovolj razumevanja za drugačnost dela, ki je bilo opravljeno. Zahvaljujeva se najinim kolegom iz projekta MINUT NAPOJ, ki so s svojimi komentarji že v osnovi v nama spodbujali razmišljanje o pouku na drugačen način in seveda mentorjema, dr. Andreju Brodniku in mag. Matiji Lokarju, ki sta bila zelo dobra podpora in vodnika na tej poti odkrivanja.

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Prepletanje kmetijske stroke, strokovne informatike in statistike ter knjižničnih znanj

Interweaving Agricultural Expertise, Professional Informatics, and Statistical and Library Knowledge

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POVZETEK

Prispevek predstavlja primer dobre prakse povezave kmetijske stroke in računalništva. Z dodatkom knjižničnih znanj, to je navajanja literature, pridemo do končnega izdelka študentov.

Namen predstavljenega primera je, da predavatelj med izvajanjem učne ure vključi čim več spletnih vsebin, s pomočjo katerih podkrepi navedena dejstva. Poleg tega je tudi študentom lažje, saj lahko sami ponovijo in predelajo obravnavano snov, kar je še pomembneje v primeru študija na daljavo.

S pomočjo spletne podatkovne baze Statističnega urada RS študenti poiščejo ustrezne podatke in jih ovrednotijo v času in prostoru. Na konkretnem primeru študentje razložijo pomen predstavljenih statističnih podatkov ter v kakšnem kontekstu jih lahko razumemo glede kmetijske proizvodnje.

Študenti so postavljeni pred praktični izziv, saj morajo na podane zahteve strank poiskati ustrezno sorto krompirja in stranke poučiti o posameznih sortnih značilnostih ter agrotehničnih ukrepih.

Na koncu predstavijo svoj izdelek in poskrbijo za pravilno navajanje virov.

KLJUČNE BESEDE

krompir, semenarske hiše, hiperpovezava, podatkovna baza SiStat, spletni viri

ABSTRACT

This article presents an example of good practice in connecting agricultural expertise with computer science. By incorporating library skills, particularly literature citation, students are able to produce a final product.

The purpose of the presented example is to encourage the lecturer to include as many online resources as possible during the lesson, thereby reinforcing the facts presented. This approach also benefits students, as they can independently review and process the material, which is especially important in the context of distance learning.

Using the online database of the Statistical Office of the Republic of Slovenia, students find relevant data and evaluate it in terms of time and space. In a specific example, students explain the significance of the presented statistical data and the context in which it can be understood in relation to agricultural production.

Students are faced with a practical challenge, where they must identify the appropriate potato variety based on client requirements and educate the clients about the characteristics of the variety and the necessary agronomic measures.

Finally, they present their product and ensure correct source citation.

KEYWORDS

potato, seed houses, hyperlink, SiStat database, online resources

1 UVOD

Današnji čas nam v izobraževanju postavlja vedno več izzivov. Na razpolago imamo več učnih metod, več učnih sredstev, ki omogočajo raznolike in bolj pestro obarvane pristope k poučevanju. Prav gotovo je medpredmetno povezovanje tista dodana vrednost, ki omogoča preplet različnih predmetov in tako bolj obogateno podajanje učnih vsebin. Pri tem pridobi predvsem stroka, saj lahko obogatena s splošnimi predmeti ponudi nekaj več. Hkrati pa se na ta način še bolj pokaže pomen splošnoizobraževalnih predmetov in podpornih znanj, saj so oplemenitena s stroko veliko bolj koristna in dosežejo tisti pravi namen. Saj poznamo tisto … kaj nam bo matematika, saj je ne bomo rabili. Če pa ji je dodan praktični pomen, potem je to čisto nekaj drugega.

V tem članku bo predstavljena praktična povezava stroke in računalništva.

2 ŠOLSKI CENTER ŠENTJUR

Je šola z dolgoletno tradicijo. Njen začetek sega v leto 1910. Danes Šolski center Šentjur sestavljata dve enoti: Srednja strokovna in poklicna šola ter Višja strokovna šola. V sklopu zavoda deluje tudi dijaški dom. Srednješolsko izobraževanje obsega programe nižjega, srednjega poklicnega, srednjega strokovnega in poklicno tehniškega izobraževanja s področja kmetijstva, živilstva in veterine. Višja strokovna šola ponuja štiri izobraževalne programe: Gostinstvo in turizem, Naravovarstvo, Upravljanje podeželja in krajine ter Živilstvo in prehrana. V sklopu šole je še šolsko posestvo [1].

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3 ŠTUDIJSKI PROGRAM UPRAVLJANJE PODEŽELJA IN KRAJINE

Študenti imajo tekom izobraževanja v programu Upravljanje podeželja in krajine tudi predmeta Gospodarjenje v poljedelstvu in vrtnarstvu [2] ter Strokovno informatiko in statistične metode vrednotenja [3].

Sama imam v omenjenem programu predavanja in vaje iz »računalništva«, obenem pa sem tudi knjižničarka. Moja osnovna stroka je kmetijska, zato jo še kar negujem, da mi ne gre preveč v pozabo. Sem tudi praktične narave, zato vedno iščem možnosti, kako se da uporabiti znanja in veščine splošnih predmetov v praksi, v vsakdanjem življenju.

In tako sem prišla na idejo, da bi pri vajah iz statistike obravnavali praktične primere, ki bi jim dodali še teoretične vsebine. Želela sem namreč celo vsebino še nadgraditi in jo postaviti v bolj strokovne okvire, da bo kot celota imela zadostno težo. Za začetek so se mi zdele najbolj primerne poljščine. In tako sem po dogovoru s predavateljico »poljedelstva« izbrala krompir.

3.1 Obravnava snovi s pomočjo hiperpovezav

Cela zadeva je ponovitev srednješolske snovi o gojenju krompirja z nadgradnjo vsebin in praktičnimi nalogami. V ta namen sem naredila predstavitev v Microsoftovem PowerPointu in vsebino opremila s spletnimi viri, torej hiperpovezavami (rumeni simboli na sliki 1). Tako sem vključila tudi knjižnična znanja, saj je pomembno, da študenti tudi sami dalje raziskujejo in tako pridobivajo širša znanja. Prav tako je pomembno, da znajo pravilno navajati spletne vire.

Slika 1: Izsek študijskega gradiva

Obe s sodelavko sva bili prisotni pri vseh teh aktivnostih v razredu, pri obeh predmetih, ki sta potekala v računalniški učilnici. Najprej je kolegica izvedla predavanje o krompirju, njegovi pridelavi in agrotehničnih ukrepih ter zakonodaji s tega področja. V ta namen je uporabila e-predstavitev, ki sem jo vnaprej pripravila. Nato so študenti vsak na svojem računalniku snov ponovili, s tem da so uporabljali hiperpovezave.

3.2 Praktična naloga

Sledil je praktični del obravnave snovi. Vsak študent je dobil delovni list in izvlekel številko, pod katero so se kasneje skrivale naloge. Prvi del naloge je zajemal statistične podatke, drugi pa strokovni nasvet stranki glede izbora sorte krompirja.

3.2.1 Podatkovna baza SiStat

Na spodnji sliki 2 so prikazane naloge, ki so jih študenti dobili v zvezi s statističnimi podatki.

NALOGA 1 - statistični podatki SiStat:

	Meritve	Vrste posevkov na njivah	Leto
Študent 1			
Študent 2			
Študent 3			
Študent 4			
Študent 5			
Študent 6			
Študent 7			
Študent 8			
Študent 9			
Študent 10			
Študent 11			
Študent 12			
Študent 13			
Študent 14			

Slika 2: Prvi del praktične naloge – statistični podatki

V ta namen smo uporabili podatkovno bazo Statističnega urada Slovenije, SiStat [4]. Izbrali smo področje Kmetijstvo, gozdarstvo in ribištvo, znotraj tega pa Rastlinska pridelava → Pridelki in površina → Pridelava poljščin. Na sliki 3 je prikazan zaslonski posnetek izbirnih polj v konkretnem primeru.

Navodila na delovnem listu:

Glede na vašo številko s povezave »Naloge« izberite ustrezne kriterije v podatkovni bazi SiStat:

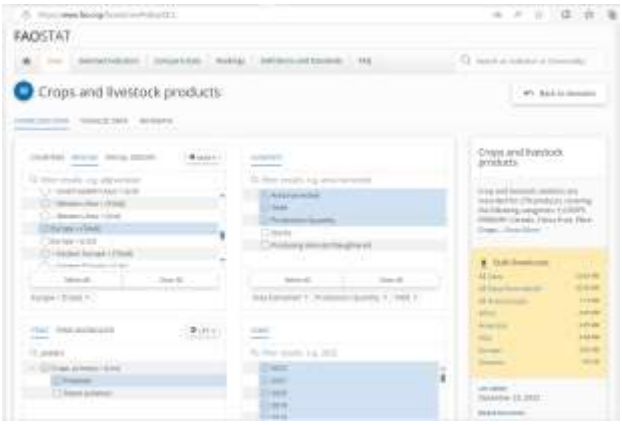
- *Meritve*
- *Vrste posevkov na njivah*
- *Leto*

Izpišite podatke, kopirajte tabelo in v ta delovni list na označeno mesto prilepite le-to tabelo. Nato kliknite na tej spletni strani na grafikon, ga kopirajte in tudi njega prilepite spodaj na označeno mesto. Pomanjšajte ga tako, da bo ves viden. Na pripravljeno mesto še prilepite vir. To je spletni naslov, na katerem ste »narisali« grafikon. Spodaj napišite komentar grafikona.

Slika 3: Zaslonska slika podatkovne baze SiStat in izbirnih polj glede pridelave krompirja v Sloveniji

Da smo dodali obravnavi celotne snovi še nekaj več, smo poiskali tudi statistične podatke, ki so na voljo v spletni bazi svetovne organizacije za prehrano in kmetijstvo FAOSTAT [5], kot je prikazano na sliki 4.

Tako smo zaokrožili strokovne vsebine glede statistike.



Slika 4: Zaslonska slika podatkovne baze FAOSTAT in izbirnih polj glede pridelave krompirja po svetu

3.2.2 Strokovni nasvet stranki, kupcu v trgovini

Drugi del praktične naloge je bil agronomsko obarvan. Študenti so bili v vlogi prodajalca v kmetijski zadrugi. Vsak primer je imel drugačne zahteve, kar je razvidno iz slike 5, in so jih mogli študenti izpolniti.

Slika 5: Drugi del praktične naloge – agrotehnično svetovanje stranki

Navodila na delovnem listu:

Ste prodajalec. K vam v kmetijsko zadrugo pride stranka, ki želi kupiti semenski krompir. Vpraša vas za nasvet glede semenskega izbora. Poda vam nekaj informacij, na osnovi katerih:

- *svetujete nakup določene sorte,*
- *seznanite stranko s priporočenimi tehnološkimi navodili in agrotehniko pridelave.*

Zdaj je vaša naloga, da na povezavi »Naloge« najdete, kopirate in sem na določeno mesto prilepite strankine zahteve glede sorte in površine, ki jo bo namenila sajenju.

Upoštevajoč strankine želje na spletu poiščite primerno sorto slovenskih dobaviteljev semenskega krompirja.

Na določeno mesto napišite ime izbrane sorte, prilepite opis te sorte ter sliko (pazite na dosledno navajanje spletnih virov). Utemeljite svojo odločitev. Če je možno, jo podkrepite z rezultati sortnih poskusov. Stranki ponudite tudi alternativo. Izračunajte, koliko semenskega krompirja rabi.

3.3 Rezultati obravnavane snovi in praktične naloge

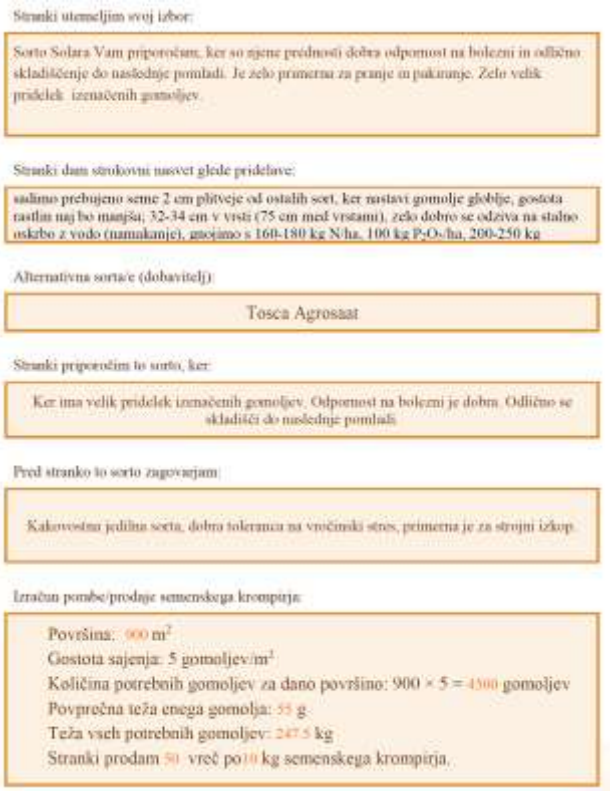
Naloga študentov je bila, da doma ob ogledu e-predstavitve ponovijo učno snov ter s pomočjo hiperpovezav pregledajo spletne vire, ki bolj podrobno opisujejo posamezne vsebine.

Na ta način je študente lažje usmeriti na ciljne vsebine, ki so verodostojne. Prav tako si prihranimo čas pri izdelavi učnih gradiv, saj lahko podamo samo bistvene podatke, na študentih pa je, da sami preberejo in predelajo dodatne vsebine.

Študenti so bili zelo zadovoljni s takim načinom obravnave učne snovi, saj so točno vedeli, kaj je bistvo in kaj je tista podporna snov, ki temu bistvu daje neke širše dimenzije.

Poseben izziv jim je predstavljala praktična naloga. Tako so se tudi lotili reševanja; resno in zavzeto. Ker je imel vsak drugačen primer, je bilo potrebno več samostojnosti, torej je bil vsak prisiljen razmišljati sam in tako tudi opraviti nalogo. Ob enem pa so si lahko nudili tehnično pomoč. Iskanje sort na spletu je nekaterim povzročilo kar nekaj preglavic, ob enem pa tudi zadovoljstvo, ko so našli ustrezno sorto. Je pač potrebno narediti vse, da bo stranka zadovoljna in se še vrnila k nam v trgovino. Na spodnji sliki 6 je prikazan en primer dela rešene naloge. Lahko rečem, da so se študenti potrudili in podali dobre odgovore. Kot prodajalci bi bili prepričljivi. Tudi sami so bili zadovoljni s tovrstno simulacijo konkretnega primera prodaje in svetovanja v kmetijstvu. In tako so ugotovili, da ni tako lahko prodajati krompir, če imaš zahtevno in izbirčno stranko.

Za potrebe pedagoškega procesa so uporabljali elektronske vire, ki so na razpolago. V prodajalni bi najbrž uporabili tiskan katalog semenskega krompirja.



Slika 6: Rešen primer dela delovnega lista

4 ZAKLJUČEK

Ob nastanku ideje nisem vedela, kakšen bo odziv študentov, izplen, sem pa pričakovala, da dober. In res je bil. Celo zelo dober. Študenti so doma zavzeto predelali učno snov in si tudi pridno pogledali dodatne učne vsebine, ki so jih našli na hiperpovezavah. Tako so natančno vedeli, kaj se od njih zahteva, katere strokovne vsebine morajo poznati.

Poleg tega so jim bile vaje iz statistike dosti bolj zanimive, saj so se nanašale na konkretne primere. Velika večina se jih je prvič srečala s temi spletnimi podatkovnimi bazami. Tako so tudi spoznali pomen statističnih podatkov ter jih še dalje sami raziskovali. Bili so navdušeni nad možnostmi, ki so na voljo za iskanje rezultatov po različnih kriterijih. Te spletne statistične podatke bodo prav gotovo še iskali za kakšne seminarske naloge in morda na koncu za diplomsko nalogo.

Ko smo preverili znanje, so si študenti res veliko zapomnili in verjamem, da jim bo to znanje ostalo.

Na enak način bi lahko obdelali vse z vidika kmetijstva pomembne kulturne rastline. Ne samo v poljedelstvu, tudi v zelenjadarstvu, sadjarstvu in vinogradništvu.

Tudi pri živinoreji bi se dalo s takim načinom dela študentom bolj kvalitetno približati učno snov.

Edina slaba stvar pri vsem skupaj je to, da takšen pristop od učitelja zahteva res ogromno dela. Vendar se da vse pripravljeno gradivo uporabiti tudi naslednja leta, s tem da je treba preveriti vse spletne vire, če so še primerni oz. jih osvežiti. No, to pa je že čar vedno večje digitalizacije, saj so nam spletni podatki na voljo praktično vedno in povsod.

Prikazan primer govori o tem, da se da tudi v strokovne predmete zelo uspešno in učinkovito vključiti razpoložljive spletne vire in na ta način naše mlade navajati, da sami iščejo ažurirane podatke in jih umestijo v ustrezen kontekst ter tako koristno uporabijo.

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Digitalne dimenzije ob Prešernovi klasiki: IKT kot orodje za sodobno obravnavo Krsta pri Savici

Digital Dimensions of Prešeren's Classic: ICT as a Tool for Contemporary Interpretation of the Krst pri Savici

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POVZETEK

V prispevku je predstavljena obravnava umetnostnega besedila Franceta Prešerna Krst pri Savici s pomočjo informacijsko-komunikacijske tehnologije. Obravnava književnega dela v izobraževalnem procesu je pomemben del pouka književnosti, saj dijakom omogoča poglobljeno razumevanje literarnih del, razvoj kritičnega mišljenja in izboljšanje njihovih jezikovnih ter interpretativnih veščin. Profesorji se pri pouku književnosti soočamo z upadom zanimanja za domače branje in analizo oz. interpretacijo literarnih del. Na izvirne načine se trudimo dijake motivirati in jih spodbuditi k branju s kritičnim razmišljanjem ter zmožnostjo aktualizacije. Klasična obravnava dela žal zaradi veliko suhoparnih podatkov vodi v dolgočasenje dijakov. Učitelji zato velikokrat iščemo zanimive načine za izvedbo pouka. Eden izmed njih je zagotovo uporaba IKT-orodij (CapCut, Crossword Puzzle, Kahoot, umetna inteligenca).

KLJUČNE BESEDE

Obravnava literarnega dela, informacijsko-komunikacijska tehnologija, sodobne metode pouka, e-gradiva

ABSTRACT

The article presents an approach to teaching France Prešeren's literary work "Krst pri Savici" using information and communication technology. The study of literary works in the educational process is a crucial part of literature classes, as it enables students to gain a deeper understanding of literary texts, develop critical thinking, and enhance their language and interpretative skills. Literature teachers face the challenge of declining interest among students in reading assigned texts and analyzing or interpreting them. We strive to motivate students in creative ways, encouraging them to read with critical thinking and the ability to contextualize the material. Traditional approaches often result in boredom due to the abundance of dry information. Therefore, teachers frequently seek engaging methods for conducting lessons. One of them is certainly the use of ICT tools (CapCut, Crossword Puzzle, Kahoot, artificial intelligence).

KEYWORDS

Study of literary works, information and communication technology, modern teaching methods, e-materials

1 PREGLED OBSTOJEČEGA E-GRADIVA

Za popestritev obravnave Prešernovega dela Krst pri Savici smo pri pouku slovenščine uporabili informacijsko-komunikacijsko tehnologijo. V uvodni uri sem dijake motivirala z napovedjo, da bo pouk potekal malo drugače in da bodo lahko pri pouku uporabljali računalnike in telefone. To delo so dijaki že prebrali za domače branje, tako da so poznali avtorja, vsebino in književne osebe. Prva zadolžitev je bila, da so v Google vpisali iskalni niz: Prešeren – Krst pri Savici. Pregledati so morali nekaj e-gradiv, tudi videoposnetke na Youtubu, ki so se jim je na prvi pogled zdeli zanimivi, in nato podati svoje mnenje – ali se jim gradivo zdi zanimivo, poučno in uporabno. Skupaj smo nato naredili nabor najboljših gradiv – na ta način so dijaki že natančneje spoznavali delo. Med njimi so našli tudi zelo uporabne PP-predstavitve, videoposnetke in zvočne zapise. Izpostavljam tri e-gradiva, ki smo jih z dijaki ocenili kot najbolj zanimiva in poučna.

- E-gradivo za slovenščino v gimnazijah in v poklicnih šolah. Projekt sta sofinancirala Ministrstvo za šolstvo in šport RS in Evropski socialni sklad pri EU (https://gradiva.txt.si/slovenscina/slovenscina-za-gimnazije-srednje-sole/2-letnik/knjizevnost/romantika-na-slovenskem/012_krst_pri_savici/uvod-58/. Vsebuje tudi zvočni zapis branja Uvoda.
- E-učbeniki: Uvod h Krstu pri Savici – obravnava dela z interaktivnimi vajami in rešitvami (https://eucbeniki.sio.si/slo8/2352/index.html).
- Zvočni posnetek branja Krsta na Youtubovem kanalu Slovenska kultura (https://www.youtube.com/watch?v=H4p-lQHKutQ).

2 UPORABA IKT

2.1 USTVARJANJE V APLIKACIJI CAPCUT

V naslednjih urah nismo imeli več možnosti izvajanja pouka v računalniški učilnici, zato smo prešli na uporabo telefonov. Večina dijakov ima na svojem telefonu aplikacijo CapCut, zato sem dijake razdelila v skupine in jih spodbudila, da na izviren in zanimiv, lahko tudi nenavaden način v tej aplikaciji predstavijo vsebino ter osebe tega dela. Da bi jim malo olajšala oziroma nadgradila njihovo delo, sem jim namignila, da lahko vsebinski del predstavijo tudi s pomočjo neumetnostnih besedil: poročilo, reportaža, intervju … To je razred, ki je že drugače zelo ustvarjalen, zato jim je bila naloga zelo všeč. Pri delitvi v skupine smo pazili na to, da je v vsaki skupini bil dijak, ki delo v tej aplikaciji obvlada, ostali pa so prispevali svoje zamisli za izvedbo glede na svoje zmožnosti. Sprva so v zvezke zapisali osnutek načrta in cilje dela, nato so se lotili ustvarjanja.

CapCut je priljubljena brezplačna aplikacija za urejanje videoposnetkov in fotografij. Dijaki so pri ustvarjanju na podlagi fotografij uporabili naslednje funkcije:

- Obrezovanje in rezanje videoposnetkov, da so odstranili neželene dele.
- Dodajanje prehodov: različni prehodi med prizori, ki videoposnetke naredijo bolj tekoče.
- Učinki in filtri, ki omogočajo prilagajanje videoposnetkov.
- Besedilo in nalepke: dodajanje besedila, naslovov in nalepk za večjo ustvarjalnost.
- Glasba in zvoki: Uporabniki lahko dodajo glasbo, zvoke ali svoje glasovne posnetke.
- Hitrostni učinki: Urejanje hitrosti videoposnetkov, vključno z upočasnjevanjem ali pospeševanjem določenih delov.
- Animacije: Dodajanje različnih animacij, ki izboljšajo dinamiko videoposnetka.

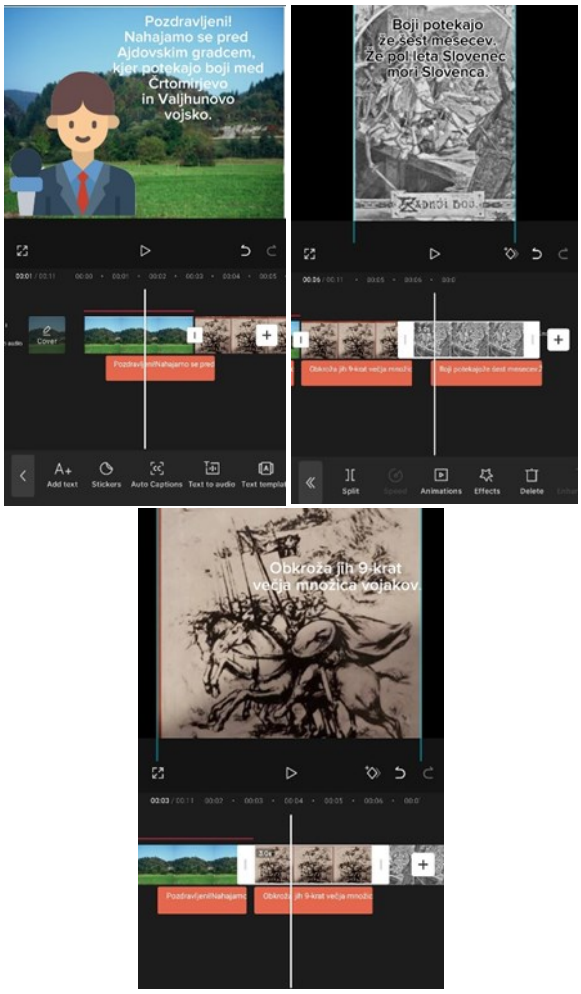
Nastale so zanimive predstavitve: reportaža, poročilo, domišljijska pripoved in intervju (slike 1, 2, 3 in 4.

Prva skupina je ustvarila reportažo – reporter se je javljal s prizorišča boja, izpred Ajdovskega gradca, in poročal o boju med Črtomirjevo in Valjhunovo vojsko. Fotografije so poiskali na spletu, jih dodali v program in obdelali ter dodali besedilo in animacije. Pri tem so ob vnosu besedila morali ves čas natančno spremljati Prešernovo besedilo Krst pri Savici in ga prilagajati izbrani besedilni vrsti.

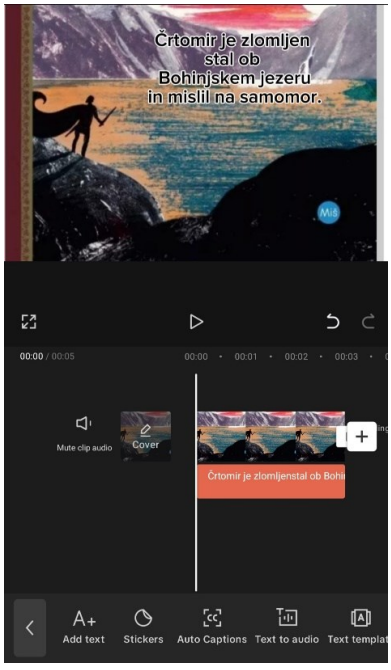
Druga skupina je ustvarila poročilo – na podoben način kot prva skupina reportažo, paziti so morali le, da je bilo vse zapisano v pretekliku, imeli so malo težjo nalogo, saj je reportaža zajemala le vsebino Uvoda, poročilo pa vsebino vseh treh delov pesnitve.

Tretja skupina se je odločila za domišljijsko pripoved z naslovom Bogomila pripoveduje – v ospredje so postavili Bogomilo in čez fotografije, ki prikazujejo potek dogajanja skozi Bogomilino videnje, posneli pripoved dijakinje. Bogomila je tako v prvoosebni pripovedi in izpovedi predstavila vsa dejstva, predvsem pa izrazila svoja čustva in doživljanja ob bridkem slovesu.

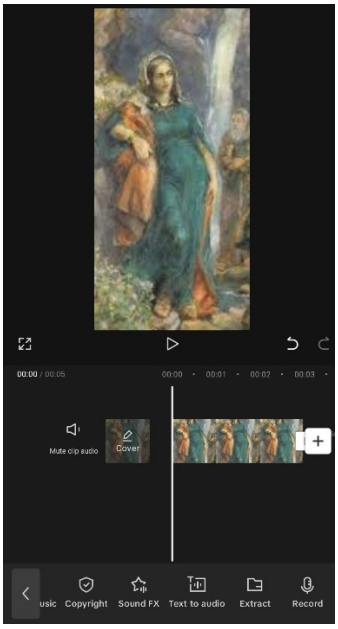
Četrta skupina je pripravila intervju z glavnim junakom – Črtomirjem tik pred bojem. Črtomir je tako iz svoje perspektive predstavil težke trenutke pred zadnjim bojem in kako je nagovoril svoje brate – vojake.



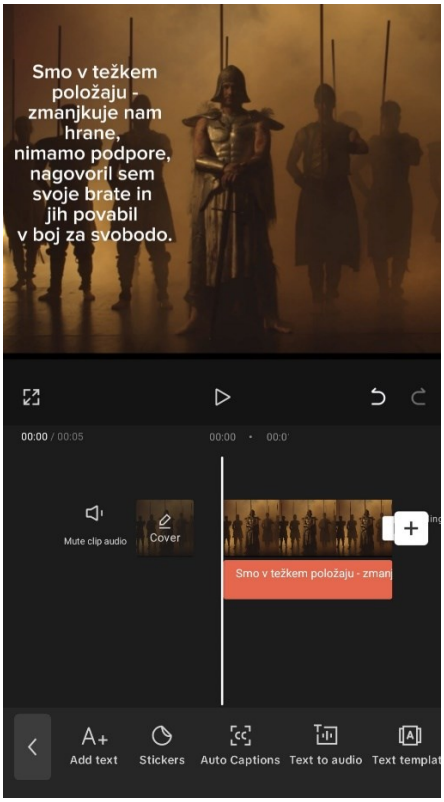
Slika 1: Reportaža, narejena v CapCutu



Slika 2: Poročilo, narejeno v CapCutu



Slika 3: Bogomila pripoveduje – CapCut



Slika 4: Črtomirjev intervju – CapCut

2.2 UI-KLEPETALNIK (AI-CHATBOT)

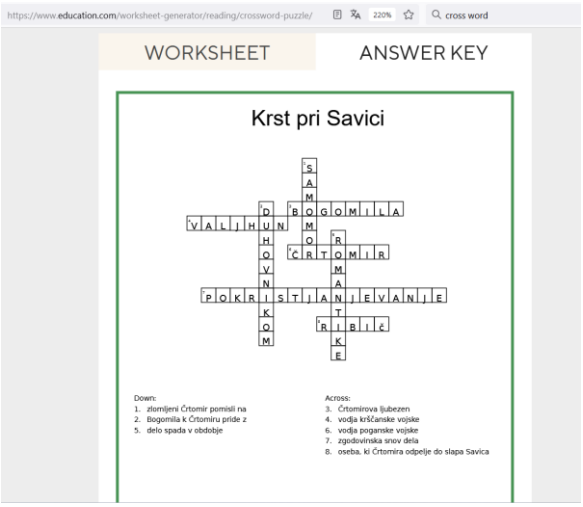
V peti skupini pa sem dijakom predstavila orodje umetne inteligence. Predlagala sem, da ustvarimo AI-chatbota, ki bo odgovarjal na vprašanja o zgodovinskem ozadju, zgradbi in sporočilu dela (slika 5). Pred tem so dijaki morali zbrati vse podatke in jih naložiti v model umetne inteligence.

Slika 5: UI-klepetalnik (AI-chatbot)

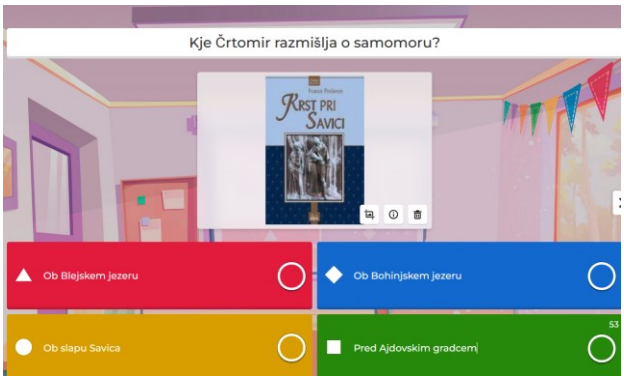
2.3 IZDELAVA KRIŽANKE IN KVIZA

Po končanem delu je sledila predstavitev ustvarjenega. Dijaki so pozorno in navdušeno spremljali predstavitve sošolcev. Zapletena vsebina, zgodovinsko ozadje in književne osebe so se jim kar izrisali pred očmi in pravijo, da jim bodo ostali v spominu dolgo časa prav zaradi teh nenavadnih, a zanimivih predstavitev. Predlagali so, da z delom nadaljujemo. Zastavili smo si nove naloge, da preverimo usvojeno znanje. Dijaki so se razdelili v dve skupini.

Prva skupina je izdelala križanko v spletnem programu Crossword Puzzle (https://www.education.com/worksheet-generator/reading/crossword-puzzle/) (slika 6). Sprva so določili gesla križanke, nato pa njihovo razlago. Druga skupina pa je ustvarila kviz v spletni platformi Kahoot (slika 7). Tako so se pomerili v znanju. Ponovno so morali prebrati Krst pri Savici in gradivo, da so lahko sestavili vprašanja za sošolce. Večkrat so navdušeno prebirali posamezne verze in na ta način neprisiljeno spoznavali podrobnosti dela. Prepričana sem, da ob enkratnem branju v šoli ne bi tako natančno spoznali pesnitve, marsikateri verz in podrobnost bi bila spregledana.



Slika 6: Izdelava križanke



Slika 7: Kviz, izdelan v Kahootu

3 POMEN UPORABE IKT PRI POUKU

Ko dijaki aktivno uporabljajo IKT, se izobraževalni proces obogati, njihovo učenje se poglobi, pouk se popestri, kar prispeva k bolj dinamičnemu, interaktivnemu učnemu okolju. Delo z IKT prinaša veliko koristi:

Razvoj digitalnih kompetenc: dijaki z uporabo različnih orodij pridobijo pomembne digitalne veščine, kar jih pripravi na učinkovito uporabo tehnologije v vsakdanjem življenju in na delovnem mestu.

Dostop do virov in vsebin: IKT omogoča enostaven dostop do številnih izobraževalnih virov (e-knjige, izobraževalni videoposnetki …). To učencem omogoča, da poglobijo svoje znanje in raziskujejo teme, ki jih posebej zanimajo.

Samostojnost in odgovornost: Aktivno delo z IKT spodbuja dijake k samostojnosti, saj pogosto sami raziskujejo, iščejo informacije in rešujejo naloge. To povečuje njihovo odgovornost za lastno učenje, saj morajo sami načrtovati svoje delo in reševati težave, ki se pojavijo med procesom.

Ustvarjalnost, izvirnost, inovativnost: S pomočjo IKT orodij lahko dijaki ustvarjajo lastne projekte, ki so lahko bolj ustvarjalni in inovativni kot navadne naloge. Lahko izdelajo videoposnetke in digitalne predstavitve, kar spodbuja njihovo ustvarjalno mišljenje.

Sodelovanje, interaktivnost in komunikacija: IKT omogoča lažje sodelovanje med dijaki, izmenjujejo si ideje in podatke. To spodbuja timsko delo in izboljšuje njihove komunikacijske veščine. Z uporabo interaktivnih tabel, tablic, računalnikov in pametnih telefonov lahko učitelji ustvarijo bolj interaktivno učno okolje. Dijaki lahko neposredno sodelujejo pri reševanju nalog, kvizih, glasovanjih ali diskusijah.

Kritično mišljenje in reševanje problemov: Aktivno delo z IKT zahteva od dijakov, da kritično razmišljajo, ocenjujejo informacije in reševanje problemov. Ko se soočajo z izzivi pri uporabi tehnologije, morajo poiskati rešitve, kar krepi njihove analitične sposobnosti.

Motivacijo in angažiranost: Uporaba tehnologije poveča njihovo motivacijo za učenje. Interaktivne naloge, takojšnja povratna informacija in možnost za ustvarjalno izražanje prispevajo k aktivnemu sodelovanju pri pouku, saj takšni izzivi lahko naredijo učenje bolj zabavno, privlačno in sproščeno.

4 ZAKLJUČEK

Želja vsakega učitelja je, da svoje dijake motivira za delo, za aktivno sodelovanje in sooblikovanje pouka, na takšen način se namreč lažje povežejo s predstavljeno vsebino in usvojijo nova kakovostna znanja. Nenehno iščemo različne načine dela, s katerimi bi te cilje dosegli. Velika nagrada za učitelja je, da ob delovni vnemi in velikem zanimanju za delo dijaki sami predlagajo dodatne naloge in izzive ter se jih lotijo z navdušenjem in iščejo izvirne rešitve. Po pregledu e-gradiv, ki obravnavajo Krst pri Savici, smo IKT-orodja preizkusili tudi sami. Dijaki so ustvarili digitalne predstavitve, kjer so izrazili svoje razumevanje in interpretacijo dela. Uporaba IKT je bila zagotovo nadgradnja in popestritev klasičnih obravnav literarnih del. Cilji so bili doseženi, dijaki motivirani za delo. Z ustvarjalnostjo in lastno aktivnostjo so podrobneje spoznali pomembno delo slovenskega romantika.

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[4] Mojca Dolinar, Anita Poberžnik. Lidija Jerše.(2013). Vodenje in podpora učencem pri pridobivanju digitalnih kompetenc. Dostopno na naslovu https://www.zrss.si/wp-content/uploads/2023/08/Vodenje-in-podpora-ucencem-pri-pridobivanju-digitalnih-kompetenc.pdf. (15. 8. 2024).
[5] Viri vseh slik so lastni, zajem zaslonske slike.

Programiranje + fizika → Igra se začne

Programming + Physics → The Game Begins

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POVZETEK

V prispevku je predstavljeno, kako preko računalniške igrice, ki jo otroci sami sprogramirajo, utrjevati učno snov pri fiziki v OŠ. S tem smo naslavljali tako učne cilje s področja informatike kot tudi fizike. Opisana sta ideja, ki je pripeljala do izvedbe te teme, in način priprave ustreznega gradiva. Predstavljeni sta tudi izvedba v razredu in ključne ugotovitve o tej izvedbi. V zaključku so navedeni načrti glede razvoja obravnave te teme in tudi uporaba tovrstnega pristopa pri obravnavanju drugih tem.

KLJUČNE BESEDE

Programiranje, Scratch, fizika, računalniška igrica, formativno spremljanje

ABSTRACT

The article presents how to consolidate learning material in physics in elementary school through a computer game that children program themselves. With this, we addressed both learning objectives in the field of informatics and physics. The idea that led to the implementation of this topic and the method of preparing the relevant material are described. The classroom implementation is also presented and the key findings about this implementation are presented. In the conclusion, plans are given regarding the development of both the treatment of this topic, as well as the use of this type of approach in the treatment of other topics.

KEYWORDS

Programming, Scratch, physics, computer game, formative monitoring

1 Medpredmetno povezovanje in projekt NAPOJ MINUT

Medpredmetno povezovanje je stara ideja, ki jo pogosto kar precej umetno vlečemo skozi celoten učni načrt. Običajno smo brez pravih idej, kako bi se stvari lotili, s katerim predmetom in sodelavcem bi se povezovali, da bi stvar stekla gladko in predstavila učencem naravo, tako kot je − torej celota, v kateri je vse povezano. Najlepše steče kakšen dan dejavnosti, ko se istega problema lotijo različni predmetni učitelji vsak s svojega zornega kota, učenci pa krožijo po delavnicah in doživijo celoto preko razdrobljenosti, ki jih povežejo v svojih glavah.

Še večji problem kot usvajanje novih znanj pa je v šoli utrjevanje znanja. Zanj učitelju pogosto zmanjkuje časa, učencem pa motivacije. Da bi se pri tem "ne bodi ga treba" še medpredmetno povezovali, je res znanstvena fantastika.

V projektu NAPOJ MINUT pa najdemo možnost, kako mimogrede utrjevati osnove fizike, to je fizikalne količine in enakomerno gibanje ob programiranju računalniške igrice v Scratchu.

Projekt NAPOJ MINUT združuje (predvsem) učitelje računalništva in informatike (RIN) in ostalih naravoslovnih predmetov, torej MINUT - M(atematika) I(nformatika) N(aravoslovje) U(metnost) T(ehnologija) predmetov.

V okviru projekta se sodelujoči:

- Redno sestajajo na spletnih (ZOOM) sestankih in izmenjujejo izkušnje.
- Razvijajo gradiva, kjer se prepletata RIN in še en predmet.
- Se srečujejo na delavnicah, kjer razvijajo učna gradiva.
- Sodelujejo na konferencah: NAK, STEAMColab, DigiDakta, VIVID.
- Obiskujejo kolege iz drugih držav, ki poučujejo na podoben način.

Na sliki 1 vidimo logotip projekta, ki je nastal prav med razvojem teme, kjer so se prepletali umetnost, matematika in računalništvo [2].

Slika 1: Logotip projekta NAPOJ MINUT

V sklopu projekta je nastalo že več kot 10 obravnav tem, določene pa so še v razvoju. Za več informacij o projektu se lahko obrnete na napoj@404.si.

1.1 Ideja projekta

Kot že rečeno je težje pripraviti učence do utrjevanja znanja kot do usvajanja novih znanj. Zastavili smo si vprašanje, kako utrjevati zaključen učni sklop pri fiziki, da bi bilo učencem zanimivo in bi hkrati predstavljal nadgradnjo njihovega znanja.

Ob tem se pojavi še vprašanje, kaj učenca vleče naprej, kaj je njegova motivacija, kdo mu daje povratno informacijo, kaj mu daje zadovoljstvo [1]

Glede na privlačnost računalniških igric [1] smo predvidevali, da bi lahko ustvarjanje oziroma programiranje in potem medsebojno preskušanje igric imelo željene učinke.

Kot trdijo avtorji v [3] ustvarjanje računalniške igrice učenca motivira. S pomočjo programa, ki bo deloval, če ga bo učenec pravilno sestavil, bo znanje učenca sprotno preverjeno in tudi nagrajeno prav s svojim delovanjem.

Dodana vrednost tega povezovanja pa se bo pokazala tudi učitelju fizike, saj je prav delovanje ali nedelovanje programa učencu povratna informacija, ki jo potrebuje za uspešno napredovanje. Na ta način bo RIN tudi opravil del formativnega spremljanja [3], ki bi ga sicer moral opravljati učitelj. Z delovanjem programa bo učenčevo delo tudi ustrezno nagrajeno.

Tako se ob povezovanju dveh predmetov fizike ter računalništva in informatike učenec nauči programirati v Scratchu ter hkrati utrjuje znanje iz enakomernega gibanja.

2 O projektu

Projekt omogoča igrifikacijo [1] učenja osnovnih pojmov iz enakomernega gibanja. Ko postane utrjevanje že dolgočasno, vendar je še vedno potrebno, se lahko vprašamo, zakaj ne bi razširili znanja fizike in ga povezali z računalništvom? Pri naši nalogi gre za povezovanje osnovnih pojmov enakomernega gibanja in osnovnih konceptov programiranja, združenih v okolju Scratch.

Slika 2: Delček programa

Ker sem kot učiteljica fizike prisotna na šoli celo šolsko leto, je bil dogovor, da bomo pri fiziki pri rednih urah usvojili operativne učne cilje iz fizike (glej razdelek 2.1), potem pa se nam za izvedbo delavnice pridruži študentka računalništva in skupaj izvedeva še računalniški del projekta ter tako učenci usvojijo tudi učne cilje iz računalništva in informatike (glej razdelek 2.1).

Del fizikalnih nalog iz enakomernega gibanja z rešitvami je predstavljenih na sliki 3.

Slika 3: Del fizikalnih nalog

Predviden potek delavnice po urah in razporeditev nalog je podan na sliki 4.

Slika 4: Del priprave za izvedbo

Izvajalke dogodka smo se najprej pripravljale in povezovale v živo na delavnici NAPOJ MINUT, potem pa preko spletnih srečanj.

2.1 Operativni učni cilji

Pri sklopu enakomerno gibanje pri fiziki v 8.razredu želimo učence pripeljati do prepoznave in nadalje avtomatske uporabe simbolov ter enot za osnovne fizikalne količine. Pri usvajanju enakomernega gibanja definiramo hitrost s pomočjo poti in časa in izvedemo eksperimente, pri katerih merimo dve fizikalni količini in tretjo izračunamo. V naslednjem koraku pa učenca preko konkretnih besedilnih nalog izzovemo, da uporablja tako znanje fizikalnih količin kot tudi formulo za izračun enakomerne hitrosti in jo po potrebi tudi obrne oziroma izrazi neznanko ter tako izračuna manjkajočo fizikalno količino.

V računalniškem delu delavnice stremimo k osvojitvi osnovnih konceptov programiranja, kot so pogojni stavki, vejitve in zanke, ter razvoju računalniškega oziroma algoritmičnega mišljenja. Učenci nove koncepte urijo v okolju Scratch, ki pri programiranju uporablja bloke kode, s katerimi učenci sestavljajo programe in jih dopolnjujejo z ustreznimi vrednostmi. Eden izmed, predvsem za začetnike kompleksnejših konceptov, s katerim se v delavnici srečujejo učenci, je sočasnost dogodkov oziroma sinhronizacija elementov, ki jih v okolju Scratch dosežejo s t. i. pošiljanjem sporočil.

2.2 Izvedba

Naše povezovanje smo izvedli v delavnici za nadarjene oziroma radovedne učence. Na ta dogodek so se lahko prijavili učenci 8. in 9. razreda do zapolnitve mest (24).

Delavnica je trajala 5 šolskih ur. Pred začetkom delavnice in po njenem zaključku so učenci izpolnili anketo, s katero smo želeli meriti uspešnost izvedenega dogodka.

Po uvodni predstavitvi delavnice, ki jo je izvedla zunanja izvajalka, so učenci spoznavali okolje Scratch in si pripravili svoje ozadje. Hitrejši so imeli tudi nekaj časa, da so lahko že samostojno raziskovali po okolju.

Sledila je predstavitev že narejene igrice; najprej so jo sami preizkusili, potem pa so se spustili v program igrice in spoznavali, kako delujejo posamezni bloki in kombinacija le-teh v Scratchu.

Za spoznavanje okolja Scratch in učenje posameznih računalniških konceptov, kot so pogojni stavki, vejitve in zanke, je bil pripravljen prazen mini program (primer končnega mini programa: https://scratch.mit.edu/projects/1029715695 in prazen mini program: https://scratch.mit.edu/projects/1029727769). Učenci so najprej skupaj z izvajalko delavnice spoznali končni program in ga nato v nadaljnjih urah poskušali postopoma vodeno poustvariti z dodatnimi razlagami posameznih konceptov.

V drugi uri so spoznavali osnovno delovanje vejitev in pogojnih stavkov (if-else stavkov), logike (Booleovo algebro) in zank, v tretji uri pa pošiljanje sporočil znotraj programa, sinhronizacije elementov ter koncept »vprašanje in odgovor«.

V tej točki so bili učenci opremljeni z vsem potrebnim znanjem programiranja v Scratchu, ki ga bodo uporabili pri reševanju fizikalne naloge in izdelavi igrice.

Učencem smo na začetku četrte ure delavnice razdelili različne fizikalne naloge iz enakomernega gibanja in njihova naloga je bila, da pripravijo oz. prilagodijo program tako, da bo deloval za njihovo nalogo. Za to nalogo je bil pripravljen prazen oziroma deloma izpolnjen glavni program (prazen glavni program: https://scratch.mit.edu/projects/1029774314 in končni glavni program: https://scratch.mit.edu/projects/1020356210).

V tem delu so učenci uporabljali svoje fizikalno znanje; prepoznavanje fizikalnih količin in enot iz besedila, zapisovanje le teh s simboli v program, priklic formule in izražanje neznanke, računanje rezultata in vnos le-tega v program, da bo v primeru uspešno rešene igrice potrdil igralca s pohvalo in aplavzom. Dogovor je bil, da so pravilni rezultati le tisti, ki vsebujejo simbol fizikalne količine, število in enoto.

Za delo so bili zelo motivirani. V primeru zapleta so za pomoč poklicali učiteljico. Vse narejene/popravljene naloge so naložili v studio, kjer so postale dosegljive za vse sodelujoče in za javnost (studio s končnimi izdelki: https://scratch.mit.edu/studios/33589412/).

Nadaljevali so z medsebojnim igranjem igric, ki so jih sestavili sošolci in si dajali tudi povratne informacije.

3 Refleksija

Učenci so po delavnici izražali zadovoljstvo. Tisti, ki jim je uspelo oddati delujočo igrico v studio, so bili ponosni. Takih je bilo 17/23. Glede na njihove odgovore v anketi bi izpostavila njihova pričakovanja in spremembo odnosa do obeh predmetov, ki sta bila povezana v projektu. Pričakovanja so bila; da bo zanimivo, da bo drugače, kot je sicer pouk, da se bodo naučili nekaj novega, da se bodo učili nekaj, kar bo povečevalo znanje na obeh področjih tako fizike kot programiranja.

Po izvedeni delavnici je v anketi glede fizike 40 % učencev ocenilo, da se je njihov odnos do fizike izboljšal.

Glede računalništva in informatike pa po izvedeni delavnici ugotavljajo, da je računalništvo bolj zanimivo, manj težko in da jih bolj veseli, kot so predvidevali. Po izvedeni delavnici je na trditev »rad programiram« 20 % več učencev kot pred izvedbo odgovorilo pritrdilno.

Moje mnenje je, da je delavnica uspela. Operativni cilji so bili doseženi in učenci zadovoljni. Res pa je, da je bila delavnica precej zahtevna, saj so morali učenci najprej usvojiti kar nekaj računalniškega znanja, da so igrici po programu lahko sledili, jo spreminjali in končno sestavili nekaj novega. Tudi njihova prosta izbira udeležbe na delavnici je gotovo botrovala motivaciji in uspehu. Glede na področje utrjevanja fizike je cilj zagotovo dosežen.

4 Zaključek

V nadalje bi bilo smiselno izvesti delavnico ločeno v nivojih s tistimi, ki že poznajo Scratch, in tistimi, ki se z njim prvič srečajo. Za tiste, ki Scratch prvič uporabljajo, bi bilo potrebno nalogo olajšati, morda tako, da bi programirali igrico po delih. Način izvedbe v okviru delavnice za nadarjene in radovedne učence se je izkazal za zelo primeren in izvedljiv v šoli. Opisani način utrjevanja bi zagotovo dobro deloval pri mnogih zaključenih enotah fizike, kemije in matematike.

V Scratchu so učenci uspešno izdelali igrico na podlagi fizikalne vsebine. Tako so pridobili znanje iz osnov programiranja. Usvojene spretnosti so prva stopnička na poti do znanja, ki je danes na trgu dela iskano in cenjeno.

ZAHVALA

Zahvaljujem se organizatorjem projekta NAPOJ MINUT za primerne izzive in podporo pri nastajanju naših gradiv ter spodbudo za njihovo izvedbo. Projekt sva pripravili z Mio Zalo Smrečnik, študentko matematike in računalništva na UL PeF, pri konkretni izvedbi nama je na pomoč priskočila Anja Količ, prav tako študentka smeri računalništvo in matematika na UL PeF, iskrena hvala obema.

VIRI

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Razvijanje digitalnih kompetenc na OŠ Prežihovega Voranca Maribor

Developing Digital Competencies at Prežihovega Voranca Elementary School Maribor

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POVZETEK

V prispevku je predstavljeno delovanje na šoli OŠ Prežihovega Voranca, ki se je v šolskem letu 2023/24 pridružila v projektu Inovativna pedagogika 5.0. Projekt temelji na razvijanju sodobnega pouka, ki je podprt z digitalnimi tehnologijami ter je usmerjen v razvijanje digitalnih kompetenc in temeljnih vsebin RIN. Predstavljeni so tudi izzivi, s katerimi se soočamo na šoli in kako jih premagujemo.

Natančneje je predstavljen tudi konkretni primer učne ure, ki je bil izveden pri pouku zgodovine in je podrobneje razvijal kompetenco avtorske pravice in licence. Pri pripravi sodobne učne ure moramo kot učitelji razmišljati celostno, vključiti znanja, spretnosti in veščine, ki so podprte z digitalnim. V ospredje si moramo postaviti dejstvo, da morajo učenci postati aktivni člen učnega procesa in ne samo tisti, ki prejemajo znanja učitelja. To so izzivi učiteljev, ki jih lahko rešujemo s skupnimi močmi in počasi odpravljamo strahove, s katerimi se na šolah srečujemo.

KLJUČNE BESEDE

Digitalne kompetence, Inovativna pedagogika 5.0, sodobni koncepti poučevanja

ABSTRACT

The paper presents the work at the Prežihov Voranca Elementary School, which joined the Innovative Pedagogy 5.0 project in the 2023/24 school year. The project is based on the development of modern teaching that is supported by digital technologies and is focused on the development of digital competences and basic content of RIN. The challenges we face at school and how we overcome them are also presented.

A concrete example of a lesson that was conducted in a history lesson that developed the competence of copyright and license in more detail is also presented. When preparing a modern lesson, we as teachers need to think holistically, incorporating knowledge, skills and skills that are supported by digital. We need to focus on the fact that students need to become an active member of the learning process and not just those who receive the teacher's knowledge. These are the challenges of teachers that we can solve together and slowly eliminate the fears we face in schools.

KEYWORDS

Digital competences, Innovative pedagogy 5.0, modern teaching concepts

1 UVOD

Na šoli smo učitelji in vodstvo šole začutili veliko potrebo po razvijanju digitalnih kompetenc. V času šolanja na daljavo smo spoznali, da nas je večina učiteljev na osnovni ravni znanj digitalnih veščin in smo v času večje uporabe računalnikov za izvajanje kvalitetnega pouka potrebovali več znanja iz tega področja. Vodstvo šole se je zato odločilo, da se v šolskem letu pridruži projektu »Dvig digitalne kompetentnosti«, ki je potekal pod okriljem Zavoda za šolstvo Republike Slovenije.

Namen projekta, ki je potekal med leti 2021 in 2023 je bil predvsem izboljšati kakovost in učinkovitost izobraževanja ter razvoj inovativnih učnih okolij. Cilj projekta je bil predvsem spodbujanje strokovnih delavcev v vzgoji in izobraževanju v razvoj prožnejših oblik učenja s pomočjo rabe digitalnih tehnologij. [1]

Z izvajanjem projekta smo bili strokovni delavci deležni različnih strokovnih izobraževanj, ki so bila glede na željo ter različno raven znanj organizirana s strani projektnega tima. Na šoli je bilo zaznati večje zanimanje za sodobne koncepte poučevanja, posledično je bilo opaziti tudi večjo motivacijo za učenje pri učencih. V šolskem letu 2023/2024 se je šola priključila projektu Inovativna pedagogika 5.0.

V prispevku je predstavljeno, kako se kot vodja projekta Inovativna pedagogika 5.0 soočam z novimi izzivi, novimi pridobljenimi znanji in spretnostmi ter kako to prenašam med strokovne delavce in učence.

Učitelji se tako kot družba soočamo s hitrim napredkom digitalnih tehnologij, ki jih učenci s pridom in spretno uporabljajo. Zavedamo se pozitivnih kot tudi negativnih posledic, ki nam jih napredek na tem področju prinaša. Kot izobraževalci smo se v prvi vrsti dolžni z izzivom napredka soočiti, saj smo tisti, ki lahko našim učencem predstavimo učinkovito rabo digitalnih tehnologij in jih učimo njihove varne rabe.

Slika 1: Logo projekta Inovativna pedagogika 5.0 – Inovativna šola.

2 PREDSTAVITEV PROJEKTA

Inovativna pedagogika 5.0 je projekt, ki se oddvija v hitro spreminjajočem svetu. Projekt odgovarja na potrebe sodobne družbe, ki od posameznika zahteva razvoj kompetenc ustvarjalnosti, kritičnega razmišljanja, reševanja problemov in veščin, ki so povezane z razvojem in uporabo digitalne tehnologije. Hkrati projekt poudarja razvoj sodelovanja, usklajevanja in učinkovitega komuniciranja v družbi. Vse to pa pomeni, da se mora izobraževalni proces premakniti od ustaljenih vzorcev ter omogočiti razvijanje digitalnih kompetenc, temeljnih vsebin RIN, kritičnega mišljenja, kreativnosti in ustvarjalnosti tako strokovnih delavcev kot tudi učencev. [2]

V prvi fazi projekta so bili v vsakem vzgojno-izobraževalnem zavodu poleg ravnatelja vključeni še vsaj 4 strokovni delavci. V prvem letu je bilo tako vključenih več kot 200 vodstvenih in strokovnih delavcev. V drugem letu bodo vključeni dodatni inovativni oddelki ter dodatnih vsaj 300 strokovnih delavcev. V letu 2026 se ne načrtuje vključevanja dodatnih strokovnih delavcev temveč dvig kakovosti dela že vključenih. [3]

2.1 Organizacija projekta

Organizacija projekta se deli na projektni svet in razvojne skupine. Projektni svet usmerja in potrjuje odločitve na nivoju celotnega projekta. Sestavljen je iz vodij posameznih razvojnih skupin. Vodi in usmerja ga vodja projekta, dr. Andrej Flogie. [3]

Razvojne skupine predstavljajo jedro razvojno raziskovalnega projekta. Vsako razvojno skupino sestavljano predstavnik razvojne institucije, predstavnik vodstva šole ter inovativni strokovni delavci. Skupaj je v delo razvojnih skupin vključenih 140 strokovnjakov in znanstvenikov. Delo razvojnih skupin usmerja, vodi in preverja projektni svet. Razvojne skupine so sledeče: katalog digitalnih kompetenc, skupina za vzorčne učne scenarije, skupina za digitalno didaktiko, skupina za usposabljanje, skupina za izvedbeni kurikul, skupina za sodobne tehnologije, učeče se skupnosti, skupina za promocijo, skupina za uvajanje temeljnih vsebin RIN, skupina za implementacijo in skupina za evalvacijo. [3]

2.2 Namen projekta

Namen projekta je razvoj didaktike za dvig digitalnih kompetenc in temeljnih vsebin RIN pri učencih z uvajanjem sodobnih pristopov in uporabo sodobnih digitalnih orodij. S takšnim pristopom je ključni namen projekta učeče se pripraviti na izzive, ki jih prinaša sodobna družba in svet. [3]

Konzorcij projekta, ki ga vodi Zavod Antona Martina Slomška, sestavlja 6 razvojnih inštitucij, 10 mentorskih šol in 30 razvojnih šol po celotni Sloveniji. [3]

Naloga vključenih v projekt je z razvojem celostnega pristopa doseči razvoj diditalnih kompetenc pri učečih se in učiteljev ter razvoj temeljinh vsebin RIN pri učečih se. Razvojni timi in učiteljski zbori vključenih šol pripravljajo inovativne učne scenarije skozi katere se predstavljajo inovativni pristopi k sodobnejšemu učnemu procesu, ki učeče se pripravlja na učinkovito soočanje s sodobno družbo.

2.3 Delovanje projekta na OŠ Prežihovega Voranca Maribor

Na OŠ Prežihovega Voranca Maribor smo v šolskem letu 2023/2024 pričeli sodelovati v projektu Inovativna pedagogika 5.0. Najprej je bila oblikovana razvojna skupina v zavodu, ki vključuje ravnateljico, pomočnika ravnateljice, koordinatorico RIN, koordinatorico ROID ter koordinatorico projekta. Naloga razvojnega tima je celostno izvajati naloge znotraj zavoda, ki so ključne za dosego namena projekta.

V mesecu septembru 2023 sem se skupaj z ravnateljico in še enim članom šolskega tima udeležila uvodnega srečanja v projetku Inovativa pedagogika 5.0. Po navodilih iz sestanka sem v Forms anketi izrazila svoj inters za sodelovanje v posamezni razvojni skupini. V prvem šolskem letu smo določili dva inovativna oddelka, kjer so učitelji razvijali digitalne kompetence. Glede na izbrana inovativna oddelka je razvojni tim k sodelovanju povabil tudi strokovne delavce, ki so bili oblikovani v projektni tim.

Učitelje na šoli, ki so tudi člani projektne skupine, sem na krajšem seznanitvenem sestanku seznanila s cilji projekta in nalogami v projektu. Na šolski spletni stani sem poskrbela za objavo projekta.

V mesecu oktobru sem sklicala srečanje razvojnega tima, namen je bil seznanitev z nalogami projekta in razmislek o prirpavi načrta delovanja na šoli. V šolski spletni učilnici sem uredila posebno mapo, ki je namenjena projektu, vanjo sem dodala vse učitelje v projektni skupini, prav tako razvojni tim. Moja naloga kot koordinatorica projekta na šoli je bila tudi prevzem uredništva in objavljanje na Facebook strani projekta ter seznanjanje projektnega tima z novostmi. Člane projektne skupine sem usmerila tudi do spletne učilnice E-skupnost učiteljev v projektu Inovativna pedagogika.

Kot pomembno nalogo semi mela tudi pripraviti akcijski načrt medpredmetnih povezovanj s poudarkom na razvoju digitalnih kompetenc ter na podlagi tega načrtovanja pripraviti tudi okvirni načrt medsebojnih hospitacij.

V mesecu novembru sem organizirala delovno srečanje projektne skupine, kjer sem članom razdelila gradivo za seznanitev z digitalnimi komeptencami. Delo sem organizirala tako, da so učitelji po že vnaprej dogovorjenih medpredmetnih povezovanjih debatirali o možnostih razvijanja digitalnih kompetenc ter iskali možnosti vključevanja digitalnih tehnologij.

Kot koordinatorica projekta na šoli sem se mesečno udeleževala videokonferenčnih srečanj, kjer smo se seznanjali z novostmi in aktivnostmi v projektu ter izpostavljali izzive, s katerimi smo se srečevali na šolah. Videokonferenčna srečanja smo imeli tudi v razvojni skupini, v katero sem bila dodeljena po predhodno opravljenem anketnem vprašalniku v Formsu.

V mesecu januarju 2024 smo pričeli na šoli izvajati kolegialne hospitacije, ki sem jo kot prva izvedla sama. Po vsaki hospitaciji smo opravili tudi poglobljeno pedagoško diskusijo, saj so člani projektnega tima opazovali razvijanje izbrane digitalne kompetence. Prednost takšnega načina opravljanja hospitacij je

predvsem v tem, da se lahko osredotočeno diskutura o prednostih takšnega načina poučevanja kot tudi negativnih vidikih, ki se lahko pojavijo. Pri odpiranju vrat učilnic sem spoznala, da imajo strokovni delavci možnost spoznati nove koncepte poučevanja, vidijo motiviranost učečih se, hkrati pa izgubljajo strah pred novostmi.

Velika novost, ki jo je prinesel projekt, je bilo tudi pisanje učnih scenarijev. Učitelji v projektnem timu so se soočali z velikimi izzivi, zato sem organizirala srečanje, kjer smo s skupnimi močmi oblikovali učne scenarije, debatirali o prednostih in slabostih takšnega vodenja učnega procesa.

Na šoli smo pričeli tudi z izvajanjem dodatnih izobraževanj za strokovne delavce, ki so bili organizirani v ovkuru Inovativne pedagogike 5.0 kot tudi znotraj šole. Namen theh izobraževanj je bil predvsem v seznanjanju z novostmi v digitalni tehnologiji, prav tako pa smo s tem želeli zmanjšati strah strokovnih delavcev pred vključevanjem sodobnih digitalnih orodij v pouk.

3 RAZVIJANJE DIGITALNIH KOMPETENC PRI POUKU ZGODOVINE

3.1 Digitalne kompetence

Digitalne spretnosti za delo in življenje so med najpomembnejšimi prednostnimi nalogami evropske politike. Cilj strategije EU za pridobivanje digitalnih spretnosti in z njo povezanih pobud je okrepiti digitalne spretnosti in kompetence za uspešnejšo digitalno preobrazbo. [4]

V okviru DigComp 2.2 so kompetence razvrščene na pet področij, in sicer: informacijska in podatkovna pismenost, komuniciranje in sodelovanje, ustvarjanje digitalnih vsebin, varnost in reševanje problemov. Prva tri področja vključujejo kompetence, ki so povezane z dejavnostmi in opravili. Četrto in peto področje pa vključujeta kompetence, ki so prečne, kar pomeni, da jih potrebujemo pri izvajanju najrazličnejših aktivnosti povezanih z uporabi digitalnih tehnologij. [4]

3.2 Praktičen primer razvoja digitalne komepence pri pouku zgodovine

Kot učiteljica zgodovine in koordinatorica projekta Inovativna pedagogika 5.0 sem se odločila, da bom pri pouku v inovativnih oddelkih postavila delo učencev pod tretje področje kompetenčnega okvirja, torej ustvarjanje digitalnih vsebin in podrobneje razvijala kompetenco 3.3 avtorske pravice in licence.

Z učenci v osmem razredu sem dve izbirni temi iz učnega načrta izvajala v obliki projektnega dela. Učna sklopa sta bila prve kapitalistične velesile in izumi, ki so spremenili življenje ljudi in življenje ljudi 19. stoletja. Projektno delo je bilo načrtovano medpredmetno, tako so učenci pri pouku zgodovine spoznavali posamezne teme, medtem ko so pri predmetu tehnika in tehnologija praktično ustvarjali izdelke. V preteklih letih so učenci takšen način dela pozitivno sprejeli, saj so pridobljeno znanje pri zgodovini lahko uporabili tudi pri praktičnem delu v delavnici. V šolskem letu 2023/2024 sem se odločila, da bom takšen način dela dopolnila še z razvijanjem digitalne kompetence.

1.1.1 Nameni učenja

Med načrtovanjem učnega procesa sem si zamislila namene učenja, ki jih želim skozi učni proces pri učencih razvijati. Po pregledu učnega načrta in DigComp 2.2 sem se odločila, da se bomo postavili pod kompetenco avtorske pravice in licence. Oblikovala sem tudi namene učenja, ki sem jih učencem predstavila. Nameni so bili naslednji: seznanili se bomo s področjem življenja in napredka obdobju prve in druge industrijske revolucije, razumeli bomo, kako je tehnološki napredek vplival na življenje različnih družbenih slojev, sklepali bomo o posledicah, ki jih je posamezen izum ali odkritje prinesel v življenje, znali bomo pridobljene informacije strniti v smiselno celoto, znali bomo selekcionirati spletne vire glede na CClicence, seznanili se bomo z relevantnimi spletnimi viri, seznanili se bomo s spletnim orodjem Oblak365 in v njem ustvarjati dokumente ter jih deliti z ostalimi.

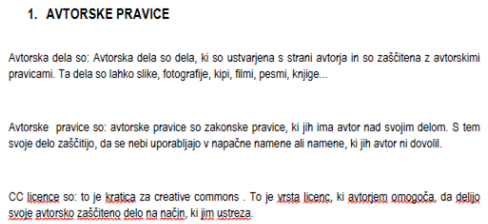
1.1.2 Preverjanje predznanja

Z računalničarko sva uro pričeli tako, da sva preverili predznanje učencev o avtorskih pravicah. Najprej sva jim predvajali posnetek posseted FAQs on copyright for teachers - Observatory (europa.eu) in po posnetku opravili razgovor z učenci. Skozi pogovor sva učence pripeljali do ugotovitve, da bomo pri projektnem delu spoznavali avtorska dela in poudarili avtorske pravice.

Nato so učenci razmišljali o lastnih izdelkih, ki so jih izdelovali pri tehniki in tehnologiji. Vodila sem jih skozi razgovor in z njihovimi odgovori ugotavljala, kakšno je njihovo znanje o avtorskih pravicah. V lažji razmislek sem jim postavila naslednja vprašanja: kdo je avtor izdelka, ali lahko tvoj sošolec izdelek fotografira in ga uporabi v svojem referatu, ali lahko na spletu vzamem sliko ali besedilo in ga uporabim v referatu?

Ker so učenci delali tudi s spletnimi viri, sem jim prebrala en primer rabe digitalnih vsebin. Učenci so imeli nalogo, da ugotovijo, kaj je pri prebranem primeru bilo napačno. Hkrati pa so podajali predloge, kako bi lahko oseba iz zgodbe uporabila spletni vir in ne kršila avtorskih pravic. Učenci so skozi razgovor kritično ovrednotili navajanje uporabljenih virov. Skupaj smo pregledali že dogovorjene načine navajanja uporabljenih virov.

Naš pogovor se je nadaljeval tako, da so učenci morali s svojimi besedami pojasniti naslednje pojme: avtorsko delo in avtorske pravice. S pridobljenim znanjem so učenci morali dopolniti svojo pisno projektno nalogo. Poudarjali smo predvsem to, da morajo pri projektni nalogi pisati z lastnimi besedami in obvezno ob uporabi drugih gradiv navesti avtorje.



1. AVTORSKE PRAVICE

Avtorska dela so: Avtorska dela so dela, ki so ustvarjena s strani avtorja in so zaščitena z avtorskimi pravicami. Ta dela so lahko slike, fotografije, kipi, filmi, pesmi, knjige...

Avtorske pravice so: avtorske pravice so zakonske pravice, ki jih ima avtor nad svojim delom. S tem svoje delo zaščitijo, da se nebi uporabljajo v napačne namene ali namene, ki jih avtor ni dovolil.

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Slika 2: Zapis učenke o avtorskih pravicah in izdelkh.

Delo je potekalo tako, da sva učence v oddelku razdelili na polovico, saj nam računalniška učilnica ne dopušča, da bi v njej delal celoten oddelek (28 učencev). Tako je polovica učencev delo opravila v računalniški učilnici, preotanek razreda pa je delo opravljal v učilnici zgodovine, kjer so imeli na razpolago prenosne računalnike.

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Slika 3: Zapis učenke o licencah.

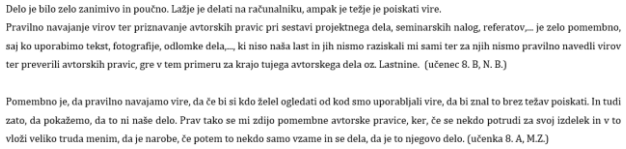
Učenci so se prijavili v spletno učilnico in na računalnike prenesli pripravljen dokument. Dokument so dopolnili s svojimi podatki in novimi spoznanji, ki so jih pridobili skozi razgovor. Učenci so dokument shranili v Oblak 365 in ga delili z učiteljico. Tega koraka z učenci nisem preverjala, saj sem vedela, da so takšen način že uporabili pri predmetu matematika in sem se lahko osredotočila na pomoč tistim učencem, za katere sem vedela, da še imajo težave pri deljenju dokumnetov.

1.1.3 Uporaba lastnega znanja in razsikovalno delo

Učenci so svojo temo individualno raziskovali, iskali so v učbeniku, knjižnih virih in spletnih virih. Delo učencev je potekalo 6 šolskih ur, prednost je ta, da imamo blok ure in so tako lahko intenzivno delali. Vse podatke so povzemali v deljen dokument in sproti navajali uporabljeno literaturo ter vire. Učenci so v referat vključili vsaj dva slikovna gradiva. Pri izbiri slikovnih gradiv so morali paziti na upoštevanje CC licenc. Učenci so ob zaključku pisanja referata zapisali tudi samorefleksijo o lastnem delu in napredku, v zapis razmisleka so vključili tudi razmišljanje o pomembnosti navajanja virov ter upoštevanju avtorskih pravic.

Delo obeh učiteljic je bilo namenjeno predvsem usmerjanju in pomoči posameznikom, ki so pomoč potrebovali. Ker so učenci njihov dokument delili z menoj, je bilo preprosto odpreti njihov dokoument in jim zapisati povratno informacijo. Povratna informacija učiteljice je bila tako sprotna in pisna, tako so lahko učenci hitro popravili pomanjkljivosti.

Učenci so z lastnim avtorskim izdelkom, ki je nastal pri predmetu tehnika in tehnologija, predstavili novo pridobljeno znanje o izumitelju in izumu. Pri sami predstavitvi zgodovinskega dela so morali vključiti tudi lasten razmislek o tem, zakaj je pomemno, da priznamo delo nekoga drugega in ga pravilno tudi navedemo.



Delo je bilo zelo zanimivo in poučno. Lažje je delati na računalniku, ampak je težje je poiskati vire.
Pravilno navajanje virov ter priznavanje avtorskih pravic pri sestavi projektnega dela, seminarskih nalog, referatov,... je zelo pomembno, saj ko uporabimo tekst, fotografije, odlomke dela,..., ki niso naša last in jih nismo raziskali mi sami ter za njih nismo pravilno navedli virov ter preverili avtorskih pravic, gre v tem primeru za krajo tujega avtorskega dela oz. Lastnine. (učenec 8. B, N. B.)

Pomembno je, da pravilno navajamo vire, da če bi si kdo želel ogledati od kod smo uporabljali vire, da bi znal to brez težav poiskati. In tudi zato, da pokažemo, da to ni naše delo. Prav tako se mi zdijo pomembne avtorske pravice, ker, če se nekdo potrudi za svoj izdelek in v to vloži veliko truda menim, da je narobe, če potem to nekdo samo vzame in se dela, da je to njegovo delo. (učenka 8. A, M.Z.)

Slika 4: Zapisan razmislek učencev o avtorskih pravicah.

1.1.4 Razmislek učiteljice ob koncu projektnega dela

Delo je potekalo brez večjih težav, vidno je bilo, da so učenci v tem šolskem letu že razvijali digitalne kompetence in težav z deljenjem dokumentov ter urejanje spletne različice Worda niso imeli. Še vedno ostaja nekaj učencev, ki potrebujejo pri delu pomoč in usmerjanje. Učencem s posebnimi potrebami smo delo organizirali tako, da so bile prisotne tudi izvajalke DSP, kar je bila velika prednost pri izvajanju aktivnosti.

Pred pričetkom izvajanja seznanjanja z novimi vsebinami sem ob pomoči ustnega razgovora ugotovila, da se učenci zavedajo, da je fizičen izdelek/slika/risba intelektualna lastnina avtorja. Manj učencev se je zavedalo, da je intelektualna lastnina tudi prisotna na spletu in da je potrebno uporabiti tiste, za katere imamo dovoljenje avtorja.

Učenci so z razmislekom pokazali, da so razumeli pomen upoštevanja avtorskih pravic. Prav tako so pri iskanju fotografij uporabljali pridobljeno znanje, torej kje preveriti CC licenco.

Ključnega pomena je, da takšno delo poteka v šolskem prostoru, saj je za nekatere učence to preveik zalogaj in potrebujejo vodneje in usmerjanje učitelja.

4 ZAKLJUČEK

Z vstopom v projekt Inovativna pedagogika 5.0 je naša šola naredila pomemben korak k sodobnemu pouku, pouku ki podpira razvoj digitalnih kompetenc med učečimi se in učitelji ter spodbuja uporabo digitalnih tehnologij. V procesu sprememb izobraževalnega sistema imamo učitelji veliko in pomembno vlogo, zato moramo biti med prvimi, ki si upamo preizkusiti nekaj novega.

Kot koordinatorica projekta na šoli se zavedam svoje vloge na šoli, saj sem že v prvem letu naletela na neodobravanje vnašanja sprememb, predvsem med učitelji. Moja naloga je bila velikokrat usmerjena v pomirjanje in seznanjanje, saj so se tako strokovni delavci pomirili in poskusili narediti kakšen korak naprej. V ta namen se je kot zelo dobro izkazalo izvajanje hospitacisjkih ur, kjer smo lahko učitelji skupaj razmišljali o izvedeni učni uri, se usmerjeno pogovarjali o prednostih in izzivih, ki smo jih učitleji pri pripravi ur podprtih z digitalno tehnologijo imeli.

Naša ugotovitev je bila tudi ta, da moramo biti pri vključevanju digitalnih tehnologij zelo previdni, saj učenci velikokrat njihovo uporabo postavijo na prvo mesto, pozabijo pa na ostala znanja, ki jih bi jih naj v izobraževalnem procesu pridobili. Učitelj, ki vključuje razvoj digitalnih kompetenc in z digitalnimi tehnologijami dopolnjuje svoj pouk, mora proces zastaviti premišljeno. Digitalne tehnologije morajo predstavljati orodje, s katerim bodo učenci lahko na zanimivejši in aktivnejši način pridobivali znanja. Vključevanje razvijanja digitalnih kompetenc pa bo učencem nudilo priložnost, da se aktivneje vključijo v učni proces.

Večje odobravanje pri takšnem načinu poučevanja vidim pri učečih se, ki se dnevno srečujejo z digitalno tehnologijo. Zato je naloga učiteljev, da novosti na tem področju spoznavamo skupaj z učenci ter jim dajemo možnosti koristne rabe digitalnih tehnologij v varnem okolju.

Naša naloga je, da učencem omogočimo, da izobraževalni proces zaključijo tehnološko pismeni, saj je tehnologija sestavni del številnih poklicnih področij. Vključevanje tehnologije v učni proces lahko pomaga učencem razviti potrebne spretnosti za prilagajanje sodobnemu svetu, ki vse bolj zahteva digitalne spretnosti, kot so programiranje, analitično razmišljanje in reševanje kompleksnih problemov.

ZAHVALA

Zahvaljujem se vodstvu šole, ki podpira in spodbuja vse moje ideje o vključevanju sodobnih konceptov poučevanja. Prav tako se zahvaljujem sodelavcem, ki se trudijo in mi pomagajo pri uresničevanju ciljev projekta.

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Povezanost psihoedukativnega pristopa in ravni pismenosti o anksioznih motnjah

The Relationship between a Psychoeducational Approach and Literacy Levels in Anxiety Disorders

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POVZETEK

Motnje razpoloženja, kot so anksiozne in depresivne motnje, so v današnji družbi zelo pogoste in predstavljajo velik javnozdravstveni problem. Kljub njihovi razširjenosti ostajajo slabo prepoznane in neustrezno obravnavane. Koncept pismenosti o duševnem zdravju (PDZ) je ključnega pomena za ozaveščanje javnosti o duševnih motnjah, njihovem zdravljenju in zmanjševanju stigme. Program OMRA, ki se je v Sloveniji začel izvajati leta 2017, je zasnovan na konceptu PDZ in vključuje izobraževalne delavnice ter spletno platformo za izboljšanje pismenosti o duševnem zdravju, zlasti o motnjah razpoloženja. V raziskavi smo preverjali raven pismenosti o anksioznih motnjah pri udeležencih in udeležencih spletnih oz. terenskih delavnic, ki so bili pred in po izvedbi psihoedukacijskega tematskega sklopa o anksiznosti povabljeni, da izpolnijo vprašalnik pismenosti o anksioznosti.

Rezultati kažejo, da se je povprečna raven pismenosti o aksioznosti po delavnici povečala za 17 % ($p < 0,05$) v primerjavi s predhodno ravnijo pismenosti, kar potrjuje učinkovitost psihoedukacije kot orodja za izboljšanje razumevanja duševnih motenj. Izzivi programa OMRA na področju prizadevanja za zmanjševanje družbenega in ekonomskega bremena duševnih motenj z izboljšanjem dostopa do informacij in s spodbujanjem pravočasnega iskanja strokovne pomoči, ostajajo. Njegov dolgoročni cilj je boljša skrbi za duševno zdravje in zmanjšanju stigme, povezane s težavami v duševnim zdravju.

KLJUČNE BESEDE

Psihoedukacija, pismenost o duševnem zdravju, motnje razpoloženja, anksiozne motnje, program OMRA

ABSTRACT

Mood disorders such as anxiety and depression are very common in today's society and represent a major public health problem. Although they are widespread, they remain poorly recognised and inadequately treated. The concept of mental health literacy (MHL) is crucial to raise public awareness of mental disorders and their treatment and to reduce stigma. The OMRA programme, launched in Slovenia in 2017, is based on the concept of mental health literacy and includes educational workshops and an online platform to improve knowledge about mental health, especially about mental disorders. The study examined the level of knowledge about anxiety disorders among the participants of the online and on-site workshops, who were asked to complete an anxiety literacy questionnaire before and after the psychoeducational topic on anxiety disorders. The results show that the average level of anxiety competence increased by 17% ($p < 0.05$) after the workshop compared to the pre-workshop level, confirming the effectiveness of psychoeducation as a tool to improve understanding of mental disorders. The OMRA programme continues to face challenges in its efforts to reduce the social and economic burden of mental disorders by improving access to information and promoting timely help-seeking. Its long-term goal is to improve mental health care and reduce the

KEY WORDS

Psychoeducation, mental health literacy, mood disorders, anxiety disorders, OMRA programme

1 Uvod

1.1 Motnje razpoloženja - motnje moderne dobe

Duševne motnje so v splošni populaciji zelo pogoste in verjetnost, da bo nekdo obolel za kakšno od njih, je med 40 in 50 % [1]. Med najbolj razširjene duševne motnje uvrščamo motnje razpoloženja, med njimi anksiozne (tesnobne) in depresivne motnje, kar predstavlja tudi resen javnozdravstveni problem tako zaradi trpljenja posameznikov in njihovih družin kakor znatnih stroškov, ki so povezani z njihovim zdravljenjem in posledicami za družbo, kot so absentizem, dolgotrajna bolniška odsotnost, prezgodnja upokojitev [2]. Tako so na primer skupni letni stroški za anksiozne motnje leta 2012 v EU dosegli 74,4 milijarde evrov [3]. Anksiozne motnje so skupina motenj (generalizirana anksiozna motnja, panična motnja, agorafobija, specifične fobije, socialna fobija, obsesivno-kompulzivna motnja) za katere je značilna trajna ali občasna izjemno poudarjena tesnoba, ki posameznika ovira pri funkcioniranju, mu povzroča težave v vsakodnevnem življenju in slabša kakovost življenja. Badelow in Michaelis [4] ocenjujeta, da ima anksiozne motnje v življenju do 33,7 % prebivalstva. Opozarjata tudi na

slabo prepoznavanje anksioznih motenj in posledično slabše zdravljenje oz. njihovo nezdravljenje. Ni dokazov, da bi se razširjenosti anksioznih motenj v zadnjih letih spreminjala. Anksiozne motnje imajo kronični potek, z leti pa se njihova izraženost omili. Zelo pogosto imajo ljudje po več različnih anksioznih motenj hkrati ali imajo različne anksiozne motnje po enkrat ali nekajkrat v življenju. Pogosto pa so anksiozne motnje pridružene drugim duševnim motnjam [5].

1.2 Koncept pismenosti o duševnem zdravju

Kljub temu, da so anksiozne motnje zelo pogoste, so še vedno slabo prepoznane. Če na eni strani raziskave razkrivajo, da obstaja veliko sivo polje neustrezne obravnave oseb, ki poiščejo pomoč pri strokovnih službah zaradi težav v duševnem zdravju, pa ne gre zanemariti dejstva, da je tudi odločitev posameznikov, da poiščejo strokovno pomoč, kompleksen problem, na katerega vpliva vrsta dejavnikov. Pomemben faktor, ki vpliva na odločitev o iskanju pomoči, je prepoznava, torej ali oseba dojema svojo težavo kot duševno motnjo. Izsledki raziskav kažejo, da znaten delež laične javnosti ne prepoznava duševnih motenj [6]. Duševne motnje se pogosto enači s psihosocialnimi pritiski ali stresom, šibkostmi osebe, ne pa z zdravstveno težavo [7][8], kar se odraža pri iskanju strokovne pomoči, zanimanju za zdravljenje in prepričanjih o učinkovitosti zdravljenja [9].

Eden učinkovitejših pristopov ozaveščanja in informiranja prebivalstva o značilnostih in posledicah motenj razpoloženja izhaja iz koncepta pismenosti o duševnem zdravju (angl. Mental Helath Literacy, v nadaljevanju PDZ) [10][11][12]. Koncept PDZ opredeljuje pismenost kot skupek kognitivnih in socialnih veščin posameznika, ki omogočajo vedenje, kako pridobiti in vzdrževati dobro duševno zdravje, razumevanje duševnih motenj in njihovega zdravljenja, zmanjševanje stigme, povezane z duševnimi motnjami, znanje, kdaj in kje poiskati pomoč, razvijanje kompetenc, namenjenih izboljšanju skrbi za duševno zdravje, in sposobnost samopomoči [10]. V novejših študijah smo priča temu, da se koncept PDZ vse bolj usmerja v pismenost o specifičnih duševnih motnjah. V ta namen se tudi hitro razvijajo specifična orodja, s katerimi se ocenjuje poznavanje in razumevanje določenih duševnih motenj, npr. pismenosti o anksioznosti [13], depresiji [14], shizofreniji [15].

1.3 Psihoedukacija in duševno zdravje

Psihoedukacija je posebna oblika izobraževanja, njen osnovni namen je pomagati ljudem s težavami v duševnem zdravju, da si pridobijo širše znanje in vedenje o svoji motnji. Psihoedukacija pomaga, da se pacienti in njihovi svojci naučijo uporabljati različne strategije, ki jim bodo pomagale pri soočenju z duševno boleznijo [16].

Psihoedukacija se je najprej uveljavila v psihiatrični klinični praksi. Z njeno pomočjo se pacientom z duševnimi motnjami in njihovim svojcem na sistematski način podaja informacije o simptomih, etiologiji, predstavi naravo in predviden potek psihične motnje, možnosti zdravljenja in rehabilitacije in dostopnost zdravstvenih in ostalih podpornih vladnih in nevladnih organizacij, informira o delovanju zdravil z njihovimi stranskimi učinki, predstavi pomen drugih vzporednih terapevtskih pristopov ter vlogo družine pri poteku zdravljenja [17]. Psihoedukacija pa se je dobro uveljavila tudi kot oblika preventivno promocijskih aktivnosti na področju skrbi za dobro duševno zdravje, ki so namenjene laičnim javnostim. Poleg tega, da omogoča učinkovito posredovanje informacij, ljudi opolnomoči, omogoča izbiro, ohranja dostojanstvo, zmanjšuje (samo)stigmo, povečuje upanje za izboljšanje ter povečuje skrb za lastno telesno in duševno zdravje [16]. Psihoedukativni pristop se lahko uporabi v različnih modalitetah ko so pisna gradiva, spletne vsebine, skupinske delavnice, lahko pa tudi v obliki individualnega svetovanja. Zadnji izsledki obširne pregledne raziskave [18] razkrivajo, da je psihoedukacija najučinkovitejši ukrep za spodbujanje kognitivnih veščin in pismenosti na področju duševnega zdravja.

2 Namen raziskave

Leta 2017 smo v Sloveniji začeli izvajati nov promocijsko preventivni program na področju duševnega zdravja OMRA (akronim programa Z večjo pismenostjo o duševnem zdravju do obvladovanja motenj razpoloženja) v obliki in vsebini, ki v slovenskem prostoru do takrat še ni bila vzpostavljena [19][20]. Program je bil utemeljen na konceptu PDZ z osrednjim ciljem dvigniti raven pismenosti o motnjah razpoloženja (depresija, anksiozne motnje, bipolarna motnja razpoloženja) v laični javnosti. V ta namen so bila razvita različna orodja in pristopi (www.omra.si). Ena od aktivnosti opismenjevanja, ki se še vedno izvaja, poteka tudi v obliki delavnic o prepoznavanju in rešitvah težav, povezanih s stresom, depresijo, anksioznimi in drugimi duševnimi motnjami, kjer uporabljamo psihoedukacijski pristop. Delavnice izvajamo tako na terenu kakor tudi v spletni obliki.

Namen predstavljene raziskave je bil preveriti raven pismenosti o anksioznosti pri udeleženkah in udeležencih delavnic pred in po njihovem obisku ter ugotoviti ali na raven pismenosti o anksioznosti vplivajo izbrane sociodemografske spremenljivke.

3 Metodološki pristop

3.1 Opis vzorca raziskave

V raziskavo so bili vključeni udeleženci in udeleženke 58 terenskih in 35 spletnih delavnic Stres povzroča stiske, okrepite svoje moči!, ki so se izvajale v obdobju od oktobra 2018 do marca 2024. Od skupno 2152 udeležencev in udeleženk delavnic, jih je bilo v raziskavo vključenih 1384. Iz analize podatkov so bili izključeni tisti, ki so oddali nepopolne oz. neveljavne vprašalnike oz. jih sploh niso izpolnjevali. Podrobnejše sociodemografske značilnosti udeležencev in udeleženk, ki so sodelovali pri preverjanju učinka delavnic na raven pismenosti o anksioznosti, so predstavljene v tabeli 1.

3.2 Pripomočki in postopek pridobivanja podatkov

Udeleženci in udeleženke spletnih oz. terenskih delavnic so bili pred in po izvedbi psihoedukacijskega tematskega sklopa o anksiznosti povabljeni, da izpolnijo vprašalnik pismenosti o anksioznosti. Na terenski delavnici so prejeli natisnjen vprašalnik, medtem ko jim je bila na spletni spletni delavnici bila Prvi sklop vprašanj se je nanašal na osnovne sociodemografske podatke (spol, starost, izobrazba, kraj prebivanja, stan). Trditve,

ki so sledile pa so bile namenjene preverjanju poznavanja značilnosti tesnobnih motenj ter njihovem zdravljenju.

Za namene ocenjevanja pismenost o anksioznosti je bil uporabljen že uveljavljen vprašalnik iz tega področja A-lit (Anxiety Literacy) (Australian National University: National Institute for Mental Health Research [20][21]. Vprašalnik ima dobre psihometrične značilnosti; notranja konsistentnost- α = 0,76; test-retest zanesljivost- r = 0,83, p = 0,003. Vprašalnik je bil za namene uporabe v delavnicah OMRA preveden v slovenščino.

Vprašalnik sestavlja 22 trditev o anksioznosti. Udeleženci in udeleženke so pri vsaki trditvi označili odgovor PRAVILNO, če so menili, da trditev drži, ali NAPAČNO, če so presodili, da navedeno ne drži. V vseh treh vprašalnikih smo uvedli tudi kategorijo odgovora NE VEM, v kolikor o trditvi niso imeli mnenja oz. niso poznali odgovora. S tem pristopom smo se želeli izogniti prisilnemu izbiranju odgovorov in ugibanju v primerih, ko udeleženci in udeleženke ne bi bili prepričani o svojem odgovoru. Pravilni odgovor se je točkoval z eno točko, nepravilni odgovori in odgovori NE VEM pa so šteli nič točk. Najvišji skupni rezultat na vprašalniku je znašal 22 točk, najmanjši pa nič točk.

3.3 Vsebina in potek psihoedukativne delavnice o anksioznosti

Vsebino in potek tematskega sklopa delavnice o anksioznosti smo zasnovali tudi s pomočjo intervjujev in fokusnih skupin, kjer smo s sogovorniki preverjali, o katerih vsebinah bi se želeli izobraževati, in v kakšni obliki naj bi bile podane. Udeležba na delavnicah je bila prostovoljna, prijava pa je potekala na spletni platformi programa ali preko lokalnih deležnikov, pridruženih partnerjev programa OMRA. Vsebinsko je bila delavnica o anksioznosti oblikovana tako, da smo v dvournem izobraževanju naslovili ključne tematike, ki se povezujejo z anksioznimi motnjami. Podrobneje smo osvetlili problematiko stresa, njegove značilnosti in povezanost z motnjami razpoloženja kot njihovem sprožilcu in vzdrževalcu. Zatem so bile predstavljene značilnosti anksioznosti, vzroki in pristopi zdravljenja. Naslovili smo tudi problematiko (samo)stigme in dileme samorazkrivanja v zasebnem in delovnem okolju.

3.4 Statistična obdelava podatkov

Za statistično obdelavo podatkov je bil uporabljen računalniški programski paket IBM SPSS Statistics 22. Preverjanje normalnosti distribucije rezultatov je potekalo s pomočjo Kolmogorov-Smirnovega testa. Za namene preverjanja razlik v ravni pismenosti o anksioznosti pred delavnicami in po njih, za primerjavo učinkov spletnih in terenskih delavnic in za preverjanje učinkov sociodemografskih spremenljivk na raven pismenosti je uporabljen neparametrični Mann-Whitneyjev U-test. V post hoc analizi povezanosti med izbranimi sociodemografskimi spremenljivkami in dosežki na vprašalniku A-lit je bil uporabljen neparametrični Spearmanov koeficient korelacije (ρ).

Tabela 1: Sociodemografske značilnosti udeležencev in udeleženk raziskave (N = 1384).

SPOL (%)	STAROST (leta)	KRAJ BIVANJA (%)	IZOBRAZBA (%)	STATUS (%)
Ženske: 86,6	M=43,4 (SD=11.3)	Mesto: 48,4	Osnovna šola ali manj: 3,5	Študent/dijak: 3,6
Moški: 12,6	M=44,8 (SD=13.2)	Podeželje: 48,7	Krajše izobraževanje: 0,7	Zaposlen: 74,5
			Poklicna šola: 5,0	Nezaposlen: 12,5
			Srednja šola: 18,0	Upokojen: 8,3
			Višja šola: 11,9	
			Fakulteta, visoka šola: 52,4	
			Magisterij ali doktorat znanosti: 8,2	

****M - Aritmetična sredina; SD- Standardna deviacija*

4 Rezultati

4.1 Psihometrične značilnosti vprašalnika pismenosti o anksioznosti

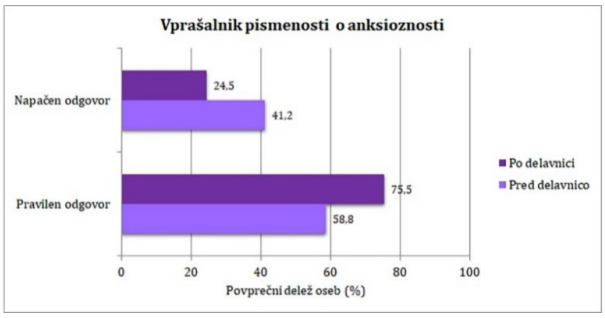
Koeficient notranje konsistentnosti (α) vprašalnika A-lit je znašal 0,77. Ker so podatki vprašalnika statistično pomembno odstopali od normalne porazdelitve (Kolmogorov-Smirnov test; $p < 0,01$), smo v nadaljevanju analize podatkov uporabili neparametrične statistične teste.

Analiza podatkov je pokazala, da je bil delež udeležencev in udeleženk, ki je po delavnicah podal pravilne odgovore na vprašalniku pismenosti primerljiv saj razlike niso bile statistično pomembne (Mann-Whitneyjev U-test: $p < 0,05$) kar kaže na to, da je vsebinski del delavnic ustrezno zastavljen in da so učinki primerljivi, ne glede na modaliteto izvedbe delavnic. Zato smo v nadaljevanju opravili analizo učinkov delavnic na vzorcu udeleženk in udeležencev terenskih in spletnih delavnic skupaj (N =1384).

4.2 Vpliv delavnic na raven pismenosti o anksioznosti

Raven pismenosti o anksioznosti se je pri udeležencih in udeleženkah delavnic ocenjevala s pomočjo vprašalnika A-lit pred izvajanjem psihoedukacije o anksioznosti in po njej. Analiza podatkov je pokazala, da se je povprečna raven pismenosti o aksioznosti pomembno povečala po delavnici v primerjavi z ravnijo pismenosti pred njo ($p < 0,05$). Delež ljudi, ki so imeli boljši rezultat po delavnici se je povečal za 16,75 % (slika 1). Povprečno so imeli ljudje po delavnici 3,7 več odgovorov pravilnih kot pred delavnico. 75,5 % ljudi je imelo boljši rezultat po delavnici; 10,2 % je imelo enak rezultat pred in po delavnici; 10,2 % je imelo enak rezultat pred in po delavnici.

Opravili smo tudi dodatno analizo postavk vprašalnika A-lit (tabela 2), kjer smo preverjali katere postavke so udeleženci in udeleženke delavnic v največjem deležu označili z napačnim odgovorom pred izvedbo delavnic. Delež oseb, ki so po delavnici na istih postavkah podali pravilni odgovor, se je povečal. Najbolj je izstopala postavka Antidepresivi so učinkovit način zdravljenja anksiozne motnje, kjer se je po delavnici povečal delež oseb za 54,8 %, ki je pravilno odgovoril na postavko.



Slika 2: Primerjava povprečnih ravni pismenosti o anksioznosti pred in po psihoedukacijski delavnici.

4.3 Vpliv sociodemografskih spremenljivk na raven pismenosti o anksioznosti

Analiza podatkov je pokazala, da so nekatere sociodemografske pomembno vplivale na raven pismenosti o anksioznosti. Starost se je izkazala kot pomemben dejavnik, ki vpliva na raven pismenosti. Post hoc analiza je pokazala, da je povezava med starostjo in učinkom delavnic negativna (ρ = -0,143, $p < 0.001$). Torej z višjo starostjo se učinek delavnice blago manjša. Tudi raven izobrazbe se je izkazala kot statistično pomemben dejavnik, ki vpliva na raven pismenosti o anksioznih motnjah. Udeleženci s fakultetno izobrazbo so statistično pomembno dosegali boljše rezultate na vprašalniku A-lit v primerjavi s tistimi s končano osnovno ($p = 0,008$), poklicno ($p = 0,011$) ali srednjo šolo ($p = 0,002$) in tistimi z višjo šolo ($p = 0,013$). Status udeležencev in udeleženk psihoedukacijskih delavnic je pomembno vplival na dosežke pismenosti o anksioznosti saj so pokazale statistično pomembne razlike med upokojenimi in ostalimi skupinami. Upokojeni ljudje so izkazali nižjo raven pismenosti v primerjavi z zaposlenimi ($p < 0,001$) in nezaposlenimi ($p < 0,001$) ter višjo v primerjavi s dijaki/študenti($p = 0.009$).

Čeprav so v povprečju ženske dosegale boljši rezultat na vprašalniku po delavnici, razlika med spoloma ni bila statistično pomembna ($p = 0.69$). Tudi kraj prebivališča (mesto/podeželje) ni pomembno vplival na raven pismenosti o anksioznosti ($p = 0,246$) kljub temu, da se izkazoval trend boljših rezultatov pri udeležencih in udeleženkah iz podeželja.

Tabela 2: Predstavitev postavk vprašalnika A-lit, na katere so udeleženci pred psihoedukacijskimi delavnicami najpogosteje odgovorili napačno oz. z možnostjo ne vem.

Postavka na vprašalniku	Delež oseb z napačnim odgovorom PRED delavnico (%)	Delež oseb z napačnim odgovorom PO delavnici (%)
• Ljudje z anksiozno motnjo pogosto govorijo nejasno in nepovezano.	67,6	20,1
• Kuhanje zamere in nesposobnost odpuščanja drugim je lahko znak anksiozne motnje.	63,1	21,6
• Antidepresivi so učinkovit način zdravljenja anksiozne motnje.	66,1	11,3
• Veliko načinov zdravljenja anksiozne motnje je učinkovitejših od antidepresivov.	79,3	36,4
• Akupunktura je enako učinkovita za zdravljenje anksiozne motnje kot kognitivno vedenjska terapija.	71,2	32,2
• Antidepresivi vodijo v zasvojenost.	53,2	17,4

4.4 Omejitve raziskave

Rezultati raziskave so se pokazali skladnost s primerljivimi mednarodnimi raziskavami s tega področja, vendar vseeno velja omeniti nekaj omejitev, ki bi lahko vplivale tudi na naravo izsledkov. Najprej: uporabljeno orodje pismenosti o anksioznosti ni standardizirano za uporabo v slovenskem okolju in zato je pri določenih postavkah lahko prišlo tudi do neenotnega razumevanja njihovih vsebin in posledično pristranskega odgovarjanja udeležencev. Nadalje: vzorec na katerem je bila opravljena raziskava vsebuje določene pristranosti kot je večje število žensk (86,6 %), prevladujočo visokošolsko izobrazbo (52,4 %) in visok delež (74,5 %) sodelujočih, ki je imelo status zaposlenih oseb. Delavnice smo izvajali tako na terenu kot v spletni obliki. Statistična analiza je sicer pokazala, da med njima ne prihaja do statistično pomembnih razlik na ravni pismenosti o anksioznosti. Vendar pa pri udeležencih in udeleženkah spletnih delavnic ne moremo popolnoma izključiti »goljufanja«, kjer bi vprašalnike namesto udeleženca ali udeleženke delavnic izpolnjeval nekdo drug, ali da so osebe bile priključene na spletno delavnico, niso pa sledile njenim vsebinam. Spletno izvajanje delavnic je pokazalo, da so se jih udeleževale predvsem osebe, ki so bile digitalno pismene, z dostopom do spleta in pretežno mlajše od 50 let.

5 Zaključek

Duševne motnje predstavljajo veliko družbeno in ekonomsko breme in po ocenah strokovnjakov bo v prihodnje njihova pojavnost pri odraslih v primerjavi z ostalimi kategorijami bolezni še naraščala, prav tako pa se bodo povečevali tudi stroški, povezani z njihovo obravnavo. Poročilo Health at a Glance: Europe 2018 (OECD/EU, [22] razkriva, da so gospodarski in družbeni stroški duševnih motenj ocenjeni na več kot 4 % BDP ali več kot 600 milijard evrov (ocena za Slovenijo je znašala 1,6 milijarde evrov oz. 4,13 % BDP). Anksiozne motnje se v EU pojavljajo pri približno 34 % populacije, kar jih uvršča med najpogostejše duševne in vedenjske motnje.

Kljub težkemu bremenu duševnih motenj za posameznike, gospodarstvo in družbo, se mu je mogoče izogniti oz. s pravočasno prepoznavo in ukrepanjem, situacijo vsaj omiliti. Številne evropske države imajo že vzpostavljene politike in programe za obravnavo duševnih motenj pri različnih starostih in ciljnih skupinah, vendar je za ohranjanje in spodbujanje duševnega zdravja mogoče storiti še veliko več. Duševne motnje so od vseh kroničnih nenalezljivih bolezni tiste, o katerih imata laična in strokovna javnost najbolj različna stališča in prepričanja. Predsodki in napačne informacije so bolj pravilo kot izjema, kar negativno vpliva tudi na pogostost in načine iskanja pomoči. To izpostavljajo tudi raziskave, ki poudarjajo, da približno polovica ljudi, ki potrebuje zdravljenje zaradi duševnih motenj, ne prejme nikakršne zdravstvene pomoči [23].

V Sloveniji smo v letu 2017 pod okriljem Ministrstva za zdravje začeli izvajati inovativni program OMRA: Z večjo pismenostjo o duševnem zdravju do obvladovanja motenj razpoloženja. Program je zasnovan večdisciplinarno in vključuje aktualne smernice na področju izvajanja promocije duševnega zdravja in opismenjevanja o duševnih motnjah, ki so trenutno najpogostejše – motnje razpoloženja. Cilj programa je povečati dostopnost do različnih informacij, povezanih z zgodnjim prepoznavanjem motenj razpoloženja in razpoložljivih oblikah (samo)pomoči s pomočjo spletne izobraževalne platforme in preko izvajanja psihoedukativnih delavnic. Izvajanje delavnic, ki so zasnovane na konceptih psihoedukacije in pismenosti o

posameznih motnjah razpoloženja (anksioznost, depresija in bipolarna motnja razpoloženja), se je izkazalo za zelo učinkovito obliko dvigovanja obveščenosti o duševnem zdravju, saj se raven pismenosti npr. o anksioznosti poveča pri udeležencih in udeleženkah delavnic v povprečju za okrog 17 %.

Visoka raven pismenosti o duševnem zdravju je tako za družbo kot posameznika ključnega pomena, saj bistveno pripomore k pravočasnemu iskanju ustrezne strokovne pomoči, zniževanju stigme in preventivni naravnanosti populacije [24]. Raziskave poročajo, da je v okoljih z visoko stopnjo pismenosti o duševnem zdravju skrb za dobro duševno zdravje boljša, več je iskanja strokovne pomoči, opažena pa je tudi povečana implementacija učinkovitih preventivno promocijskih strategij, kar na daljši rok zmanjšuje socialno in ekonomsko breme, ki ga povzročajo duševne motnje pri posamezniku in v družbi [10][25][26]. Oblikovalci programa OMRA zato upamo, da bo tudi Slovenija odločneje zakorakala v smeri povečane in pravočasne skrbi za dobro duševno zdravje in da se bo poleg izobraževalne platforme OMRA vzpostavilo še več preventivno promocijskih programov, ki bodo z dokazi podprtimi intervencijami spodbujali višjo raven pismenosti o duševnem zdravju v različnih ciljnih skupinah.

AVTORSTVO

Obe avtorici sta enakovredno prispevali k pripravi članka.

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Kaj lahko postorimo za svojo varnost na osebnem računalniku?

What Can We Do for Our Security on a Personal Computer?

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POVZETEK

Cilj predavanja je udeležence opremiti z znanjem in praktičnimi nasveti za izboljšanje varnosti na njihovih osebnih računalnikih, s čimer bodo zmanjšali tveganje za izgubo podatkov in kibernetske napade. Predavanje se osredotoča na ključne korake, ki jih lahko posamezniki sprejmejo za zaščito svojih podatkov in zasebnosti pri uporabi osebnega računalnika. Predavanje temelji na osebnih izkušnjah. Poudarek bo na naslednjih temah:

Osnove kibernetske varnosti: Razumevanje pomena varnosti na spletu, prepoznavanje potencialnih groženj (npr. virusi, zlonamerna programska oprema, phishing) in kako te grožnje vplivajo na računalnik in osebne podatke.

Posodobitve in varnostne nastavitve: Pomembnost rednega posodabljanja operacijskega sistema in programske opreme, saj posodobitve pogosto vključujejo popravke za varnostne ranljivosti. Pregled osnovnih varnostnih nastavitev, ki jih je treba omogočiti na osebnem računalniku.

Uporaba močnih gesel: Praktični nasveti za ustvarjanje in upravljanje močnih, unikatnih gesel ter uporaba dvofaktorske avtentikacije za dodatno zaščito.

Varna uporaba spleta in aplikacij: Kako prepoznati zlonamerne spletne strani, izogibanje prenosu nepreverjenih programov in pomembnost prenosa programske opreme iz uradnih virov.

Varnostno kopiranje podatkov: Razlogi, zakaj je pomembno redno varnostno kopirati podatke ter različne metode za varnostno kopiranje, kot so oblačne storitve in zunanji trdi diski.

Zaščita pred socialnim inženiringom: Prepoznavanje tehnik socialnega inženiringa, s katerimi kriminalci pridobijo občutljive informacije, in kako se pred njimi zaščititi.

ABSTRACT

The aim of the lecture is to equip participants with knowledge and practical tips for improving security on their personal computers, thereby reducing the risk of data loss and cyberattacks. The lecture focuses on the key steps individuals can take to protect their data and privacy while using a personal computer. It is based on personal experiences. The emphasis will be on the following topics:

Basics of Cybersecurity: Understanding the importance of online security, identifying potential threats (e.g., viruses, malware, phishing), and how these threats affect computers and personal data.

Updates and Security Settings: The importance of regularly updating the operating system and software, as updates often include fixes for security vulnerabilities. A review of the basic security settings that should be enabled on a personal computer.

Using Strong Passwords: Practical advice for creating and managing strong, unique passwords, as well as using two-factor authentication for added protection.

Safe Use of the Internet and Applications: How to identify malicious websites, avoid downloading unverified programs, and the importance of downloading software from official sources.

Data Backup: The reasons why regular data backups are important and various methods for backing up data, such as cloud services and external hard drives.

Protection against Social Engineering: Recognizing social engineering techniques used by criminals to obtain sensitive information and how to protect oneself from them.

Digitalna pismenost v osnovnošolskem izobraževanju

Digital Literacy in Primary Education

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POVZETEK

Prispevek obravnava pomen digitalne pismenosti in veščin v sodobnem izobraževalnem sistemu. V ospredju je potreba po digitalni transformaciji osnovnošolskega izobraževanja, ki vključuje uporabo sodobnih tehnologij in digitalnih virov v učnem procesu. Opisan je pomen izobraževanja učiteljev in učencev o varni in odgovorni rabi digitalnih orodij ter informiranja o kritičnem presojanju digitalnih medijev. Prispevek prav tako obravnava izzive in prednosti digitalne pismenosti, ter opozarja na nevarnosti, kot so zloraba osebnih podatkov in spletno nadlegovanje. Izpostavljen je sistematičen pristop k izobraževanju o digitalni pismenosti, ki presega zgolj tehnične vidike in vključuje širši družbeni in kritični pogled na digitalne medije.

KLJUČNE BESEDE

Digitalna pismenost, digitalne veščine, digitalna medijska pismenost, digitalna bralna pismenost, osnovnošolsko izobraževanje

ABSTRACT

The paper discusses the importance of digital literacy and skills in the modern education system. In the foreground is the need for digital transformation of primary school education, including modern technologies and digital resources in the learning process. The importance of educating teachers and students about the safe and responsible use of digital tools and informing them about the critical assessment of digital media is described. The paper also discusses the challenges and benefits of digital literacy and warns of dangers such as misuse of personal data and online harassment. A systematic approach to digital literacy education is highlighted, which goes beyond mere technical aspects and includes a broader social and critical view of digital media.

KEYWORDS

Digital literacy, digital skills, digital media literacy, digital reading literacy, primary school education

1 UVOD

Tehnološki napredek je na podlagi digitalne preobrazbe tako v javnem kot tudi v zasebnem sektorju omogočil podlago za digitalizacijo izobraževalnih procesov in nadgradnjo izobraževalnega sistema [1].

Ta preobrazba je tesno povezana z razvojem tehnologij, digitalizacijo procesov in virov, ter zahtevo po stalnem posodabljanju na najnovejše tehnološke rešitve [2].

V tem kontekstu so se tudi osnovne šole odločile za digitalno preobrazbo, pri čemer so vključile tehnologije v svoje izobraževalne, administrativne in komunikacijske procese. Različne izobraževalne platforme in elektronske komunikacije, kot so e-pošta in sporočila, so postale nepogrešljiv del vzgojno-izobraževalnega procesa [3].

S tem so učitelji in učenci pridobili dostop do sodobnih tehnologij in digitalnih virov, kar je spodbudilo šole, da prenovijo svoje tradicionalne izobraževalne modele. Vodenje in zagotavljanje digitalne preobrazbe v osnovnošolskem izobraževanju pa zahteva razvoj spretnosti tako učiteljev kot učencev, da lahko učinkovito izkoristijo napredne tehnološke rešitve [4].

2 DIGITALNA PISMENOST, VEŠČINE IN KOMPETENCE

Nastanek in širitev socialnih omrežij v digitalni dobi je privedla do družbenih sprememb, ki imajo velik vpliv na področje osnovnošolskega izobraževanja. Programi za izobraževanje učiteljev se soočajo s izzivom priprave bodočih učiteljev, da lahko kritično interpretirajo digitalne medije. Učitelji morajo biti v tem delu odgovorni in kritični, če želijo iz otrok razviti državljane, ki so dobro obveščeni. Pri tem se v ospredju postavlja dilema, ali so učitelji v skladu z razvojem digitalnih medijev sposobni kritičnega mišljenja [5].

Uporabniki digitalne tehnologije morajo za učinkovito učenje s pomočjo tehnologije že zgodaj pridobiti znanje in veščine. Eden od izzivov je, da morajo uporabniki pridobivati nove in razvijati obstoječe veščine za delovanje in smiselno uporabo tehnologije. Digitalna preobrazba osnovnošolskih učilnic presega zgolj uporabo orodij in programske opreme, vpliva na znanje in veščine njenih uporabnikov, učiteljev in učencev ter didaktiko in procese izobraževalnih ustanov [6].

Primeri uporabe izobraževalne tehnologije se lahko najdejo v digitalnih pedagogikah, tehnoloških modelih ter prilagodljivih, odprtih in pametnih tehnologijah. Vsi deležniki osnovnošolskih izobraževalnih ustanov morajo za učinkovito digitalno učenje skozi prizmo digitalne preobrazbe vseskozi slediti inovacijam na tem področju, predvsem pa morajo biti pozorni in pripravljeni, da sledijo spremembam in implementirajo novosti, ki jih prinaša

digitalna preobrazba osnovnošolskega izobraževanja. Ker se tehnologija nenehno razvija, nove spretnosti ne bodo ostale statične, ampak se bodo nenehno spreminjale [7].

3 DIGITALNA MEDIJSKA PISMENOST

Zagovorniki sodobnega izobraževanja, ki je vse bolj pod vplivom digitalne transformacije, poudarjajo pomen krepitve digitalne pismenosti tako otrok kot tudi učiteljev v osnovnošolskem izobraževanju. Tradicionalne metode se pogosto osredotočajo zgolj na praktično uporabo digitalnih orodij, ne upoštevajo pa njihovega širšega vpliva. Vedno bolj se priznava, da na digitalne tehnologije ne bi smeli gledati le kot na tveganja ali priložnosti, ampak skozi celovito lečo, ki vključuje digitalno pismenost in spletno varnost. Namesto ozke osredotočenosti na digitalne prakse je bistveno razviti kritičen pristop k razumevanju vpliva digitalnih medijev v osnovnošolskem izobraževanju. To vključuje posodobitev obstoječih pedagoških okvirov in strategij za soočanje z novimi izzivi, ki jih prinašata digitalizacija in razvoj družbenih medijev [5].

Razmerje med tehnologijami in produkcijo digitalnih medijev ni novo, vendar postaja bolj zapleteno, saj sedanje in prihajajoče tehnologije preusmerjajo naše medijske prakse stran od množične produkcije k različnim oblikam komunikacije. Obstaja potreba po novi fazi izobraževanja o digitalni medijski pismenosti predvsem v razredih osnovnih šol. Čeprav se številne šole ukvarjajo s konceptom "digitalne tehnologije" v različnih stopnjah, je poudarek predvsem na tehničnih veščinah. To je razumljivo, saj učitelji v osnovnih šolah običajno nimajo formalnega izobraževanja ali usposabljanja na področju digitalne medijske pismenosti [8].

V ospredju je miselnost, da bi morala medijska pismenost otrok presegati zgolj frazo z dobronamernim pomenom, ki zahteva medijsko izobraževanje kot sistematičen program poučevanja in učenja za vse otroke v osnovnih šolah. Vendar to ne izključuje potrebe po regulaciji saj potrebujemo oboje. Digitalno medijsko izobraževanje ni namenjeno zgolj posamezniku, ki se uči spopadati z izzivi povečane rabe IKT gre tudi za zahtevo po spremembah v dojemanju novodobnih medijev [9].

V kontekstu usposabljanj in izobraževanj na področju digitalne pismenosti je potrebno izpostaviti Erasmus+ projekt "Digitalna medijska pismenost" Združenja EPEKA, katerega namen je izboljšanje digitalne medijske pismenosti med otroci in mladostniki. V okviru tega projekta je bila junija leta 2023 izvedena diseminacijska aktivnost, kjer so otrokom in mladostnikom v lokalnem okolju predstavili izsledke projekta in jih opremili z dodatnimi znanji na področju digitalne medijske pismenosti. Cilj te aktivnosti je bil omogočiti pridobitev ključnih kompetenc za odgovorno in kritično uporabo digitalnih medijev. Projekt se osredotoča na deset korakov za spodbujanje digitalne pismenosti med otroci in mladostniki. Ti vključujejo izobraževanje skozi delavnice, seminarje in predavanja, razvoj kritičnega mišljenja, dostop do kakovostnih virov in orodij, spodbujanje kreativnosti ter izmenjavo izkušenj. Poudarjajo tudi varno uporabo digitalnih medijev, aktivno udejstvovanje pri ustvarjanju digitalnih vsebin, razvoj komunikacijskih veščin, sodelovanje s starši in izobraževalnimi ustanovami ter sledenje trendom na področju digitalnih medijev. Namen projekta je naslavljati pomanjkanje digitalne pismenosti med otroci in mladostniki in jih pripraviti na izzive sodobne digitalne družbe ter opolnomočiti za samostojno, odgovorno in kritično uporabo digitalnih medijev [14].

4 DIGITALNA BRALNA PISMENOST

Nasloviti izzive, ki jih prinaša digitalna preobrazba slovenskega sistema osnovnošolskega izobraževanja, omogoča neprekinjen prehod od tradicionalnega k modernemu izobraževalnemu sistemu in s tem izboljšanje digitalne bralne pismenosti.

Tradicionalni sistem osnovnega šolskega izobraževanja, ki ga poznamo danes, se sooča z spremembami in reformami. Povečuje se povpraševanje po novem znanju in večji digitalni bralni pismenosti v modernem izobraževalnem sistemu. V zadnjih letih se je s predstavitvijo digitalnih tehnologij v slovenskih osnovnih šolah znatno povečalo število digitalnih učnih gradiv, ki so na voljo učiteljem in učencem. Hkrati so se pojavili specifični izzivi pri njihovi uporabi, kot so razlike med učitelji, pomanjkanje usposabljanja učiteljev za delo z digitalnimi učnimi gradivi ter pomanjkanje ustrezne opreme in naprav v šolah.

Z zagotavljanjem celovitega zajema okvirja ocenjevanja branja in izvajanjem skupinskega prilagodljivega načrta je nastala raziskava PIRLS 2021, ki predstavlja najobsežnejše in najbolj kompleksno mednarodno ocenjevanje digitalne bralne pismenosti učencev doslej, ki je vključevalo 18 nizov besedil in nalog ePIRLS. PIRLS 2021 je edino mednarodno ocenjevanje izobraževalnih dosežkov, ki je uspešno zbralo podatke med motnjami v šolanju učencev v času epidemije Covid-19. Mednarodna zbirka podatkov PIRLS 2021 zagotavlja izjemno bogat in dragocen vir podatkov za raziskovanje, ki so jih povzročili vplivi Covid-19 na digitalizacijo poučevanja in učenje branja. Raziskava se osredotoča na ocenjevanje bralne pismenosti otrok ob koncu 4. razreda osnovne šole, kar pomeni, da so udeleženci raziskave v povprečju stari približno 10 let. Ta ocenjevanja se izvajajo v rednih petletnih intervalih. Junija 2021 je bilo tako izvedeno merjenje bralne pismenosti na šolah. V sklopu raziskave se zbirajo podatki s pomočjo vprašalnikov, ki jih izpolnijo učenci, učitelji in ravnatelji. S temi vprašalniki se pridobijo informacije o različnih dejavnikih, ki lahko vplivajo na uspešnost pri branju. Rezultati nalog in podatki, pridobljenih iz vprašalnikov, se nato primerjajo in analizirajo. Tako se proučujejo bralni dosežki učencev in povezave med temi dosežki ter različnimi dejavniki, tako med državami kot znotraj Slovenije [11].

Mednarodna raziskava PISA - Raziskava PISA (ang. Programme for International Student Assessment) je globalna raziskava OECD, ki meri kompetence 15-letnikov v matematiki, naravoslovju in bralni pismenosti, vključno z digitalno pismenostjo. Rezultati raziskave PISA v Sloveniji nudijo vpogled v digitalne kompetence slovenskih otrok. PISA V Sloveniji je 75 odstotkov učencev doseglo raven osnovnih bralnih spretnosti (raven 2), kar je za 8 odstotnih točk manj kot leta 2018. Najvišjo stopnjo bralnega znanja in spretnosti (ravni 5 in 6) doseže 4 odstotke slovenskih učencev in 7 članic OECD. Opredelitev bralne pismenosti v raziskavi PISA je opredeljena kot: razumevanje, uporaba, razmišljanje o zapisanem besedilu in angažiranost ob branju besedila, ki bralcu oziroma bralcu

omogoča doseganje zastavljenih ciljev, razvijanje lastnega znanja in spretnosti ter potencialov ter aktivno sodelovanje v družbi [12].

Ob prvem pregledu rezultatov raziskave PISA lahko opazimo, da naši učenci dosegajo nadpovprečne rezultate v primerjavi z vrstniki iz drugih držav OECD, kar kaže na učinkovitost našega izobraževalnega sistema. Vendar, za celovito razumevanje in smiselno interpretacijo teh rezultatov v kontekstu našega nacionalnega osnovnošolskega sistema je potrebno dodatno premisliti o natančnih dejavnikih teh rezultatov [13].

V raziskavi PISA je še posebej pomembno prepoznati vpliv uporabe informacijsko-komunikacijske tehnologije (IKT) na digitalno pismenost otrok v osnovnošolskem izobraževanju. Digitalna pismenost, ki vključuje zmožnost učinkovite uporabe IKT orodij in virov, je ključna za uspešno vključevanje v sodobno družbo in izobraževanje. Vendar pa razlike v dostopu do IKT in raznolikosti učnih priložnosti lahko prispevajo k digitalnemu razkoraku med učenci. Zato je pomembno, da se šole in izobraževalne ustanove osredotočijo na enakopravno dostopnost do IKT orodij ter razvijanje digitalnih veščin pri vseh učencih. [14].

5 UPORABA DIGITALNE TEHNOLOGIJE V UČNEM PROCESU

Za uspešno vključevanje digitalnih tehnologij v osnovnošolski izobraževalni sistem je potrebno, da tako učenci kot učitelji že v zgodnji fazi osvojijo ustrezno znanje in veščine. Primarni namen uporabe digitalne tehnologije pri pouku je izboljšanje kakovosti poučevanja in učenja, hkrati pa postopno razvijamo digitalne spretnosti, koncepte in njihovo uporabo v različnih okoljih. To omogoča uspešno reševanje kompleksnih življenjskih problemov.

Kot primer uporabe digitalnih tehnologij v učnem proces lahko navedemo model SAMR, ki vključuje zamenjavo (S – ang. Substitution), obogatitev (A – ang. Augmentation), spremembo (M – ang. Modification) in redefinicijo (R – ang. Redefinition) in je eden izmed pristopov k vključevanju digitalne tehnologije v učni proces. Ta model predstavlja štiri različne načine, kako vključiti tehnologijo v poučevanje in učenje, pri čemer se ravni razlikujejo glede na učinkovitost uporabe digitalne tehnologije. Na najnižji ravni (zamenjava) digitalna tehnologija nadomesti tradicionalna orodja brez dodane vrednosti. Na primer, učenci namesto pisanja v zvezke tipkajo na računalnike. Naslednja raven (obogatitev) izboljša učinkovitost učnih aktivnosti, kjer digitalni dokumenti omogočajo lažje urejanje in deljenje informacij, kar naredi učne procese bolj učinkovite. Na višji ravni (sprememba) tehnologija spreminja učne aktivnosti in omogoča doseganje bolj kompleksnih in višjih učnih ciljev. Uporaba simulacij in interaktivnih orodij omogoča globlje razumevanje zapletenih konceptov. Najvišja raven (redefinicija) vključuje učne aktivnosti, ki so možne le s pomočjo digitalne tehnologije, kot so globalne kolaboracije med učenci iz različnih držav preko spleta, kar omogoča učenje in izmenjavo idej na načine, ki brez digitalne tehnologije ne bi bili mogoči [15].

Razvoj digitalnih kompetenc pri učencih in dijakih je ključnega pomena za njihovo uspešno vključevanje v sodobno digitalno družbo. Model SAMR ponuja strukturiran pristop k vključevanju tehnologije v učni proces, ki omogoča postopno nadgradnjo učnih aktivnosti in doseganje kompleksnejših učnih ciljev. S tem pristopom lahko digitalno tehnologijo uporabimo ne le kot orodje za zamenjavo tradicionalnih metod poučevanja, temveč kot sredstvo za inovacije in globlje učenje.

6 ZAKLJUČEK

Povečana uporaba digitalnih tehnologij v osnovnih šolah odpira nove priložnosti, vendar prinaša tudi izzive, kot so spletno nadlegovanje, neprimerna spletna komunikacija, izsiljevanje, kraja identitete in širjenje lažnih informacij. Deviantno vedenje učencev pri digitalizaciji izobraževanja se lahko kaže v odvisnosti od digitalnih naprav in iger, kar vpliva na akademski uspeh ter socialne in čustvene vidike. Pomembno je zagotoviti ustrezno infrastrukturo in opremo, da se omogočijo enake možnosti za vse učence, hkrati pa preprečiti, da prevelika odvisnost od tehnologije negativno vpliva na socialne veščine in kompetence otrok. Digitalne tehnologije lahko izboljšajo učni proces, če se z njimi modro ravna. Ključna je tudi ustrezna izobrazba učiteljev in učencev o varni in odgovorni uporabi IKT, da bodo učitelji znali pravilno širiti znanje o teh temah in učenci učinkovito uporabljati pridobljene veščine.

Internetna podjetja, ki omogočajo digitalne socialne platforme pri tem ne morejo biti popolnoma izvzeta odgovornosti za njihovo vsebino, saj objavljajo in distribuirajo medijske vsebine, ne glede na to, kdo jih ustvari. Potrebna je nova regulacija, kot npr. za politične oglase, ki so na televiziji strogo nadzorovani. Podobna pravila morajo veljati tudi za internet. Druga težava je zasebnost, saj ljudje pogosto ne berejo pogojev, preden se strinjajo z njimi, kar omogoča zlorabo njihovih podatkov. Otroci so na to posebej ranljivi saj so na spletu izpostavljeni škodljivim medijskim kampanjam. Pri izvajanju kampanj se morajo podjetja zavzemati za bolj sprejemljiv in uravnotežen pristop pri promociji izdelkov. Monopoli niso koristni za zaščito zasebnosti podatkov, zato bi morala vlada spodbujati konkurenco. Medijska in tehnološka podjetja bi morala plačati več davkov, kar bi lahko financiralo digitalno medijsko izobraževanje v osnovnih šolah in skupnostih.

Za zagotavljanje kakovostnega, varnega in spodbudnega učnega okolja je nujno, da naslovimo ta vprašanja in poiščemo ustrezne odgovore, ki bodo prispevali k izboljšanju digitalne pismenosti in splošnega učnega uspeha otrok v osnovnošolskem izobraževanju.

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Učenje španščine z jezikovno aplikacijo Duolingo

Learning Spanish with the Duolingo Language App

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POVZETEK

Dandanes ima praktično že vsak dijak pametni telefon, na katerega lahko naloži številne aplikacije za učenje jezika in z njimi dopolni klasičen način poučevanja. Glede na upad motivacije dijakov za šolo in učenje na sploh, je modro, da učitelji najdemo še druge načine poučevanja, ki so dijakom bližje. Mobilno učenje dijakom omogoča fleksibilen način samoučenja izven pouka, ki pa lahko postopoma poveča tudi motivacijo za sam pouk. S številnimi vajami, ki so razdeljene na lekcije in spretnosti, jezikovna aplikacija Duolingo uči besedišče in slovnico. Pri tem se ves čas uporabljata tako izvirni kot ciljni jezik. Vaje v aplikaciji vključujejo različne spretnosti, kot so izgovorjava, prevajanje, slušno razumevanje, in vajami (prepoznavanje besede s pomočjo slike, narek, prevajanje iz izvirnega v ciljni jezik in obratno, razvrščanje besed v pravilen besedni red, tematske zgodbe z vprašanji za razumevanje, itd.). V raziskavi smo preverjali, kakšen učinek ima jezikovna aplikacija Duolingo na dijake španščine. Ugotovili smo, da dijaki Duolingo uporabljajo 1-krat na dan (42 %) in s tem vzdržujejo niz zaporednih dni v aplikaciji, da je za veliko večino dijakov (80 %) aplikacija enostavna za uporabo, jim pomaga pri učenju španščine (60 %) in imajo radi učenje z njo (53 %), kar je zelo pozitivno in lahko sklepamo, da gre za učinkovito orodje za samostojno učenje španščine.

KLJUČNE BESEDE

Duolingo, jezikovna aplikacija, samoučenje, španščina, učenje tujih jezikov

ABSTRACT

Nowadays, practically every student has a smartphone, on which they can download many language learning applications and use them to supplement the classical teaching method. Given the decline in students' motivation for school and learning in general, it is wise for teachers to find other ways of teaching that are closer to students. Mobile learning allows students a flexible way of self-learning outside of classes, which can also gradually increase motivation for the class itself. With many exercises divided into lessons and skills, the Duolingo language app teaches vocabulary and grammar. Both the source and target languages are used at all times. The exercises in the application include various skills such as pronunciation, translation, listening comprehension, and exercises (recognizing a word with the help of a picture, dictation, translating from the original to the target language and vice versa, sorting words into the correct word order, thematic stories with comprehension questions, etc.). In the research, we examined the effect of Duolingo on students of Spanish. We found that students use Duolingo 1 time per day (42%) and thus maintain a streak of consecutive days in the app, that the vast majority of students (80%) find the app easy to use, that it helps them learn Spanish (60%) and that they like learning with it (53%), which is very positive and we can conclude that it is an effective tool for independent Spanish learning.

KEYWORDS

Duolingo, language app, learning foreign languages, self-study, Spanish

1 UVOD

Dandanes ima praktično že vsak dijak pametni telefon, na katerega lahko naloži številne aplikacije za učenje jezika in z njimi dopolni klasičen način poučevanja.

Kot pojasni Ramírez Montoya [6], je mobilno jezikovno učenje naslednik e-učenja, ki je kakršnokoli učenje s podporo elektronskih orodij in virov. Mobilno učenje oz. m-učenje dijakom omogoča fleksibilen način samoučenja izven pouka, ki pa lahko postopoma poveča tudi motivacijo za sam pouk. V nadaljevanju se bomo osredotočili na jezikovno aplikacijo Duolingo, do katere lahko dijaki dostopajo z mobilnimi telefoni ali po spletu.

2 PREGLED LITERATURE

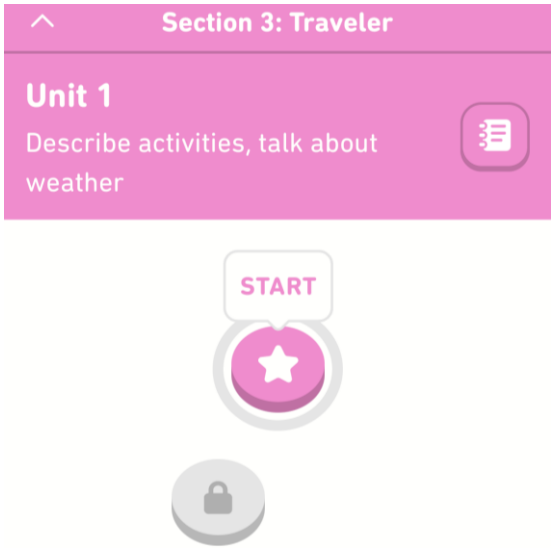
Duolingo je jezikovna aplikacija, ki sta jo novembra 2011 ustvarila Luis Von Ahn in Severin Hacker. Gre za brezplačno aplikacijo, ki ponuja tudi plačljivo nadgradnjo. Slednja uporabniku omogoči neomejeno ponavljanje brez izgubljanja življenj in draguljev, ki so neke vrste valuta v aplikaciji. S številnimi vajami, ki so razdeljene na lekcije in spretnosti, Duolingo uči besedišče in slovnico. Pri tem se ves čas uporabljata tako izvirni kot ciljni jezik. Nabor jezikov in kombinacije izvirnih ter ciljnih jezikov so številne, npr. angleščina in španščina, ruščina in kitajščina itd. Cilj aplikacije je, da uporabniki z vsemi rešenimi vajami in ponovitvami dosežejo nivo B2 v ciljnem jeziku. Ena glavnih značilnosti aplikacije je ponavljanje s pomočjo algoritmov, ki zaznajo, katere besede ali stavke mora uporabnik ponoviti glede na pretekle napake. Vaje v aplikaciji vključujejo različne spretnosti, kot so izgovorjava,

prevajanje, slušno razumevanje, in vajami (prepoznavanje besede s pomočjo slike, narek, prevajanje iz izvirnega v ciljni jezik in obratno, razvrščanje besed v pravilen besedni red, tematske zgodbe z vprašanji za razumevanje, itd.) [5].

Pomembno je tudi izpostaviti, da Duolingo uporabnikom hkrati nudi takojšnjo povratno informacijo po vsaki opravljeni vaji. Po mnenju Garcíe je povratna informacija podana na več načinov: kot pohvala, kot komentar na opravljeno aktivnost, s točkami izkušenj XP in z dragulji [2]. S slednjim Duolingo uporabnike usmerja k samoučenju. Gre za »učenje, pri katerem konceptualizacijo, oblikovanje, vodenje in vrednotenje učnega projekta usmerja uporabnik sam« [1].

Kot razloži Munday, je aplikacija razdeljena na različna področja [5]:

1. Drevo, ki vključuje vsebinska področja z vajami, ki spreminjajo barve, začenši s sivo (ki označuje, da se z vajo še ni začelo), nadaljuje se z različnimi barvami (ki označujejo začetek opravljanja vaje) in konča z zlato (ki označuje, da je uporabnik usvojil vajo in opravil vse ponovitve), kot prikazuje Slika 1. Pri vsakem vsebinskem področju Duolingo nudi tudi kratek pregled slovnice in besedišča. Po vsaki opravljeni vaji je uporabnik nagrajen s točkami izkušenj XP, dragulji in pohvalo s strani aplikacije.

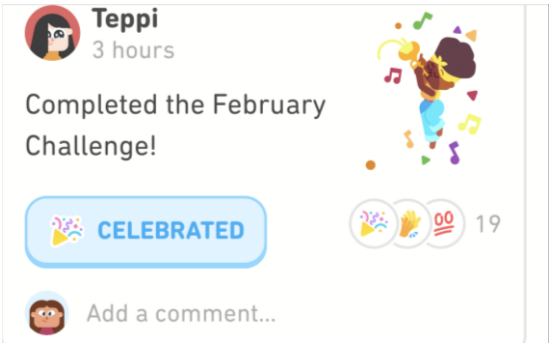


Slika 1: Drevo z vsebinskim področjem aktivnosti in vremena

2. Sodelovanje z drugimi uporabniki je omogočeno na podoben način kot na drugih socialnih omrežjih. Uporabniki lahko sledijo drug drugemu, reagirajo na opravljene dosežke in se na ta način spodbujajo, kot prikazuje Slika 2. V aplikaciji so tudi lestvice najboljših po vsem svetu v različnih ligah, ki v uporabnikih vzbujajo tekmovalnost in željo po zmagi. Uporabniki so nanje uvrščeni po točkah izkušenj XP, ki jih pridobijo z opravljanjem vaj. Vsako nedeljo ob 19. uri po času ZDA se lestvice osvežijo.

3. Dosežki uporabnikov, ki se beležijo sproti in so zanje uporabniki nagrajeni z različnimi značkami, dvojnimi točkami izkušenj XP, možnostjo zamrznitve zaporednega niza dni reševanja vaj ali celo z nekajdnevno brezplačno nadgradnjo aplikacije, ki je sicer plačljiva. Kot dosežki se smatrajo zaporedni niz dni reševanja vaj v aplikaciji, doseženo določeno število točk izkušenj XP, minimalno število napak pri reševanju vaj, dnevni čas reševanja vaj, skupen izziv opravljanja vaj s prijateljem itd.

4. Profil uporabnika, ki vključuje ustvarjen avatar ali poljubno fotografijo, uporabniško ime, datum pridružitve aplikaciji, sledilce in osebe, ki jim sledi, statistiko in dosežke.



Slika 2: Dosežki sledilcev in reakcije

Kot lahko opazimo, je Duolingo zelo moderna jezikovna aplikacija, ki je podobna igri, čeprav je večina vaj zelo tradicionalnih, osnovanih na prevodu, nareku in izgovorjavi [5]. Kot zatrjuje Krashen [4], vaje v Duolingo vključujejo zavestno učenje, ki pa po njegovem mnenju ne vodi do jezikovne kompetentnosti, saj gre za tradicionalni način poučevanja, ki ga je v 60. letih 20. stoletja nadomestila komunikativna metoda. Pomembno se je zavedati, da z aplikacijo ne želimo nadomestiti poučevanja v razredu, temveč ga popestriti in dijake usmeriti k samoučenju. Hall, Graham in Cook [3] celo poudarjajo, da je prevajanje v številnih kontekstih naravno in učinkovito sredstvo učenja jezika, razvija pomembno spretnost, odgovarja učenčevim potrebam in ščiti učenčevo jezikovno ter kulturno identiteto.

Ravno z raziskavo na Srednji ekonomski šoli Ljubljana bomo preverili, kaj dijakom ustreza in kaj ne.

3 REZULTATI

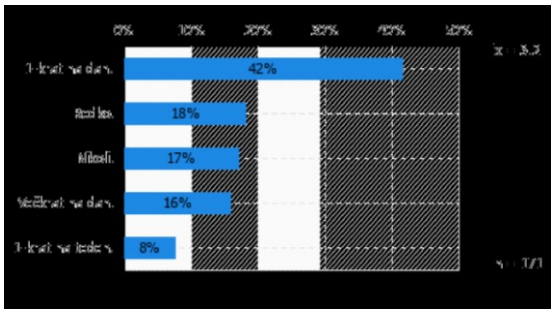
Cilj raziskave je presoditi, ali se lahko jezikovna aplikacija Duolingo uporablja kot učinkovito orodje za samostojno učenje španščine in za dopolnitev pouka španščine. Dijaki lahko aplikacijo uporabljajo kadarkoli in kjerkoli pod pogojem, da imajo dostop do interneta, si sami prilagajajo težavnost glede na vaje, ki jih rešujejo, in utrjujejo že pridobljeno znanje španščine.

Raziskava temelji na deskriptivni in kavzalno-neeksperimentalni metodi empiričnega pedagoškega raziskovanja. Za zbiranje podatkov smo uporabili tehniko anketiranja, kot inštrument pa anketni vprašalnik. Podatke smo pridobili preko spletne ankete 1KA na začetku pouka španščine.

Izhodišče raziskave je vzorec 173 dijakov srednje strokovne šole, in sicer Srednje ekonomske šole Ljubljana. V vzorcu je bilo anketiranih 114 žensk in 59 moških. Povprečna starost je bila 16 let (1. letnik). Prvi del vprašalnika zajema splošna podatka o dijakih: spol in letnik, ki ga na srednji strokovni šoli obiskujejo. Sledijo sklopi vprašanj, ki se nanašajo na namen raziskave. Sklopi so razdeljeni glede na pogostost rabe Duolinga, na motivacijsko plat aplikacije in na rabo aplikacije tudi v prihodnje.

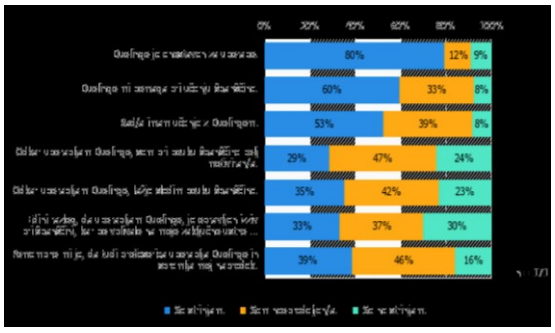
Vprašanja so zaprtega tipa. Anketni vprašalnik obsega 5 vprašanj. Podatki so prikazani grafično tabelarično.

S Slike 3 je razvidno, da dijaki Duolingo uporabljajo 1-krat na dan (42 %) in s tem vzdržujejo niz zaporednih dni v aplikaciji. Nekateri so še bolj motivirani in aplikacijo uporabljajo večkrat na dan (16 %). Drugi aplikacijo uporabljajo le redko ali nikoli (35 %).



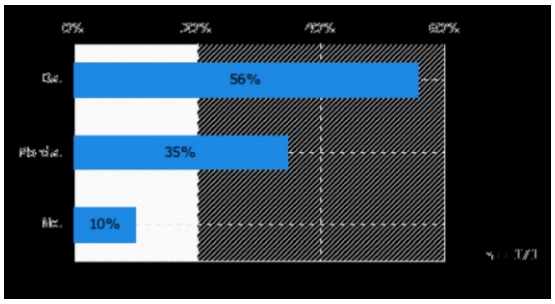
Slika 3: Pogostost uporabe aplikacije Duolingo

Na Sliki 4 so vidni odgovori dijakov na dane trditve o Duolingu. Za veliko večino dijakov (80 %) je aplikacija enostavna za uporabo, jim pomaga pri učenju španščine (60 %) in imajo radi učenje z njo (53 %), kar je zelo pozitivno in lahko sklepamo, da gre za učinkovito orodje za samostojno učenje španščine. Pri bolj specifičnih trditvah so dijaki večinoma neopredeljeni. Odkar uporabljajo aplikacijo, ne vedo, če so bolj motivirani za pouk španščine (47 %) ali če pouku lažje sledijo (42 %). Kljub vsemu 35 % dijakov pa zaradi uporabe Duolinga lažje sledi pouku. Neopredeljeni tudi, ko profesorica spremlja njihov napredek (46 %), čeprav smo menili, da bo to pozitivno vplivalo na njihovo motiviranost in to v 39 % primerih tudi drži. Domnevamo, da so neopredeljeni, ker se počutijo nadzirane in ne dodatno motivirane za učenje španščine. Kar se tiče razloga za uporabo Duolinga, prav tako niso enotni. Nekateri ga uporabljajo le zaradi opravljenega izziva (37 %), kar je eden izmed delov alternativnega ustnega ocenjevanja pri pouku španščine, drugi imajo tudi druge razloge (30 %).



Slika 4: Trditve glede uporabe aplikacije Duolingo

Na Sliki 5 so vidni odgovori dijakov glede uporabe aplikacije Duolingo v bodoče, pri čemer je več kot večina dijakov (56 %) odgovorila pritrdilno in 35 % dijakov z morda, kar ponovno potrdi dejstvo, da je Duolingo lahko učinkovito dopolnilno orodje za pouk tujega jezika in za samostojno učenje.



Slika 5: Vprašanje glede uporabe aplikacije Duolingo v bodoče

4 ZAKLJUČEK

V raziskavi smo preverjali, kakšen učinek ima jezikovna aplikacija Duolingo na dijake španščine. Najprej je Duolingo začela uporabljati profesorica, nato so si aplikacijo pri pouku na svoje mobilne telefone naložili še dijaki. Ugotovili smo, da dijaki Duolingo uporabljajo 1-krat na dan (42 %) in s tem vzdržujejo niz zaporednih dni v aplikaciji, da je za veliko večino dijakov (80 %) aplikacija enostavna za uporabo, jim pomaga pri učenju španščine (60 %) in imajo radi učenje z njo (53 %), kar je zelo pozitivno in lahko sklepamo, da gre za učinkovito orodje za samostojno učenje španščine. Čeprav iz raziskave ni tako zelo razvidno, smo povečano motivacijo dijakov za pouk španščine opazili iz številnih komentarjev na hodniku in pred samim poukom španščine. Bili so predvsem na temo zaporednih dni in novih dosežkov v aplikaciji. Tisti, ki aplikacijo redno uporabljajo, so opazili tudi vključenost profesorice, in sicer, da redno spremlja njihove dosežke z danimi emodžiji v aplikaciji.

Kljub vsemu ima Duolingo tudi določene pomanjkljivosti. Vrsta vaj je omejena, ponavljanje določenih besednih zvez (pre)pogosto, novih besed ter besednih zvez ni veliko in po določenem času lahko uporaba aplikacije postane monotona, dolgočasna. Hkrati lahko postane tudi naporno opravljati vaje vsak dan, da se vzdržuje niz zaporednih dni, vendar je to za dijake izziv, ki jim bo koristil tudi v življenju na sploh, saj se s tem učijo vztrajnosti.

Predlagamo, da učitelji tujih jezikov premislijo, če bi tudi oni aplikacijo uporabili za dodatno motivacijo za pouk tujega jezika in morda tudi kot del ocene v primeru določenega števila zaporednih dni.

ZAHVALA

Zahvalila bi se ravnateljici za podporo in dijakom Srednje ekonomske šole Ljubljana za aktivno uporabo aplikacije Duolingo ter sodelovanje v raziskavi.

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Vloga umetne inteligence pri ustvarjanju zgodb v animiranih filmih: »Vpliv na kognitivne procese in izobraževalni sistem«

Role of Artificial Intelligence in Animated Storytelling: »Impact on Cognitive Processes and the Education System«

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POVZETEK

Pripovedovanje zgodb je od nekdaj ključno orodje za prenos idej, kultur in znanja med ljudmi. S prihodom umetne inteligence (UI) se je način pripovedovanja predvsem pa ustvarjanja zgodb bistveno spremenil, saj so se pojavile inovativne metode za ustvarjanje in doživljanje zgodb. V Dreamfarm studiu v članku »How Artificial Intelligence will change animation forever« [1] raziskujejo, kako lahko z UI izboljšamo scenarije, in sicer z analizo uspešnih vzorcev v prejšnjih produkcijah in spremljanjem povratnih informacij gledalcev. Z uporabo umetne inteligence lahko izboljšate svojo zgodbo s prilagoditvijo vsakega dialoga. Algoritmi lahko izboljšajo pisanje scenarijev za animacijo z analizo vzorcev uspeha v prejšnjih produkcijah in dominantnih povratnih informacij gledalcev. Poleg scenarija se lahko posvetujete z UI, ki vam predlaga ustvarjalne ideje ali prilagodi obstoječe. Seveda pa UI na tem področju še potrebuje veliko dela in človeški ustvarjalec je še vedno zelo pomemben člen v verigi celotnega procesa ustvarjanja animiranih filmov. Cilj tega članka je raziskati in predstaviti, kako UI spreminja področje pripovedovanja ter ustvarjanja zgodb v animaciji, zlasti v kontekstu animiranega filma. Poleg tega bomo preučili, kako dojemanje zgodb vpliva na kognitivne procese dijakov in kako lahko tehnologija, podprta z UI orodji, izboljša proces ustvarjanja in kreiranja novih zgodb ter izboljša učni proces, saj omogoča bolj učinkovito in angažirano učenje dijakov. Naše raziskave temeljijo na prejšnjih ugotovitvah Fritza Heiderja in Marianne Simmelove [2], Davida Eagleman [3] ter različnih sodobnih raziskavah o pomembnosti pripovedovanja zgodb za človeški um avtorjev, kot so Dwayne Harapnuik [4], Rachel Gillett [5] in Rahul Prakash [6]. Temeljno vodilo izvedbe je bilo poiskati ustrezne učne cilje, učne aktivnosti in načine ocenjevanja, v okviru katerih bi lahko vsak dijak ob koncu zaključnega letnika sam ali v skupini izdelal svoj animirani film s poudarkom na sporočilnosti oz. pomenu zgodbe, pri katerem bi si pomagal s sodobnimi orodji, ki podpirajo uporabo UI. Namen prispevka je bil:

- pojasniti, kako dojemanje ljudi vpliva na proces ustvarjanja zgodb, pri čemer se osredotočamo na način, kako ljudje pripisujejo človeške lastnosti in namere neživim objektom na podlagi njihovih gibanj in interakcij;
- Ugotoviti, kako lahko tehnologija, podprta z UI orodji, bistveno izboljša, predvsem pa pohitri, proces ustvarjanja in kreiranja novih zgodb ter izboljša učni proces, saj omogoča bolj učinkovito in motivirano učenje dijakov;
- prikazati, kako formativno spremljanje in sumativno ocenjevanje znanja omogočata celostno izobraževanje, kjer dijaki ne le pridobijo teoretično znanje, temveč tudi razvijajo praktične spretnosti in kompetence;
- predstaviti primer dobre prakse z uporabo različnih orodij za ustvarjanje zgodb in generiranje slik ter kako so uporabljena orodja vplivala na dijakov ustvarjalni proces in učne rezultate.

V prispevku bomo predstavili implementacijo in integracijo UI orodij predvsem za ustvarjanje zgodb (Simpleshow in ChatGPT), UI orodje za izdelavo vizualne pripovedi zgodbe v obliki zgodborisa (Boords) ter UI orodja za generiranje slik (Kitl AI Image Generator in Dalle). Ta orodja so bila vključena v učni proces z namenom izboljšanja ustvarjalnih zmožnosti dijakov in premagovanja omejitev, ki jih postavljajo obstoječa programska orodja. Ustvarjalne zmožnosti znotraj te implementacije, v nasprotju z omejitvami tradicionalnih tehnik in metod poučevanja, omogočajo dijakom, da preizkusijo različne pristope k ustvarjanju zgodb in vizualnemu pripovedovanju zgodbe. S kombinacijo teh orodij in individualnemu pristopu dela v skupinah smo dijakom omogočili bolj dinamično in interaktivno učno okolje. Za formativno spremljanje, samovrednotenje in vrstniško vrednotenje znanja smo uporabili različna orodja (1KA, Padlet in spletne učilnice). Pričakuje se, da bodo zaključki iz tega prispevka vodili k boljšemu razumevanju ustvarjalnega procesa v kontekstu integracije UI orodij v izobraževalni proces. To vključuje povezovanje tehnoloških inovacij in ustvarjalnega dela, kar omogoča dijakom, da razvijejo tako teoretične kot praktične spretnosti pri izdelavi medijskih vsebin, v našem primeru animacije.

KLJUČNE BESEDE

Animirani film, formativno ocenjevanje, kognitivni procesi, pripovedovanje zgodb, umetna inteligenca

ABSTRACT

Storytelling has always been a crucial tool for transmitting ideas, cultures, and knowledge among people. With the rise of artificial intelligence (AI), the way stories are told, and specially created, has fundamentally changed, introducing innovative methods for story creation and experience. The article "How Artificial Intelligence Will Change Animation Forever" by Dreamfarm Studio explores how AI can enhance scripts by analyzing successful patterns in previous productions and tracking viewer feedback. Using AI, you can refine your story by making small adjustments to each dialogue. Algorithms can improve animation scriptwriting by analyzing success patterns in past productions and dominant viewer feedback. Beyond scripting, AI can be consulted to suggest creative ideas or adjust existing ones. However, AI in this field still requires significant development, and the human creator remains a vital part of the entire animation production process.

The goal of this article is to explore and present how AI is transforming the field of storytelling and story creation in animation, particularly within the context of animated films. Additionally, we will examine how the perception of stories impacts the cognitive processes of students and how technology, supported by AI tools, can enhance and accelerate the process of creating new stories, improving the educational process by enabling more efficient and engaged student learning. Our research is based on previous findings by Fritz Heider and Marianne Simmel [2], David Eagleman [3], and various contemporary studies on the importance of storytelling for the human mind by authors such as Dwayne Harapnuik [4], Rachel Gillett [5], and Rahul Prakash [6].

The fundamental guiding principle of the implementation was to identify appropriate learning objectives, activities, and assessment methods through which each student could create their own animated film by the end of their final year, emphasizing the message and meaning of the story, aided by modern tools that support AI use. The purpose of the article was to:

- Explain how human perception influences the storytelling process, focusing on how people attribute human characteristics and intentions to inanimate objects based on their movements and interactions;
- Determine how AI-supported technology can significantly improve and speed up the process of creating new stories, thereby improving the educational process by facilitating more efficient and motivated student learning;
- Demonstrate how formative assessment and summative evaluation of knowledge allow for education, where students not only gain theoretical knowledge but also develop practical skills and competencies;
- Present a case of good practice in using various tools for story creation and image generation, and how these tools influenced the students' creative process and learning outcomes.

In this article, we will present the implementation and integration of AI tools primarily for story creation (Simpleshow and ChatGPT), an AI tool for creating visual storytelling in the form of storyboards (Boords), and AI tools for image generation (Kitl AI Image Generator and Dalle). These tools were integrated into the learning process to improve the students' creative capabilities and overcome the limitations posed by existing software tools. The creative possibilities within this implementation, in contrast to the limitations of traditional techniques and teaching methods, allow students to experiment with different approaches to storytelling and visual storytelling. By combining these tools and an individualized approach to group work, we enabled students to engage in a more dynamic and interactive learning environment. For formative monitoring, self-assessment, and peer assessment of knowledge, we used various tools (1KA, Padlet and online classrooms). The conclusions from this article are expected to lead to a better understanding of the creative process in the context of integrating AI tools into the educational process. This includes connecting technological innovations with creative work, allowing students to develop both theoretical and practical skills in creating media content, specifically in our case, animation.

KEYWORDS

Animated Film, Formative Assessment, Cognitive Processes, Storytelling, Artificial Intelligence

1 UVOD

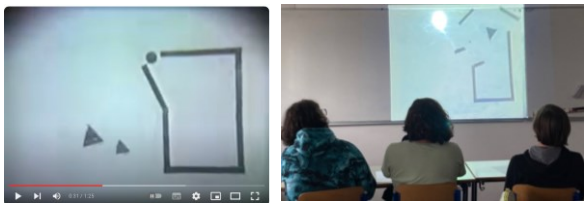
Sodobni izobraževalni sistemi se soočajo z izzivom vključevanja novih tehnologij v pedagoške prakse. UI ponuja obetavne priložnosti za izboljšanje izobraževanja z uporabo animacije. Ta pristop omogoča bolj interaktivne in angažirane učne izkušnje, kar je še posebej pomembno za današnje dijake, ki so navajeni vizualnih in digitalnih vsebin. Poleg tega razvoj orodij s podporo UI omogoča formativno spremljanje znanja, kar učiteljem pomaga pri prilagajanju učnih načrtov in metod poučevanja potrebam posameznih dijakov. V tem prispevku raziskujemo preplet UI in ustvarjanja zgodb v kontekstu medijskih vsebin, predvsem v animiranem filmu. S poudarkom na percepciji dijakov glede drugačnega načina poučevanja, uporabi UI orodij za generiranje slik in strukturiranju zgodb ter formativnem spremljanju znanja želimo prikazati potencial in izzive, ki jih prinaša integracija UI v izobraževanje. Raziskava vključuje analizo anketnih podatkov dijakov, ki so si ogledali video o gibanju geometrijskih oblik in ustvarili zgodbo ter izdelali kratki animirani film z uporabo UI orodij. Poleg tega bomo predstavili orodja, ki nam omogočajo formativno spremljanje znanja, ki je ključnega pomena za prilagajanje učnih procesov in izboljšanje učnih izidov.

2 METODA DELA

Raziskava je vključevala dijake, ki so si ogledali animirani film z geometrijskimi oblikami, ne da bi vedeli, kdo je film naredil ali kaj naj bi pomenil. Po ogledu animiranega filma je 64 dijakov izpolnilo anketni vprašalnik, ki je meril njihove interpretacije in čustvene odzive na gibanje oblik. Anketna vprašanja so bila zasnovana za merjenje percepcije, razumevanja in čustvenega odziva dijakov na animirane vsebine. Poleg ankete so dijaki izdelali tudi končni izdelek, kratki animirani film. Na koncu so izrazili svoje dojemanje, mnenje in razmišljanje s pomočjo zastavljenih vprašanj ter orodjem Padlet, ki nam je omogočal takojšnjo diskusijo in medsebojno interakcijo.

2.1 Kognitivni procesi v socialni percepciji in nagnjenost k sklepanju

Nedavne znanstvene raziskave [7] kažejo, kako zgodbe spreminjajo naš odnos, prepričanja in vedenje. Fritz H. in Marianne S. [2] sta izvedla klasično študijo, ki je preučevala, kako ljudje pripisujejo človeške lastnosti, namere in čustva preprostim geometrijskim oblikam, kot so trikotnika in krog, na podlagi njihovega gibanja in interakcij. S pomočjo animiranega filma, v katerem so trikotniki in krogi komunicirali med seboj skozi gibanje, sta odkrila, da ljudje te oblike pogosto interpretirajo kot namerne akterje, ki sodelujejo v kompleksnih socialnih interakcijah, kot so preganjanje, izogibanje, boj in sodelovanje. Ta raziskava je pokazala, kako močno je človeško nagnjenje k antropomorfizaciji in kako pomembni so kognitivni procesi v socialni percepciji. V povezavi s to študijo smo izvedli raziskavo med dijaki, ki so si ogledali animirani film z geometrijskimi oblikami, ne da bi vedeli, kdo je film naredil ali kaj naj bi pomenil. Raziskavo smo izvedli, ker nas je zanimalo, kako današnje generacije, ob tako močnem vplivu digitalizacije, dojemajo te vsebine. Slika 1 nam prikazuje študijo animiranega filma Fritza H. in Marianne S. [2] ter dijake med gledanjem animiranega filma.



Slika 1: Prikaz študije anim. filma Fritza H. in Marianne S. [2] ter dijake med gledanjem anim. filma.

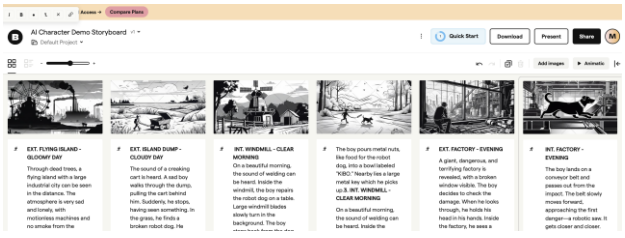
Človeški um deluje kot procesor zgodb in ne kot logični procesor. To pomeni, da so zgodbe ključen način, kako ljudje dojemajo svet, si zapomnijo informacije in komunicirajo med seboj [4]. Zgodbe nam pomagajo ustvarjati smiselne povezave med novimi in starimi izkušnjami, kar je temeljno za proces učenja. V izobraževalnih okoljih je zato priporočljivo uporabljati pristop, ki omogoča avtentične učne priložnosti, kjer imajo učenci izbiro, lastništvo in glas v procesu učenja. Dijaki lahko z uporabo zgodb celo izboljšajo svoje učenje in razumevanje kompleksnih konceptov. Naši možgani hrepenijo po zgodbah, ker nam pomagajo ustvarjati čustvene povezave in bolje razumeti ter si zapomniti informacije [5]. Med branjem zgodb so naši možgani bolj aktivni, saj se aktivirajo enaki deli možganov, kot bi se ob dejanskem doživljanju izkušnje. Zgodbe pomagajo tudi pri izboljšanju spomina in povezanosti s prejeto vsebino, kar je ključnega pomena za učinkovito trženje in komunikacijo. Študija, objavljena na spletnem dnevniku Prakasha, R. [6] poudarja, da je pripovedovanje zgodb ključno pri sprejemanju odločitev. Ljudje uporabljajo zgodbe za oblikovanje in krepitev svojih kognitivnih procesov, saj zgodbe pomagajo pri razumevanju kompleksnih situacij in omogočajo globlje čustvene povezave. Zgodbe so močno orodje, ki vpliva na naše zaznavanje in odločanje, saj nam pomagajo interpretirati svet okoli nas in sprejemati premišljene odločitve. Pri ustvarjanju zgodb je pomembno, da poznamo dejstva, kako naši možgani obdelujejo zvoke in slike, kako zaznavamo resničnost ter kako nezavedni procesi vplivajo na naše odločitve in obnašanje [3]. Predstavitev teh študij dijakom je ključna, ker jim omogoča, da razumejo, kako močno zgodbe vplivajo na naše možgane in zakaj so tako učinkovite pri komuniciranju kompleksnih idej. Pri pisanju in ustvarjanju animiranih filmov lahko dijaki uporabijo te ugotovitve za:

- razvijanje zgodb, ki so čustveno nabite in povezujejo gledalce na globlji ravni, s čimer izboljšajo angažiranost in pomnjenje vsebine;
- uporabo kognitivnih procesov za oblikovanje likov in zgodb, ki odražajo človeške lastnosti in namere, kar omogoča gledalcem, da se povežejo z liki in razumejo njihove motive;
- za učinkovito sporočanje idej in vrednot, kar poveča vpliv animiranega filma na gledalce in spodbuja kritično razmišljanje.

Integracija teh študij v izobraževalni proces omogoča dijakom, da bolje razumejo pomembnost pripovedovanja zgodb in kako lahko uporabijo te tehnike za izboljšanje svojega dela pri ustvarjanju animiranih filmov. S tem se ne le izboljša kakovost njihovih projektov, temveč tudi njihovo splošno razumevanje kognitivnih procesov in sposobnost učinkovitega komuniciranja skozi vizualne in narativne medije.

2.2 Vloga umetne inteligence pri pripovedovanju zgodb v animiranih filmih

Dijaki so za pisanje scenarija sprva uporabili orodje ChatGPT**.** Kljub temu da jim je ChatGPT pomagal oblikovati zgodbo, rezultati niso bili povsem zadovoljivi glede kreativnosti in izvirnosti. Zato so se dijaki odločili, da raje uporabijo svojo avtorsko zgodbo, ki so jo nato dodatno razvili in strukturirali z uporabo UI orodja Simpleshow, ki jim je pomagal organizirati ključne točke zgodbe v koherentno strukturo, vključno z uvodom, zapletom, vrhuncem, razpletom in zaključkom. Ko je bil scenarij dokončan, so dijaki prešli na ustvarjanje zgodborisa. Slika 2 nam prikazuje uporabo UI orodja Boords**,** za risanje zgodborisov. Dijaki so ustvarili okvirne risbe za vsak prizor iz scenarija, pri čemer jim je UI orodje Boords omogočil, da vizualizirajo dogajanje in določijo ključne točke zgodbe. Zgodboris je vključeval pomembne vizualne elemente, kot so postavitev likov, premiki kamere in zaporedje dogodkov.



Slika 2: Izdelana vizualna pripoved zgodbe z uporabo UI orodij.

Animacija je orodje, s katerim animatorji poskušajo popeljati gledalca skozi umetno ustvarjen svet na tak način, da se gledalec vživi vanj. Za prvi prizor so dijaki želeli uporabiti futuristični svet. Z uporabo UI orodja Kitl AI Image Generator so ustvarili realistično in estetsko privlačno sliko, ki ustreza viziji njihove zgodbe. Dijaki so vnesli ključne elemente vpisa v Kitl AI Image Generator, ki je na podlagi teh podatkov zgeneriral več možnih

slik. Dijaki so izbrali najbolj primerne slike, jih uredili v orodjih za urejanje slik, jih združili in uporabili v animaciji. Slika 3 nam prikazuje primer umetno ustvarjenega sveta v tehniki 2D računalniške animacije.

Slika 3: Umetno ustvarjen svet v tehniki 2D računalniške animacije.

Ostale elemente zgodbe so dijaki izrisali in animirali s pomočjo Adobe programskega okolja, ki prav tako vključuje podporo UI. Adobe orodja, kot so Adobe Illustrator, Adobe After Effects in Adobe Photoshop, so jim omogočila, da ustvarijo profesionalno izgledajoče animacije in vizualne učinke. UI funkcionalnosti v teh orodjih so jim pomagale optimizirati delovni proces in izboljšati kakovost končnega izdelka. Slika 4 nam prikazuje posamezne prizore iz končnega animiranega filma Kibo.

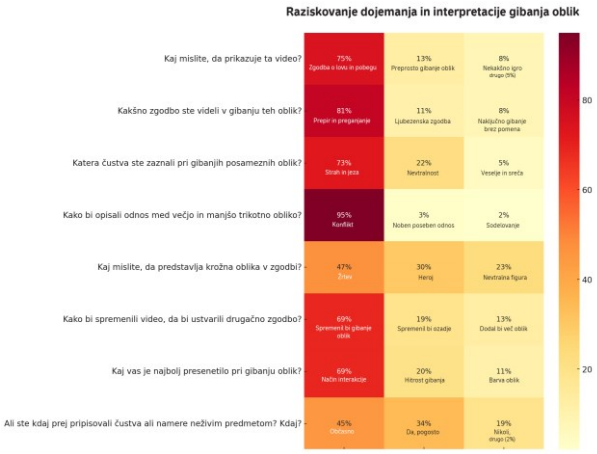
Slika 4: Prikaz posameznega prizora iz končnega animiranega filma Kibo.

2.3 Formativno in sumativno spremljanje in ocenjevanje znanja

Spremljanje, preverjanje in ocenjevanje znanja je zaradi kompleksnosti tisti del izobraževalnega procesa, ki zahteva premišljeno načrtovanje in izvedbo. S stalnim spremljanjem razvoja znanja posameznega učenca zbiramo podatke o vrzeli v znanju zato, da najdemo vzroke za motnje učenja, medtem ko lahko ugotovitve vključimo v naslednjo fazo načrtovanja, učenja in poučevanja. V prispevku bomo predstavili, kako to izvajamo na srednješolskem nivoju pri pouku odprtega kurikula Animacije. Uporabili bomo tako formativno kot tudi sumativni način spremljanja in ocenjevanja znanja.

Formativno ocenjevanje je proces zbiranja podatkov o učenčevem učenju med učnim procesom, da bi učitelji in učenci lahko prepoznali močne in šibke točke ter izboljšali poučevanje in učenje. Glavni namen je zagotoviti sprotne povratne informacije, ki pomagajo pri prilagoditvi poučevanja in učenja [8, 9]. Sumativno ocenjevanje je proces ocenjevanja učenčevega znanja in spretnosti na koncu učnega obdobja ali enote, da bi se ocenila stopnja doseganja učnih ciljev. Glavni namen sumativnega ocenjevanja je ovrednotiti končno znanje in dosežke učencev ter jih primerjati s standardi ali cilji [10].

Rezultati ankete so pokazali, da dijaki še vedno interpretirajo gibanje oblik na podoben način kot v študiji Fritza H. in Marianne S., kar potrjuje trajnost teh kognitivnih procesov. Iz raziskave dojemanja in interpretacije gibanja oblik, kjer je sodelovalo 64 dijakov, so se pokazali zanimivi rezultati. Večina dijakov (75 %) je menila, da video prikazuje zgodbo o lovu in pobegu, medtem ko jih je 13 % videlo preprosto gibanje oblik, 8 % pa je menilo, da gre za nekakšno igro. Pri vprašanju o zgodbi, ki so jo videli v gibanju oblik, jih je 81 % zaznalo prepir in preganjanje, 11 % ljubezensko zgodbo, 8 % pa naključno gibanje brez pomena. Glede čustev, ki so jih zaznali pri gibanjih posameznih oblik, je 73 % dijakov zaznalo strah in jezo, 22 % nevtralnost, 5 % pa veselje in srečo. Kar 95 % dijakov je odnos med večjo in manjšo trikotno obliko opisalo kot konflikt, medtem ko jih je 3 % menilo, da ni nobenega posebnega odnosa, 2 % pa je zaznalo sodelovanje. Krožna oblika v zgodbi je za 47 % dijakov predstavljala žrtev, za 30 % heroja, za 23 % pa nevtralno figuro. Pri vprašanju, kako bi spremenili video za ustvarjanje drugačne zgodbe, bi 69 % dijakov spremenilo gibanje oblik, 19 % bi spremenilo ozadje, 13 % pa bi dodalo več oblik. Najbolj presenetljivo pri gibanju oblik je bilo za 69 % dijakov način interakcije oblik, za 20 % hitrost gibanja, za 11 % pa barva oblik. Glede pripisovanja čustev ali namenov neživim predmetom je 45 % dijakov odgovorilo, da to počnejo občasno, 34 % pogosto, 19 % pa nikoli. Slika 5 nam prikazuje rezultate ankete v obliki toplotne karte. Močnejša kot je rdeča barva, več dijakov je izbralo to trditev. Na sliki se lepo vidi, kako so elementi »dramatičnosti« v gibanju poganjali domišljijo zgodb.



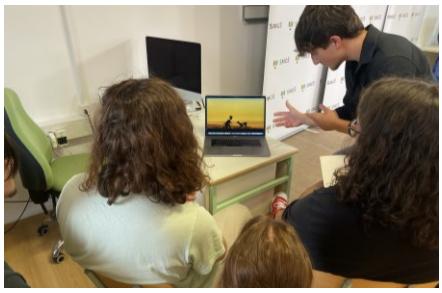
Slika 5: Prikaz rezultata ankete: Raziskovanje dojemanja in interpretacije gibanja oblik.

Ta podobnost med zgodovinsko študijo in našimi rezultati poudarja trajnost in univerzalnost kognitivnih vzorcev v interpretaciji animiranih vsebin. Naše ugotovitve so v skladu s sodobnimi raziskavami o pomembnosti pripovedovanja zgodb za

človeški um [4]. Zgodbe imajo ključno vlogo pri našem dojemanju sveta in pri učenju.

Rachel [5] poudarja, da naši možgani hrepenijo po zgodbah, ker nam pomagajo bolje razumeti in si zapomniti informacije. Poleg tega pripovedovanje zgodb vpliva na naše odločitve in krepi kognitivne procese, kar še dodatno potrjuje pomen naših ugotovitev v izobraževalnem kontekstu.

V kontekstu, kako UI spreminja področje animacije s poudarkom na ustvarjanju zgodb in uporabi UI orodij za generiranje scenarijev, slik in ostalih elementov, učni cilji na formativni ravni obsegajo predvsem razumevanje kognitivnih procesov v socialni percepciji, spoznavanje različnih tehnik animacije, razumevanje razvoja animacije kot umetniške in pripovedne oblike ter razumevanja, kako UI vpliva na proces ustvarjanja animacije. Na formativni ravni se učni cilji osredotočajo na razvoj spretnosti in kompetenc skozi kontinuirano ocenjevanje in povratne informacije. Cilj je pomagati dijakom pri izboljšanju njihovega učenja in prilagajanju učnih pristopov. V kontekstu animiranega filma in uporabe UI v izobraževanju so dijaki aktivno sodelovali pri razvijanju svoje sposobnosti ustvarjanja in pisanja zgodb z vključevanjem vizualne pripovedi zgodbe. Dijaki so razvijali spretnosti ustvarjanja animacij, pri čemer so uporabljali različne tehnike in orodja, ki so podpirala UI. Z uporabo kritične analize in refleksije so se dijaki naučili analizirati in kritično samovrednotiti ter tudi vrstniško vrednotiti animirane vsebine, ki so jih ustvarili sami ali njihovi sošolci. Skozi proces so dijaki reflektirali svoj učni proces in sprejemali ukrepe za izboljšanje svojih spretnosti in znanj. Učitelj je ves čas formativno spremljal napredek posameznega dijaka oz. skupine skozi posamezne procese izdelave (povratne informacije na osnutke nalog, diskusije v razredu, samoevalvacija in vrstniška evalvacija) ter jim posredoval redne povratne informacije, ki so dijakom pomagale razumeti, kaj so naredili dobro in kje so potrebne dopolnitve.



Slika 6: Prikaz diskusije v razredu.

Integracija formativnih učnih ciljev ter sumativnega ocenjevanja v izobraževalnem procesu omogočata celostno izobraževanje, kjer dijaki ne le pridobijo teoretično znanje, temveč tudi razvijajo praktične spretnosti in kompetence. Uporaba UI v tem kontekstu omogoča bolj inovativne in dinamične učne metode, ki spodbujajo kreativnost, kritično mišljenje in aktivno učenje. Formativno ocenjevanje se torej osredotoča na zbiranje sprotnih informacij od dijakov med učnim procesom, medtem ko sumativno ocenjevanje analizira končne rezultate in dosežke dijakov po zaključku učne enote. Postopek ocenjevanja se je začel v fazi sumativnega povzemanja, ko sta dijak in učitelj skupaj ugotovila, da sta dosegla želeni cilj oz. standard znanja glede na predhodno določene kriterije in navodila, zato sta lahko končala proces učenja z vrednotenjem. Dijaki so delali samostojno ali v skupinah in so se samovrednotili ter medvrstniško vrednotili (uporaba orodij Padlet, osebna demonstracija svojih rešitev, kritičnega prijateljevanja, diskusija ...). Preverjanje vmesnih faz izdelave je bilo usmerjeno v to, da dijaki ustrezno pojasnijo, kako rešitve danih izzivov delujejo, ocenjevanje pa se izvaja na podlagi odobritve načeloma ustreznih rešitev. Učitelj je zagotavljal sprotne formativne povratne informacije o tem, kako izboljšati pristope v reševanju izzivov. Projektna naloga je bila predstavljena na zaključnem seminarju z diaprojekcijo. Menimo, da če lahko dijak dokaže dvig učnih dosežkov in kakovost znanja s tem, da izdela kratki animirani film z uporabo UI orodij, ki ima močno sporočilnost in je sposoben samovrednotenja oz. medvrstniškega vrednotenja, je nalogo uspešno opravil. Tak pristop omogoča celostno izobraževanje, kjer dijaki ne le pridobijo teoretično znanje, temveč tudi razvijajo praktične spretnosti in kompetence, kot jih poudarjajo v članku omenjene študije [4, 5, 6].

Slika 7 nam prikazuje uporabo aplikacije Padlet, kjer so dijaki ob zaključku in po predstavitvi projekta podali svoje mnenje. Dijaki so s pomočjo QR kode zajeli vprašanja ter nanje anonimno odgovarjali. Odgovarjali so na pet vprašanj:

1. Kaj že vem o zgradbi zgodbe, pisanju scenarijev, kakšne so moje predstave o izdelavi anim. filma s pomočjo UI?
2. Zakaj so snov, veščine, vrednote zame pomembne? Kako jih bom lahko uporabil/-a pri drugih predmetih, v bodočem poklicu?
3. Koliko časa potrebujemo za izdelavo zgodbe, scenarija in koliko za izdelavo anim. filma?
4. Kako bom dokazal/-a, da sem cilj dosegel/-a?
5. Kaj sem se naučil/-a? Kako učinkovit/-a sem bil/-a?

Slika 7: Prikaz analize po zaključku izdelanega projekta.

Opaziti je bilo, da je uporaba aplikacije Padlet spodbudila učence k bolj kritičnemu in iskrenemu premisleku o zgradbi zgodbe, pisanju scenarijev in predstavi o izdelavi animiranega filma s pomočjo UI. Učenci so bili zmožni anonimno izraziti svoje dojemanje, kar je povečalo stopnjo odprtosti in iskrenosti v povratnih informacijah. Učenci so tudi dobro sprejeli možnost, da svoje mnenje delijo brez pritiska javnega izpostavljanja, kar je izboljšalo kakovost njihovih odgovorov. Kot pozitivno bi izpostavili, da je orodje omogočilo takojšnje razmišljanje in interakcijo, kot izziv pa bi se lahko štelo omejevanje globine razprave zaradi narave kratkih odzivov na platformi. Za prvo

vprašanje lahko podamo, da so dijaki pokazali široko razumevanje zgradbe zgodb, pisanja scenarijev in uporabe UI pri izdelavi animiranih filmov. Navdušeni so nad potencialom UI, ki olajša delo, pospeši procese in generira nove ideje, vendar se zavedajo njene kompleksnosti in omejitev. Razumejo, da mora biti zgodba smiselno zgrajena in kreativna, scenarij pa vključuje opise dogajanja in dialoge, pri čemer UI pomaga avtomatizirati proces, vendar človeški prispevek ostaja ključnega pomena. Menijo, da UI dopolnjuje človeško kreativnost, saj je za končno izdelavo čustveno bogate zgodbe nujno vključevanje človeške perspektive. Pri drugem vprašanju, zakaj so snov, veščine, vrednote za njih pomembne in kako jih bodo lahko uporabili, so dijaki prepoznali pomembnost snovi, veščin in vrednot, saj te prispevajo k njihovemu celovitemu razvoju in uspehu v bodočem poklicu. Znanje, pridobljeno pri tem projektu, jim omogoča nenehno izboljševanje, kritično mišljenje in ustvarjalnost. Poudarjajo, da so pridobljene veščine uporabne pri drugih predmetih ter pri reševanju realnih izzivov v poklicnem življenju, medtem ko vrednote usmerjajo njihove etične odločitve in vedenje. Ugotovili so, da jim umetnost in kreativnost dodajata smisel življenja ter omogočata, da v vsakdanje življenje vnašajo delčke umetnosti. Koliko časa potrebujejo za izdelavo, so dijaki odgovorili, da je čas, potreben za izdelavo zgodbe, scenarija in animiranega filma, odvisen od zapletenosti projekta in kakovosti, ki jo želijo doseči. Pisanje zgodbe lahko traja od nekaj dni do tednov, medtem ko scenarij zahteva več tednov do mesecev. Izdelava animiranega filma je najdaljša faza, ki lahko traja od nekaj mesecev do več let, odvisno od dolžine in zahtevnosti animacije. Glede doseganja cilja so dijaki menili, da ga bodo dosegli, ko bodo zadovoljni s končnim izdelkom animiranega filma. Uspeh bodo merili s ponosom na dosežene rezultate in prepoznavanjem lastnega napredka. Na vprašanje, kaj so se naučili in kako so bili učinkoviti, so odgovorili, da so se naučili celoten proces izdelave animiranega filma, pridobili izkušnje timskega dela, razporeditve nalog in praktičnih tehnik animacije.

3 ZAKLJUČEK

V raziskavi smo preučili vpliv UI na ustvarjanje zgodb v animiranih filmih in njegov pomen za izobraževalni sistem. Ugotovili smo, da lahko uporaba UI orodij, kot so Simpleshow, Boords in Kitl AI Image Generator, bistveno pohitrijo in izboljšajo proces ustvarjanja zgodb in animiranih vsebin, kar omogoča bolj učinkovito in angažirano učenje dijakov. Naša raziskava je pokazala, da so dijaki, ki so sodelovali v procesu, razvili sposobnosti za ustvarjanje kompleksnih in čustveno nabitih zgodb, kar je povečalo njihovo angažiranost in sposobnost pomnjenja vsebine. Analiza rezultatov ankete je potrdila ugotovitve prejšnjih študij Fritza H. in Marianne S. [2], saj so dijaki interpretirali gibanje geometrijskih oblik trikotnikov in krogov kot zgodbe z elementi lova, zasledovanja in konfliktov. Študije Eaglemana [3], Harapnuika [4], Gillett [5] in Prakasha [6] poudarjajo pomembnost pripovedovanja zgodb za človeški um, saj zgodbe pomagajo bolje razumeti, si zapomniti informacije ter vplivajo na sprejemanje odločitev. Integracija formativnih učnih ciljev v izobraževalni proces omogoča celostno izobraževanje, kjer dijaki ne le pridobijo teoretično znanje, temveč tudi razvijajo praktične spretnosti in kompetence. Skozi celoten proces so dijaki prejeli sprotne povratne informacije, ki so jim pomagale izboljšati njihove pristope in rešitve, kar je ključno za uspešno formativno spremljanje in ocenjevanje znanja. Učenje torej postane vidno, ko učitelj pri sebi razjasni namene poučevanja, predvsem pa z učenci razjasni namene učenja. Jasni nameni učenja izboljšajo kakovost učenja in učnih dosežkov učencev. Formativno spremljanje in vrednotenje je pokazalo, da izboljša strategijo učenja in poučevanja, poveča kakovost znanja, predvsem pa vpliva na večjo odgovornost dijakov za lastno učenje in znanje. Sklepamo lahko, da je uporaba UI orodij v izobraževalnem procesu učinkovita metoda za izboljšanje učnih izidov, saj omogoča bolj dinamične in interaktivne učne izkušnje. Tak pristop ne le izboljša kakovost izobraževanja, temveč tudi pripravi dijake na prihodnje izzive v svetu, kjer bo umetna inteligenca igrala vse bolj pomembno vlogo.

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Matematika, logika in Mathematica

Mathematics, Logics and Mathematica

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POVZETEK

Sodobna (matematična) logika izvira iz matematike, v nasprotni smeri pa se še vedno v matematiki uporabljajo oznake, ki niso povsem v skladu z logičnimi pravili. Na primer, nariši graf funkcije f(x), namesto nariši graf funkcije f. Gre za definicije, kjer ni dovolj poudarka na vlogi parametrov v izrazih. Programski jeziki morajo upoštevati logiko, zato prihaja do določenih težav pri razumevanju matematike s strani tistih, ki jim matematika ne leži.

KLJUČNE BESEDE

Definicija, modul, postopek, funkcija, spremenljivka, parameter

ABSTRACT

Modern (mathematical) logic originates from mathematics, but in the opposite direction, notations are still used in mathematics that do not fully conform to logical rules. For example, plot the graph of the function f(x) instead of plot the graph of the function f. These are definitions where there is not enough emphasis on the role of parameters in the expressions. Programming languages must use logic, so there are certain difficulties in understanding mathematics by those who do not like mathematics.

KEYWORDS

Definition, module, procedure, function, variable, parameter

1 Matematika

Matematična praksa je, da se porabi čim manj znakov, zato takile izrazi: $|x|$, x^2, $\sin x$, $n!$, a_n. To nekoliko zamegljuje pravilo definicije. Včasih so bile funkcije (realne spremenljivke x) matematični izrazi, v katerih nastopa samo spremenljivka x. Naloga se je lahko glasila, da narišemo funkcijo $\sin x$ in se ne razlikuje med $\sin x$ (vrednost funkcije pri x) in funkcijo sin. Naloga, dan je polinom $p(x)=x^4+x^3+ax^2+2bx+6$. Za a=0 in b=3 poiščite realne ničle polinoma. Določite a in b tako, da bo polinom p deljiv s $q(x)=x^2+bx+2$ (pri definicijah za p in q parametri niso navedeni in izgleda, da leva stran ni odvisna od parametrov, desna pa je). Splošna kvadratna funkcija je podana z enakostjo $f(x)=ax^2+bx+c$, kjer so a, b in c dana števila in ni a=0. V matematiki se znak '=' bere 'je enako' v logiki pa 'je isto kot'. Tako je eno od maturitetnih vprašanj 'kdaj sta dve množici enaki?' V logiki bi se vprašali 'kako ugotovimo, da gre za isto množico?' Še nekaj primerov definicij. Diferenčni količnik funkcije f v x pri spremembi h = $(f(x+h)-f(x))/h$. Odvod funkcije f v točki x: $f'(x)=\lim_{h\to 0} (f(x+h)-f(x))/h$. Desna stran je odvisna of f in x (to sta prosti spremenljivki), ni pa odvisna od h (vezana spremenljivka). Pozor, definirano je $f'(x)$, ne pa tudi $(f(x))'$. Zadnje je očitno prepuščeno dijakom. Gre za pravilno definicijo. Oznaka za nedoločeni integral je ena od najslabših matematičnih oznak. **Nedoločeni** integral funkcije f je vsaka takšna funkcija F, da je F'=f (to je pravilna definicija). V simbolizmu F ε NI(f) ⇔ F'=f (ε pomeni **je**). (Ne pa F = NI(f) ⇔ F'=f .) Ni pa prav naslednje: $\int 2x dx=x^2+C$ (leva stran je neodvina of C, desna pa je. $\int 2x dx=x^2+C$ bi morali zapisati $\int 2x dx=\{x^2+C; x\in R\}$. Postavlja se vprašanje, ali je naslednje sklepanje pravilno: $\int 2x dx=x^2+1$, $\int 2x dx=x^2$, $x^2+1= x^2$, 0=1. Iz $x^2\in\int 2x dx$ in $x^2+1\in\int 2x dx$ ne moremo sklepati $x^2+1= x^2$. Iz $a\in M$ in $b\in M$ ne sledi a=b; iz a=c in b=c pa sledi a=b. Enostavna rešitev bi bila da definirano pojma nedoločen in nedoločeni integral. **Nedoločen** integral funkcije f je vsaka takšna funkcija F, da je F'=f. **Nedoločeni** integral pa je dogovorjeno izbran nedoločen integral (po izrazu najbolj enostaven). Torej, nedoločen integral funkcije sinx je $\{-\cos x+C; C\in R\}$, nedoločeni integral funkcije $\sin x$ je $-\cos x$ (po dogovoru). Oznako $\int$ bi uporabljali za nedoločeni integral (torej $\int \sin x dx=-\cos x$). Na vprašanje, ali je to edina funkcija, pa je odgovor ne. Vse funkcije $-\cos x+C$ imajo odvod $\sin x$. Pri večini nalog v gimnaziji potrebujemo (Newton-Leibnizovo pravilo) le eno primitivno funkcijo (nedoločen integral). Če potrebujemo vse primitivne funkcije pa dodamo C. Problem nedoločenega intagrala je v tem, da je to inverzna relacija k odvajanju, vendar ni enolična. Podobno je z inverzi trigonometričnih funkcij. Tole je pravilna definicija: $y = \text{arctg}(x) \Leftrightarrow (y\in[-\pi/2, \pi/2] \wedge x = \text{tg}(y))$. Zelo slaba je tudi tale opredelitev: funkcija f:A->B, je predpis, ki vsakemu elementu množice A priredi natanko določen element množice B. Slabost te definicije je izraz 'predpis'. Tu je rešitev teorija množic, kjer je funkcija opredeljena kot enolična relacija, relacija pa je neka množica urejenih parov. Tu lahko definiramo tudi pojem inverzne relacije in pojem omejitve relacije na neko množico.

2 Logika

Matematična logika je logika, v kateri lahko aksiomatsko izpeljemo celotno matematiko. Tu nastopata v bistvu dve možnosti. Prva je teorija množic, to je teorija, ki jo formuliramo v logiki prvega reda z enakostjo (identiteto). Aksiom, da skozi

dve različni točki poteka natanko določena premica, bi v logiki izrazili brez 'različni', saj če imamo dve točki, gotovo nista istovetni. Vsi matematični objekti so množice in je na primer 1=sin slovnično pravilen, a neresničen stavek. Druga možnost je teorija tipov, v kateri so na primer funkcije nekaj drugega kot števila. Tu 1=sin sploh ni stavek (števila spadajo v drug tip kot funkcije). Oglejmo si sedaj pravila definicij v logiki.

Najenostavnejši primer je eksplicitna definicija novega funkcijskega znaka. Na primer tan$x$=sin$x$/cos$x$. Ali pa f(x)=2x+3, ki pa velja le znotraj posamezne naloge. Splošno kvadratno funkcijo lahko uvedemo z definicijo K[a,b,c](x)=ax^2+bx+c. Pravilo je naslednje. Definicija uvaja nov znak 'K', ki mu v oklepaju (ali oklepajih) sledijo vse spremenljivke in parametri (vsak samo enkrat), ki nastopajo prosto na desni strani. Zgornjo nalogo s polinomi bi po naše formulirali takole: dan je polinom (ali dvoparametrična družina polinomov) p[a, b](x)=x^4+x^3+ax^2+2bx+6. Poiščite realne ničle polinoma p[0, 3]. Določite a in b tako, da bo polinom p deljiv s q[b](x)=x^2+bx+2. Oglejmo si še nekaj pravilnih definicij relacij. Identiteta funkcij: f=g $\Leftrightarrow \forall x \in \mathbf{R}(f(x)=g(x))$, a|b $\Leftrightarrow \exists c(b=ac)$ (a deli b). Za relacijo 'večkratnik' nimamo posebnega znaka, lahko pa bi uporabili $|^{-1}$, če smo prej definirali pojem inverzne relacije: $x\mathrm{R}^{-1}y \Leftrightarrow y\mathrm{R}x$.

V matematiki pogosto nastopajo definicije kot so: Lik A je paralelogram $\Leftrightarrow$ A je štirikotnik, ki ima dva para vzporednih stranic. Lik A je deltoid $\Leftrightarrow$ A je štirikotnik, ki ima dva para enakih sosednih stranic. Lik A je trapez $\Leftrightarrow$ A je štirikotnik, ki ima en par vzporednih stranic. To so definicije z navedbo najbližjega roda (genus proximum, v zgornjih primerih je to štirikotnik) in vrste s specifično razliko (differentia specifica). Definicije z ekvivalenco so pogoste v matemtiki. Primeri: L je krožnica $\Leftrightarrow (\exists S \exists r>0)(L=\{A;\ d(A,S)=r\})$, L je krog $\Leftrightarrow (\exists S \exists r>0)(L=\{A;\ d(A,S) \leq r\})$, funkcija f je injektivna funkcija iz A v B $\Leftrightarrow (\forall a,b \in A)(a \neq b \Rightarrow f(a) \neq f(b))$. Pojem praštevila definiramo lahko takole: število n je praštevilo $\Leftrightarrow (\forall m \in N)(m|n \Rightarrow m=1 \vee m=n)$.

3 Wolfram Mathematica

Če bi v definiciji funkcije napisali 'algoritem' na mesto 'predpis', bi bili že pri programiranju. Temu bi lahko rekli tudi konstruktivna matematika. Mathematica je programski sistem (jezik), ki je zelo blizu običajni matematični praksi. Splošno linearno funkcijo dobimo z stavkom L[k_,n_][x_]:=kx+n. Brez tistih črtic pri spremenljivkah, je to običajna definicija. Če bomo vpisali to definicijo, potem pa vnesli L[1,2][3], bo odgovor 5. Zgornja definicija praštevila ni konstruktivna, saj bi lahko začeli preverjati deljivost števil n+1, n+2, … z n. Konstruktivna je definicija P(n) $\Leftrightarrow (\forall m<n+1)(m|n \Rightarrow m=1 \vee m=n)$.

Če hkrati narišemo y=sin(x) in x=sin(y), dobimo fig 1, če narišemo hkrati y=sin(x) in y=arcsin(x) pa fig 2.

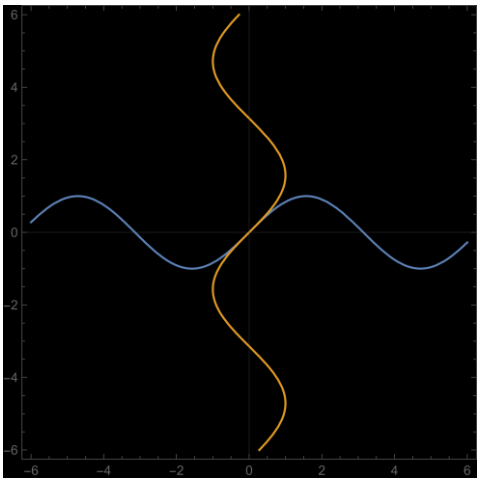

Fig 1: Graf y=sin(x) in x=sin(y)

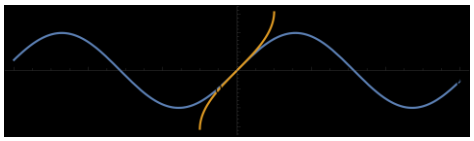

Fig 2: Graf y=sin(x) in y=arcsin(x)

Če zapišemo Integrate[Sin[x],x] bomo dobili -Cos[x] in ne -Cos[x]+C, kar je v skladu s predlogom, da je nedoločeni integral izbran nedoločen integral. Če pa rešujemo diferencialno enačbo y'=sin(x) dobimo Function[{x}, c1-Cos[x]] (beremo: funkcija spremenljivke x, določena z izrazom c1-Cos[x] . Če definiramo f= Function[{x}, c1-Cos[x]] in pišemo f[x], dobimo c1-Cos[x]. Tu je še ostanek tradicionalizma, saj bi pričakovali rešitev diferencialne enačbe v obliki Function[{x, c1}, c1-Cos[x]], torej tudi kot funkcijo parametra. Seveda pa lahko samo definiramo g[x_,C_]:= C-Cos[x].

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Reklama za branje knjig

Promotion of Reading Books

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POVZETEK

Živimo v dobi pospešene digitalizacije in komuniciranja preko mobilnih naprav in družbenih omrežij. Največji izziv v tem času predstavlja za učitelje in skrbnike, kako otroke odvrniti od prekomernega gledanja v ekrane in jih preusmeriti v branje knjig. Že res, da tudi preko spleta veliko beremo, vendar se moramo zavedati, da je to branje samo površinsko in ne daje globokega ter kritičnega razmišljanja o prebranem. Če želimo vzgojiti mladega otroka v kritičnega in samostojnega intelektualca, je potrebno spodbujati interes za branje kakovostne litereature, ki bo bogatila besedni zaklad ter kritično razmišljanje. Sodobna tehnologija nam naj bo v podporo pri delu in učenju, ne pa glavno orodje za zapolnitev prostega časa. V prispevku smo povzeli aktivnost, ki smo jo izvajali v šoli v sklopu knjižnično-informacijskih znanj pri starejših učencih v osnovni šoli in z njo poskušali učence notranje motivirati za branje, jih spomniti, zakaj je branje tako pomembna aktivnost v dobi šolanja, ter hkrati na zabaven način s pomočjo sodobne tehnologije (Actionbound aplikacija) povezati učence v timskem spobudnem učnem okolju.

KLJUČNE BESEDE

Bralna pismenost, promocija branja, aplikacija Actionbound, timsko delo, medpredmetna povezava, spodbudno učno okolje, formativno spremljanje

ABSTRACT

We live in an era of accelerated digitalization and communication via mobile devices and social networks. The biggest challenge at this time for teachers and parents is how to distract children from excessive using of mobile devices and redirecting them to reading books. The truth is that we read a lot online, but this kind of reading is shallow, not deep and without critical reflection on what is read. If we want to raise a young child to be a critical and independent intellectual, it is necessary to encourage interest in reading quality literature that will enrich student's vocabulary and critical thinking. Modern technology should support and not lead our work and study. In the paper we summarized the activity that we carried out at during lesson of library and information skills (KIZ) for older student in primary school and we tried to motivate students to read (more), remind them why reading is such an important activity, especially during primary education and at the same time a fun way to connect students in a team-oriented learning environment with the little help of modern technology (Actionbound application).

KEYWORDS

Reading literacy, promotion of reading, Actionbound application, team work, cross-curricular learning, stumulating learning environment, formative assesment.

1 MOTIVACIJA ZA BRANJE

Prepoznavanje različnih elementov bralne motivacije je prvi korak k razumevanju in spodbujanju zavzetosti za vseživljenjsko branje (Bucik in Pečjak, 2004) [1]. Pri otrocih poznamo različne motivacijske dejavnike za branje, ki jih delimo na zunanje in notranje. Pri zunanjem motivacijskem dejavniku otrok bere zaradi posledic, ki jih branje prinese, na primer pohvala drugih, nagrada, ocena ipd., in ne, ker bi ga to veselilo. Pri notranji motivaciji za branje pa želimo, da otrok dojame branje kot pozitivno aktivnost, ki prinaša užitek, sprostitev in tudi znanje. To motivacijo je pri otrocih najtežje doseči in jo vzdrževati. Zato je pomembno, da v času digitalizacija poudarjamo pomen branja knjig zaradi pozitivnih posledic na otrokov bodoči intelektualni razvoj in izobrazbo. Branje mora biti povezano s pozitivnimi bralnimi izkušnjami in pozitivnimi čustvi. Bucikova in Pečjakova (2004) ugotavljata, da morajo pri bralnih spodbudah sodelovati vsi pedagoški delavci z več branja v šoli, z večjo možnostjo izbire bralnih gradiv, z večjim upoštevanjem bralnih interesov učencev, s sistematičnim razvijanjem bralnih sposobnosti in zavedanjem, da je branje process, ki ga je potrebno spodbujati na različne načine in v vseh obdobjih življenja, zlasti pa v osnovni šoli. Zelo pomembno je redno obiskovanje knjižnic in knjigarn, pogovor o prebranem ter zgled in spobude staršev vse od zgodnjega otroštva dalje.

1.1 ZAKAJ MORAMO BRATI?

To vprašanje si pogosto zastavljajo učenci, ko se učijo črke, povezovati v besede, besede pa v povedi. Prav tako se to sprašujejo učenci zadnje triade osnovne šole. Vsako šolsko leto pripravim učno uro na to temo in z razlinimi oblikami ter aktivnostmi pripeljem na koncu učence do spoznanja, da brez branja ni znanja. Učence sem v skupinah (po 3 ali 4) pozvala, da na plakat s pomočjo možganske nevihte zapišejo čimveč razlogov, zakaj je branje koristno. Njihovi skupni odgovori so bili znani vsem: širjenje besednega zaklada, učenje novih

spoznanj, razvijanje empatije, razvijanje domišljije, izboljšanje spomina, kritično razmišljanje, telovadba za možgane, razgledanost, sprostitev in zabava. Ugotovili so veliko razlogov za branje, a za mnoge učence še vedno ne dovolj za začetek branja knjig.

2 SPODBUDNO UČNO OKOLJE

Številne raziskave kažejo na velik pomen, ki ga ima varno in spodbudno učno okolje na kakovost in uspešnost vzgoje in izobraževanja.

K dobri vključenosti učencev in njihovi učni zavzetosti odločilno prispevajo: zanimiv pouk, ki ga učenci doživljajo kot smiselnega in vrednega zavzemanja, učni proces, v katerega so učinkovito vključeni, dober odnos oz. stik učitelja z učenci in učinkovito vodenje razreda. (Rutar Ilc, 2021) [2].

Spodbudno in varno učno okolje je prav tako ena od smernic na šoli, h kateri stremimo in si zanjo prizadevamo. Učenci so bili tekom dveh ur zelo motivirani za delo, dobili so jasna navodila in spodbude s strani knjižničarke.

3 MEDPREDMETNO POVEZOVANJE

Medpredmetno povezovanje je didaktični pristop, kjer povezujemo vsebine in spretnosti različnih predmetnih področij. Ima veliko pozitivnih učinkov, kot npr. spodbujanje aktivne vloge učencev v učnem procesu, ki pridobivajo trajnejše znanje, uporabo v novih situacijah. Učenci so za delo in učenje bolj motivirani. Učitelji tako prihranimo na času, saj se vsebine v učnih načrtih zelo povezujejo. V učni uri sem povezala slovenščino v 8. razredu (reklama) in KIZ (motiviranje za branje). Učenci so spoznali cilje iz UN za SLJ 3. VIO: tvorijo besedilo določene vrste (oglasno besedilo).

Standardi znanja/pričakovani dosežki:

- tvorijo besedilnovrstno ustrezna, smiselna in razumljiva besedila, skladna z jezikovno in slogovno normo knjižne zvrsti,
- vrednotijo zanimivost, verodostojnost, razumljivost, zgradbeno ustreznost in jezikovno ustreznost in pravilnost besedila, ustreznost nebesednih spremljevalcev govorjenja oz. pisanja ter utemeljijo svoje mnenje in predlagajo izboljšave.

Cilji učne ure KIZ-a v 3. VIO:

Poznajo knjižnico kot prostor predstavljanja ustvarjalnosti.

Berejo različne leposlovne vsebine za osebno rast in razvedrilo.

Motivirajo sošolce za branje knjig. (https://www.gov.si/assets/ministrstva/MVI/Dokumenti/Osnovna-sola/Ucni-nacrti/obvezni/UN_slovenscina.pdf, 20. 8. 2024) [3].

4 APLIKACIJA ACTIONBOUND

Actionbound je aplikacija za igranje digitalno interaktivnih lovov na zbiralce, ki učenca vodijo na pot odkrivanja (slika 1). Uporablja se lahko na pametnih telefonih ali tablicah. Temu večpredstavnostnemu lovu pravimo 'meje'. Program dobesedno širi našo resničnost tako, da izboljša interakcijo ljudi v resničnem življenju med uporabo njihovih pametnih telefonov in tablic. Ustvarite lahko svojo igro pobega, ki temelji na aplikaciji, digitalni časovni trak dogodkov ali ogled zanimivih krajev z uporabo koordinat GPS ter vnaprej postavljenih kod in skrivnosti. Odlično orodje za vaje prebijanja ledu, zgodovinska ali arheološka najdišča, ali preprosto za predstavitev vizije za prihodnost. (povz. po https://en.actionbound.com/, 2. 8. 2024) [4].

Učenci so jo uporabili za snemanje in montiranje kratkih filmčkov kot reklama za branje knjig ter na koncu za medvrstniško evalvacijo.

Slika 1: Aplikacija Actionbound (naslovna stran)

5 FORMATIVNO SPREMLJANJE

S formativnim spremljanjem učitelj omogoča učencem soustvarjanje učnega procesa (namenov učenja, kriterijev uspešnosti, osebnih ciljev, zastavljanje vprašanj, samovrednotenje, vrstniško vrednotenje itd.), kar vodi k aktivnejši vlogi učencev ter h kakovostnemu in trjnejšemu znanju. Učenci vrednotijo svoje delo in so deležni kakovostnih povratnih informacij tako s strani učitelja kot sošolcev z namenom izboljševanja učenja (ugotavljanja v kolikšni meri so dosegli zastavljene cilje ter izboljševanja dosežkov (http://www.zrss.si/strokovne-resitve/formativno-spremljanje-2/, 2. 8. 2024) [5].

Na šoli že več let sledimo načelom formativne pedagogike ter jo vnašamo v svoje pedgoške ure. Elemente formativnega spremljanja pogosto vpeljujem v svojo prakso, saj prinašajo pozitivne učinke na učenje in poučevanje. Tokrat sem uporabila metodo možganske nevihte za iskanje razlogov za branje (namen učenja) ter skupno oblikovanje kriterijev uspešnosti o dobri reklami, načrtovanje aktivnega dela - snemanja filma (scenarij) ter končno medvrstniško evalvacijo posnetih reklam. Prav povratna informacija je bistven element učenja.

S konstruktivno, pozitivno in prilagojeno povratno informacijo podpiramo vsakega učenca na njegovi učni poti ter mu omogočamo razvijanje samozavesti, samostojnosti in notranje motivacije za nadaljnje učenje (www.formativno.si, 5. 8. 2024) [6]. Prav tako uporabna je povratna informacija učencev učitelju, saj dobi učitelj potrditev ali mnenje učencev o učni uri.

6 POTEK UČNE URE

Učence sem na začetku dveh učnih ur naključno razdelila v skupine (po 3 ali 4) in jih pozvala naj zapišejo razloge, zakaj je koristno brati. Sledilo je poročanje vsake skupine in razgovor o slišanem. Skupaj smo ugotavljali, kaj bo namen teh učnih ur. Napovedala sem, da bodo morali posneti reklamo za branje knjig.

Ker je reklama del učne snovi pri slovenščini v 8. razredu, sva z učiteljico slovenščine dorekli, da bomo to snov medpredmetno povezali z uro knjižnične vzgoje. Sledil je pogovor o lastnostih dobre reklame in hkrati skupno oblikovanje kriterijev uspešnosti za njihov izdelek – video reklama za branje knjig. Z učenci smo dorekli, da mora biti reklama privlačna na pogled, imeti mora slogan, po katerem si reklamo zapomnimo, govorci morajo pred kamero govoriti jasno, razločno in glasno, vsebinsko mora vsebovati vsaj tri razloge za branje knjig ter vsaj en interaktivni element (glasbo, napis, zvočni ali video efekt).

Naslednjo učno uro je sledilo načrtovanje snemanja, porazdelitev vlog v skupini, pisanje scenarija ter snemanje po različnih kotičkih šole. Pri snemanju z mobilnimi telefoni so učenci spoznali apliakcijo Actionbound in jo hitro usvojili. Ko so bili zadovoljni s svojim izdelkom, so ga naložili v skupen prostor na aplikaciji. Sledil je zabaven zaključek ure – ogled vseh video reklam (slika 2). Učence sem usmerila na kriterije uspešnosti, ki smo jih predhodno oblikovali, saj so morali podati ustno povratno informacijo pri vsakem video izdelku glede na kriterije. Učenci so se zelo zabavali ob gledanju video reklam in hkrati večkratno obnovili, zakaj je branje res pomembno. Na koncu učne ure so prejeli izstopni listek, na katerem so izrazili, kako so se počutili med urama ter kaj jim je bilo najbolj všeč.

Slika 2: Skupina osmošolcev pri snemanju reklame.

7 ZAKLJUČEK

Učni uri z naslovom Reklama za branje knjig sta dokaz, da lahko učinkovito združimo več metod in oblik dela v skop dveh učnih ur, in sicer: skupinsko delo, formativno pedagogiko, spodbudno učno okolje, medpredmetno povezanost ter IKT orodja. Učenci so bili nad skopom ur navdušeni, saj so v izhodnih listkih, kjer sem želela izvedeti o počutju in pozitivnih vidikih ure, največkrat izjavili, da jim je bila ura všeč, ker so bili aktivni, ker so sodelovali v skupini s pomočjo telefonov in aplikacije, ker so bili motivirani, da izdelajo najboljšo video reklamo za branje knjig. Hkrati smo večkrat spomnili drug drugega na prednosti branja knjig, na katere učenci velikokrat pozabijo. Ker opažam same pozitivne lastnosti in veliko učinkovitost, bom tak način dela in tovrstno aktivnost izvajala vsako šolsko leto.

VIRI

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Uporaba video kamere pri poučevanju športne vzgoje

Using Video Cameras in Teaching Physical Education

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POVZETEK

Informacijsko-komunikacijska tehnologija (IKT) je v današnjem hitro spreminjajočem se svetu postala ključni element vsakdanjega življenja. Prispeva k sodobni družbi in omogoča posameznikom bolj udobno življenje ter olajšuje številne napore. Z razvojem interneta in napredkom IKT se spreminja tudi način učenja in poučevanja v srednjih šolah. Učitelji vse pogosteje integrirajo IKT v pouk, medtem ko dijaki izkoriščajo tehnologijo za svoje učenje. Sodobna tehnologija tako dopolnjuje in izboljšuje izobraževalni proces. Z uporabo IKT lahko učitelji pouk naredijo bolj interaktiven in učinkovit, spodbujajo sodelovanje dijakov ter dodatno povečujejo motivacijo za učenje. V prispevku je predstavljena uporaba video kamere kot pripomočka za poučevanje športnih vsebin pri predmetu športna vzgoja, kar še dodatno obogati in raznoliko popestri izkušnjo dijakov.

KLJUČNE BESEDE

IKT, športna vzgoja, video kamera, video analiza

ABSTRACT

Information and Communication Technology (ICT) has become a key element of everyday life in today's rapidly changing world. It contributes to modern society, enabling individuals to lead more comfortable lives and facilitating numerous efforts. With the development of the internet and advancements in ICT, the way teaching and learning are conducted in secondary schools is also evolving. Teachers increasingly integrate ICT into their lessons, while students utilize technology for their learning. Thus, modern technology complements and enhances the educational process. Through the use of ICT, teachers can make lessons more interactive and effective, promote student collaboration, and further increase motivation for learning. The article explores the use of video cameras as a tool for teaching sports topics in physical education, enriching and diversifying students' learning experiences.

KEYWORDS

ICT, Phyisical Education, video camera, video analysis

1 UVOD

V učnem načrtu predmeta športne vzgoje je le-ta opredeljena kot »nenehen proces bogatenja znanja, razvijanja sposobnosti in lastnosti ter pomembno sredstvo za oblikovanje osebnosti in odnosov med posamezniki«. Med športno vzgojo poučujemo otroke o pomenu vključevanja športnih aktivnosti v njihovo vsakdanje življenje, kar je ključno za ohranjanje zdravega življenjskega sloga. S tem jim omogočamo, da skrbijo za svoje dobro počutje, zdravje, vitalnost ter ohranjajo pozitiven pogled na življenje [1].

Svetovna zdravstvena organizacija – World Health Organization (WHO) opredeljuje gibalno aktivnost kot vsakršno gibanje telesa, ki ga povzročajo skeletne mišice in ki za to zahteva porabo energije. Gibalna neaktivnost (pomanjkanje gibalne dejavnosti) je četrti vodilni dejavnik tveganja za svetovno umrljivost – 6 % smrtnih žrtev na svetovni ravni [2]. WHO že nekaj let opozarja na zaskrbljujoče razmere, saj večina mladostnikov med 11. in 17. letom starosti premalo telovadi in preveč časa preživi z zasloni mobilnih telefonov. To stanje predstavlja resno tveganje za njihovo zdravje, pa tudi za razvoj možganov in socialnih veščin, opozarjajo strokovnjaki WHO. WHO priporoča, da bi se otroci vsaj eno uro na dan gibali, vendar je neaktivnost med dekleti še posebej pogosta.

Podobne težave se pojavljajo tudi v Sloveniji. Leta 2016 je bilo kar 80 odstotkov mladostnikov premalo telesno aktivnih, kar je le za drobec manj kot leta 2001. Športna vzgoja se izkaže kot eden od ključnih učnih predmetov, saj je gibanje uporabljeno kot sredstvo za pridobivanje znanja. Tudi tisti učenci, ki imajo sicer težave pri učenju akademskih vsebin, lahko izkažejo izjemne sposobnosti v športni vzgoji. A športna vzgoja ni le gibanje, zabava in sprostitev; je predmet, ki sledi določenim ciljem v razvoju gibalnih sposobnosti in pridobivanju znanja o pravilni izvedbi gibov [3].

Po Škofu (2010) je prav skrb za razvoj telesne pripravljenosti/zmogljivosti in zdravja mladih oziroma vzgoja za zdrav življenjski slog otrok in mladine osrednji cilj športne vzgoje v današnjem času. [4].

Športni način življenja ni le niz vrednot; je celoten sistem prepričanj, ki se razvijajo skozi naše življenje in postanejo naš edinstven osebni pristop k življenju. Postopoma oblikujemo svoje življenjske vzorce, ki izražajo naše individualne potrebe in izhajajo iz našega notranjega jaza. Ta notranja usmerjenost nas vodi k vzpostavitvi discipline in nam daje univerzalno

življenjsko energijo, ki odpira nova obzorja in dimenzije našega bivanja [5].

2 KAJ JE INFROMACIJSKO-KOMUNIKACIJSKA TEHNOLOGIJA (IKT)?

Informacijska-komunikacijska tehnologija (IKT) je skupen izraz različnih računalniških, informacijskih in komunikacijskih naprav, ki so postale naš vsakdanji spremljevalec [6].

Novljan IKT opredeljuje kot informacijsko pismenost, katero dosegamo z določenimi komunikacijskimi mediji (računalniški programi, medmrežje, videoposnetki in njihove analize itd.). Opredeljuje jo kot sposobnost opredelitve informacijske potrebe, pridobivanja, vrednotenja in uporabe informacij iz različnih virov [7].

Informacijsko-komunikacijske tehnologije (IKT) so širok pojem, nadpomenka, ki vključuje vse vrste komunikacijskih naprav ali aplikacij. Zajemajo radio, televizijo, mobilno telefonijo, računalnik, medmrežje, programsko in strojno opremo, satelitske sisteme, pomnilniške enote in mnogo drugih sodobnih tehnologij. Omenjene tehnologije nudijo številne storitve, med njimi so videokonference in učenje na daljavo. Tudi te storitve opredeljujemo kot IKT. Na področju izobraževanja nam IKT nudi podporo pri učenju in poučevanju, predstavlja pa tudi razvoj poučevanja in okolja, v katerem poučujemo ali se učimo [8].

Neke enotne definicije, ki bi opredeljevala IKT ni. V literaturi je mogoče zaslediti več različnih opredelitev IKT.

2.1 IKT V IZOBRAŽEVANJU

Danes si je težko predstavljati izobraževanje brez uporabe tehnologije. Informacijsko-komunikacijska tehnologija (IKT) se vse bolj uveljavlja v vseh vidikih šolskega delovanja, kar vpliva ne le na izobraževalni proces, ampak tudi na splošno delovanje in razvoj šole kot celote.

Lahko ga uporabljamo kot sredstvo za poučevanje v različnih predmetih ali pa kot osrednji predmet, ki se ga učijo ločeno. [9]. Začetek vključevanja IKT v izobraževanje se je prvič pojavil v prvi polovici sedemdesetih let prejšnjega stoletja, ko so šole po svetu začele v poučevanje vključevati računalniško tehnologijo. V nekaj letih so bile šole že sposobne povezati računalnike v mreže, nato pa so v devetdesetih letih združile tako informacijsko kot komunikacijsko tehnologijo, ki je tako postala stalni izobraževalni dejavnik v mnogih državah [10].

Nove tehnologije podpirajo izobraževanje, ga nadgrajujejo in naredijo bolj fleksibilnega. Omogočajo učinkovitejšo komunikacijo učitelja z učenci, ki pred uporabo IKT ni bila mogoča [11].

S pomočjo IKT lahko učitelji učinkoviteje pripravijo, načrtujejo in izvajajo pouk, pri čemer enostavno posredujejo tako praktične kot teoretične vsebine. S tem omogočajo dostop do ustreznejših informacij tako sebi kot tudi učencem.

Cilji uvajanja sodobne IKT v izobraževanje se lahko razdelijo v tri sklope:

- pridobivanje določenih znanj in spretnosti vezanih na sodobne tehnološke procese pri poznejšem vključevanju v delo;
- zagotavljanje ključnih informacij o IKT, njenem delovanju in posledicah vsem učencem;
- izboljšanje pogoje učenja in poučevanja [12].

Uvedba IKT v pouk ima naslednje pomembne vplive na izobraževanje:

- razvijanje spretnosti učencev, ki so potrebne za življenje in delo v 21. stoletju;
- učitelje spodbuja k spremembi načina učenja v razredu z interaktivnimi in dinamičnimi viri;
- za učence zagotavlja bogatejšo izkušnjo učenja in več motivacije [10].

2.2 UPORABA IKT PRI PREDMETU ŠPORTNA VZGOJA

Učenje in poučevanje s pomočjo IKT, svetovnega spleta in virtualnih okolij, je vsekakor tudi pri pouku športne vzgoje dobrodošlo in potrebno, saj ponuja številne priložnosti za kvalitetnejše usvajanje zastavljenih ciljev ter doseganje čim boljših rezultatov učenja. Uporaba IKT nadgradi in bogati klasično poučevanje in naj ne bo predmet učenja ali orodje za učenje, temveč medij, ki pomaga pri pridobivanju znanja. Največkrat se pri športni vzgoji uporablja video kamera ali fotoaparat, razna CD in DVD gradiva, svetovni splet, merilnike srčnega utripa, štoparice in prenosni računalnik [13].

Jurak s sodelavci (2007), navaja več primerov možnosti uporabe IKT pri pouku športne vzgoje:

- pri načrtovanju športno-vzgojnega procesa,
- pri spremljanju in vrednotenju telesnih značilnosti in gibalnih sposobnosti učencev,
- pri vzdržljivostni vadbi,
- pri posredovanju, utrjevanju in ovrednotenju gibalnih znanj,
- pri posredovanju, utrjevanju in ovrednotenju športnih teoretičnih znanj,
- pri objavi dosežkov učencev na šolskih športnih tekmovanjih, obvestilih učencem in staršem,
- pri posredovanju informacij učencem in staršem [7].

Z izkoriščanjem aktivnih učnih metod in vseh potencialov, ki jih ponuja IKT tehnologija, učitelji spodbujajo učence in dijake k sodelovanju v športnih dejavnostih tako v šoli kot v vsakdanjem življenju. Pri tem upoštevajo posameznikove sposobnosti ter razpoložljivost, primernost in dostopnost opreme.

2.2.1 ATLETIKA

Atletiko uvrščamo v skupino monostrukturnih športov, za katere je značilna standardna struktura cikličnega ali acikličnega gibanja, pri čemer je osnovni cilj premagovanje prostora z lastnim telesom ali predmetom, ki ga mečemo. Sestavljajo jo številne atletske discipline, ki jih delimo v tri osnovne skupine: teki, skoki, meti [14].

Atletika kot ena izmed temeljnih športnih panog, ki vpliva na celovit otrokov razvoj, je sestavni del tako šolske športne vzgoje kot interesnih dejavnosti, ki se odvijajo v prostem času v organiziranih združenjih, kot so športna društva in klubi.

2.2.2 UČENJE POSKOKOV ATLETSKE ABECEDE S POMOČJO VIDEO POSNETKA

Pri poučevanju poskokov atletske abecede (nizki skiping, visoki skiping, hopsanje, striženje …) si lahko pomagamo z video kamero. Posnetek je zajemal:

- posnetek demonstracije pravilne izvedbe/gibanja in

- opis pravilne končne izvedbe posameznega poskoka s poudarkom na najpomembnejših delih gibalne naloge (slikovna in zvočna ponazoritev).

Slika 1: Postavitev in gibanje rok pri visokem skipingu

Slika 2: Postavitev zamašne noge in dela stopal pri hopsanju

Slika 3: Prikaz dela pete pri »zametavanju«

Nekateri profesorji športne vzgoje so pripravili video posnetke gibalnih nalog nekaterih športnih panog (atletika, gimnastika …) (Slika 1, 2 in 3). Vso gradivo je bilo objavljeno v razrednih skupinah MS Teams, do katerih imajo dostop tudi dijaki. Na ta način smo vsem omogočili, da so se lahko naučili ali ponovili oz. utrdili posamezne gibalne naloge tudi v času, ko niso imeli pouka športne vzgoje (npr. priprava na ocenjevanje, učenje v primeru različnih izostankov ipd.). To pa je bil tudi glavni namen priprave teh posnetkov.

3 ZAKLJUČEK

V športni vzgoji lahko integracija IKT prinese številne koristi tako učiteljem kot dijakom. Kljub temu pa je ključno, da jo uporabljamo premišljeno, ne prekomerno, ter le takrat, ko je to smiselno. IKT ne sme nadomestiti praktičnega dela pouka, temveč naj ga dopolnjuje. Namenjena naj bo predvsem kot pomoč učiteljem pri pripravah in izvedbi pouka ter kot orodje, ki izboljšuje učne rezultate, kadar je to primerno.

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Učenje preko ustvarjanja: uporaba IKT v projektu Knjiga podajanka

Learning through Creation: Using ICT in the Pass the Story – the collaborative book Project

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POVZETEK

Sodoben pouk zahteva nove pristope in uporabo modernih tehnologij. Čeprav se morda področje slovenščine kot maternega jezika zdi tradicionalno, je možnosti uporabe IKT veliko in od učitelja je odvisno, kaj in kdaj ter kako bo tehnologijo pri pouku uporabil.

Ena od možnosti je tudi ustvarjanje skupne knjige podajanke – projekt za devetošolce. Cilj je napisati svojo knjigo. Dogovorijo se o žanru, ustvarijo književne osebe, določijo dogajalni kraj in čas. Vsak učenec napiše svoje poglavje knjige, ga ilustrira in sodeluje pri nastajanju skupnega izdelka. V veliko pomoč nam je sodobna IKT, saj tekom projekta uporabljamo spletne učilnice, kjer uporabniki oddajajo vse, kar je nastalo v povezavi s knjigo – ilustracije, poglavja, mnenja, popravke. Delo preko spletnih učilnic ustvarjanje zelo olajša, saj so vse informacije zbrane na enem mestu in dostopne vsem v skupini, kadarkoli jih potrebujejo.

S to metodo dela na drugačen, sodobnejši način sledimo mnogim ciljem v učnem načrtu in jih tudi dosežemo. Dosežemo pa tudi druge cilje, ki niso povezani le s slovenščino, ampak življenjem – veščine sodelovanja, pomoči, podpore, znajdenja, povezanosti, odkrivanja in razvijanja raznovrstnih talentov ter povezovanja različnih znanj.

KLJUČNE BESEDE

Spletne učilnice, IKT, slovenščina, knjiga podajanka

ABSTRACT

Modern education requires new approaches and the use of modern technologies. Although the field of Slovene as a mother tongue may seem traditional, there are many possibilities for using ICT, and it depends on the teacher what, when, and how technology will be used in teaching.

One option is also creating a collaborative book – Pass the Story, a project for ninth graders. The goal is to write their own book. They agree on the genre, create literary characters, determine the setting and time. Each student writes their own chapter of the book, illustrates it, and participates in creating a common product. Modern ICT is very helpful to us because during the project we use online classrooms where they submit everything created in connection with the book – illustrations, chapters, opinions, corrections. Working through online classrooms makes creation much easier, as all information is collected in one place and accessible to everyone in the group whenever they need it.

By following this method of work in a different, more modern way, we achieve many goals outlined in the curriculum. Additionally, we also achieve other objectives that extend beyond Slovene language skills and contribute to life skills – such as cooperation, assistance, support, problem-solving, discovery, and the development of diverse talents by integrating various knowledge domains.

KEYWORDS

Online classrooms, ICT, Slovene, pass the Story – the collaborative book project

1 UVOD

S sodelovanjem v današnjem tehnološko podprtem in informacijsko bogatem okolju državljani sooblikujemo digitalno okolje, ki je ključno za demokratične procese in prakse ter v katerem je mogoč medkulturni dialog. Digitalizacija tako skoraj ni več izbira, temveč je pričakovanje, ki postaja nujnost. [1] Digitalna kompetenca sodi med ključne kompetence v hitro spreminjajoči se družbi. [2] Zato je povsem logično, da se je tudi sistem vzgoje in izobraževanja z razvojem informacijsko-komunikacijske tehnologije (IKT) začel spreminjati. Ne le sistem, tudi učenci zahtevajo nove pristope in sodobne metode ter aktivno vlogo v procesu učenja.

Pouk slovenščine v duhu sodobnega pouka in priporočil Zavoda RS za šolstvo poteka tudi v spletni učilnici, ki je opremljena z e-didaktičnimi gradivi in pripomočki ter orodji, ki omogočajo iskanje podatkov in informacij, dostop do brezplačnih učnih gradiv, avtorskih programov, spletnih slovarjev, komuniciranje z uporabo internetnih storitev, sodelovanje v mrežnih projektih, forumih in različnih spletiščih za učenje slovenskega jezika kot materinščine. [3]

Učni načrti in katalogi znanj ne zapišejo, kdaj in v kolikšni meri naj učitelji in učenci pri pouku uporabljajo digitalno tehnologijo, zato lahko učitelj sam izbira, kako jo bo vključil v

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pouk glede na interese učencev, znanje, ki ga ima o uporabi tehnologije in glede na tehnologijo, ki jo ima na voljo on in njegovi učenci. Z uvajanjem novih oblik in načinov dela z uporabo sodobne informacijsko-komunikacijske tehnologije učitelji krepijo digitalno pismenost učencev, a mora raba tehnologije potekati skladno s cilji pouka in ne sme stopiti v ospredje na način, da bi bila pomembnejša od zmožnosti in ciljev, zapisanih v UN in KZ za slovenščino. [4]

V prispevku je predstavljen vsakoletni razredni projekt devetošolcev pri pouku slovenščine, ki smo ga poimenovali Knjiga podajanka. To je sodobna didaktična metoda, s pomočjo katere dosegamo več ciljev iz učnega načrta. Del učnega načrta pa je tudi (s)poznavanje IKT vsebin, kritična raba računalnika za delo z informacijami, komunikacijo in sodelovanje v medmrežju. Natančneje, pri realizaciji projekta uporabljamo spletne učilnice, kjer nastaja vse, kar je povezano s knjigo.

2 KNJIGA PODAJANKA

Vsako leto je devetošolcem predstavljena možnost sodelovanja v večmesečnem oddelčnem oz. skupinskem (če na šoli poteka pouk v manjših učnih skupinah) projektu, poimenovanem Knjiga podajanka. Projekt poteka vsako leto in ni se še zgodilo, da se učenci projekta ne bi lotili ter ga tudi dokončali.

Projekt je skupinski, sodelujejo vsi v oddelku oz. skupini, vsak po svojih zmožnostih, željah, sposobnostih, talentih. Cilj je skupen izdelek – napisati čisto svojo knjigo in jo izdati tudi v fizični obliki. Vsak učenec napiše svoje poglavje, ga (lahko) ilustrira, podnaslovi. Za dosego cilja pa morajo poleg želje po sodelovanju, raziskovanju in širjenju obzorij imeti aktiven še AAI-račun. Učenci račune večinoma že imajo, saj spletno učilnico pri pouku uporabljamo za različne dejavnosti.

2.1 Cilji projekta

Ciljev je več. V prvi vrsti sledimo ciljem iz učnega načrta – splošnim, to je razmišljujoče in kritično sprejemanje ter vrednotenje raznovrstnih umetnostnih besedil, razvijanje pripravljenosti za pisanje, ubesedovanje svojega znanja, misli. Učenci so sposobni tvoriti učinkovita slovnično-pravopisno pravilna besedila. Skozi ta projekt pa dosegajo tudi specifične cilje, kot so določanje glavne in stranske književne osebe, dogajalnega prostora in časa, teme besedila, pisanje zgodbe z različnih perspektiv, razvijajo nov domišljijski svet v različnih žanrih. V učnem načrtu za slovenščino je navedena tudi uporaba IKT in vključevanje kompetenc, povezanih s tem. Urijo se v tvorjenju besedil v računalniških programih, uporabi okolja spletnih učilnic ter elektronskih sporočil in uporabi elektronske pošte. Učenci razvijajo kritično rabo računalnika za delo z informacijami, komunikacijo in sodelovanje v medmrežju. [5]

Morda pa so še pomembnejši cilji, ki jih dosegamo že med ustvarjanjem: krepitev medvrstniškega sodelovanja, povezovanje oddelčne skupnosti, pomoč med vrstniki, učenci kritično razmišljajo, ves čas krožijo povratne informacije, v ospredju je ustvarjanje in kreativno pisanje. Nenazadnje poteka skozi proces tudi odkrivanje novih zanimanj in talentov, razvijanje različnih področij nadarjenosti. Vsakič se v skupini izpostavi kakšen posameznik, ki si prej ni upal/zmogel pokazati, da ga likovno področje zelo zanima in je pri tem nadarjen. Ali pa ima morda z velikim veseljem spoznava računalniška omrežja in programe ter se izkaže kot oblikovalec končnega izdelka. Nadarjeni na literarnem področju pa so glavni motor projekta, ki ženejo nalogo proti cilju, spodbujajo in pomagajo drugim.

Cilj je tudi medpredmetno povezovanje, predvsem z likovno umetnostjo in računalniškimi predmeti ter programom za nadarjene učence.

2.2 Prvi koraki v projekt

Prvi korak je izbira žanra knjige. Najpriljubljenejši izbiri sta mladinski ali kriminalni roman. Izbor je logičen, saj je mladostnikom prvi žanr najbližji, drugi pa je med najbolj izposojanim gradivom v splošnih knjižnicah na oddelkih za odrasle. [6] Če izbira ni soglasna, učenci glasujejo o predlogih in tako demokratično zmaga predlog žanra z največ glasovi.

Ko je žanr dogovorjen, se lotimo dogajalnega kraja in dogajalnega časa. Tudi kraj in čas izberemo skozi debato – kaj je primerno žanru, kaj je lažje vplesti v zgodbo, kaj zgodbo podpre.

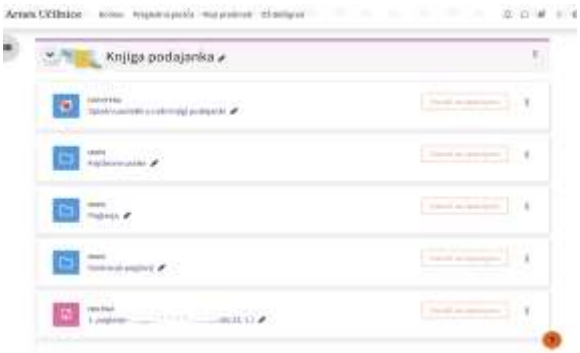
Po tem so na vrsti književne osebe. Skozi debato ugotovimo, kakšne književne osebe so primerne za izbrani žanr njihove knjige. Vsak učenec nato doma ustvari eno književno osebo, jo ilustrira, poimenuje, opiše in označi. Na dogovorjeni dan v šolo prinesejo svoje izdelke (Slika 1).

Slika 1: Ilustracija, oznaka in opis književne osebe

Skupaj jih pregledamo, pokomentiramo, katera bi bila primerna za glavno književno osebo, katere osebe bodo stranske. Učenci podajo povratno informacijo, če je pri kateri od oznak oz. opisov potreben popravek in kakšen (starost, poklic, značajska značilnost).

2.3 Spletna učilnica kot uporaben pripomoček

Isto uro pregledamo skupno spletno učilnico in razdelek, kjer bo knjiga podajanka nastajala. Predstavimo delo v spletni učilnici – mapo, kjer bodo objavljene ilustracije z oznako in opisom književnih oseb, mapo že napisanih poglavij, mapo z ilustracijami poglavij, dokument, v katerem je zapisan izbrani žanr, kraj in čas dogajanja knjige ipd. Nato mentorica vse izdelke z optičnim bralnikom preslikam v elektronsko obliko in jih objavim v spletni učilnici v razdelku Knjiga podajanka v mapi Književne osebe. (Slika 2)



Slika 2: Znajdenje v spletni učilnici v razdelku Knjiga podajanka

Dogovorimo se, da bo imel vsak avtor časa za pisanje poglavja sedem dni. Zadnji rok za oddajo svojega poglavja v spletno učilnico je večer pred uro slovenščine, med katero bomo poglavje vsak teden prebrali in ga pokomentirali. Največkrat se učenci že kar sami javijo in določijo, kdaj bi pisali svoje poglavje – po navadi se odločajo glede svojih drugih obveznosti. Mentorica nato v spletno učilnico vnesem poimensko in terminsko označene oddaje nalog, kamor lahko avtorji v dogovorjenem času oddajo svoje poglavje.

Če se pri oddaji poglavja v spletni učilnici pojavijo težave, se lahko učenci obrnejo na učiteljico ali si med seboj pomagajo z nasveti, lahko tudi oddajo v imenu drugega učenca. Lahko pa svoje poglavje pošljejo tudi preko elektronske pošte svoji učiteljici.

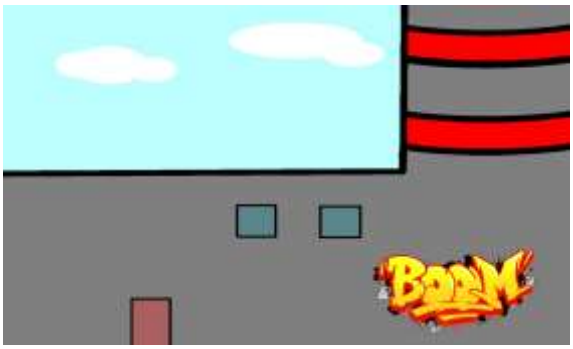
2.4 Globoko v procesu fizičnega in virtualnega ustvarjanja

Ko posamezni učenec napiše svoje poglavje, ga prikažemo preko projektorja na tablo in ga glasno preberemo. Zatem učenci z mentoričino pomočjo debatirajo o zapisanem: kaj je bilo dobro, katere spremembe in kakšen nadaljnji razvoj zgodbe predlagajo.

Avtor poglavja spremlja debate in vnese morebitne popravke. Pisec naslednjega poglavja pozorno posluša, aktivno sodeluje v pogovoru, saj so tako njegovi naslednji koraki veliko lažji. S skupnimi idejami oblikujejo smer, v katero se bo njihova zgodba odvila. S povratnimi medvrstniškimi in mentoričinimi informacijami se učenci učijo, urijo v jezikovnih spretnostih, kreativnem pisanju, znajdenju v spletnem okolju in delom v programih za urejanje besedil. Na tej točki tudi kritično presojajo, utemeljujejo svoje ideje, kreativno razmišljajo. Če zgodba zaide na stransko pot, jo morajo s skupnimi močmi pripeljati nazaj do glavne teme. Paziti morajo tudi, da smiselno vključujejo književne osebe, da dogajanja vestno zaključujejo ter natančno sledijo zgodbi.

Poglavje lahko napišejo tudi v paru, če morda čutijo, da bi potrebovali pomoč vrstnika.

Knjigo oz. poglavja tudi ilustrirajo. To nalogo po navadi prevzamejo tisti učenci in učenke, ki radi likovno ustvarjajo. Nekateri tudi s pomočjo risalnih tablic in računalniških programov. (Slika 3).



Slika 3: Ilustracija poglavja s pomočjo programa Slikar

Nekatere generacije se odločijo, da bodo svoja poglavja tudi podnaslovile. Z lansko generacijo učencev smo preizkusili tudi novejše orodje v spletnih učilnicah, in sicer možnost pripisovanja v PDF-dokument. (Slika 4) Nekateri učenci so jo z veseljem uporabili, nekateri pa so svoje predloge raje posredovali v živo v učilnici.

Slika 4: Prikaz uporabe orodja pripisovanja v PDF-dokument

Učenci prav tako sami oblikujejo naslovnico. Tudi to nalogo prevzamejo tisti, ki jim je likovno ustvarjanje v užitek in tako pripomorejo k najboljši verziji knjige podajanke. (Slika 5)

Slika 5: Ilustracija naslovnice knjige podajanke

2.5 Večmesečni projekt se bliža koncu

Ko se pisateljski in ilustratorski del ustvarjanja skupne knjige zaključi, je na vrsti izbor naslova. Tudi naslov se izbira s predlogi avtorjev, nato pa se glasuje za najljubšega. Izbranega se doriše oz. vstavi v naslovnico.

Učenci so ob zaključevanju projekta naprošeni, da kot enega zadnjih korakov zapišejo svoje misli o prehojeni poti. Svoje misli so lahko tako kot svoja poglavja oddajali v spletni učilnici, lahko pa so mi jih poslali po elektronski pošti.

Sledile so zadnje naloge – ponovno branje, popravki in dopolnitve, lektoriranje, vstavljanje ilustracij, računalniško oblikovanje. Teh nalog se loteva vsaka generacija drugače – nekatere večino uspejo narediti same, druge potrebujejo več mentoričine pomoči in usmerjanja. Predvsem jezikovni pregled, včasih tudi računalniško oblikovanje in priprava na tisk, je največkrat naloga mentorice in manjše skupine učencev, ki izkažejo zanimanja za določena področja.

Ko je jezikovni pregled opravljen, računalniško oblikovanje pri koncu, sledi še zadnji splošni pregled, ali je vse narejeno, kot so bile želje in vizije. Če je vse potrjeno, je na vrsti tiskanje. Po zaključku tiskanja pa se vsak izvod še ročno spne, da nastane prava knjiga v formatu A5. Vsak učenec namreč zadnji šolski dan ob zaključnem spričevalu prejme tudi svoj izvod knjige podajanke.

3 POVRATNE INFORMACIJE

Povratne informacije skozi ves projekt so bile ključnega pomena – tako o vsebini poglavij kot tudi znajdenja v spletnih učinicah ter oblikovanja dokumentov z urejevalniki besedil ter uporabe digitalnih pripomočkov za ilustracije. Informacije so krožile tako med učenci, tudi v popoldanskem času med neformalnimi srečanji, in v šolskem okolju, kot tudi med učenci in mentorico ter obratno. Vsaka generacija dobi kakšno novo zamisel, poda drugačen predlog (npr. dva različna konca zgodbe, vzporedna zgodba ene od književnih oseb …), tako se tudi sama marsičesa vsako leto naučim.

To pa je nekaj misli učencev – avtorjev različnih generacij o procesu pisanja knjige podajanke:

“Knjiga podajanka mi je zelo všeč. Super mi je, da predebatiramo, kako bi zgodbo peljali naprej in da v tem projektu res sodelujemo vsi. Zdi se mi, da do sedaj vse napreduje odlično in verjamem, da bo tako še naprej.”

“Projekt mi je bil zelo všeč in mislim, da nam gre zelo dobro. Všeč mi je, da imamo vsi možnost sodelovati in skupaj debatirati o napisanem. Všeč mi je tudi to, da se učimo tudi uporabe spletnih učilnic in drugih uporabnih stvari za življenje. Ničesar ne bi spremenila.”

“Ko sem začel pisati svoje poglavje, sem imel mešane občutke. Sploh nisem znal začeti. Razmišljal sem o vseh možnih kombinacijah, a začeti je bilo res težko. S pomočjo učiteljice in sošolcev mi je steklo in sem med pisanjem nepričakovano celo užival. Vesel sem, da nas je učiteljica popeljala skozi ta izziv, saj smo se veliko naučili in zdaj imamo svojo knjigo! Koliko učencev se lahko pohvali s tem?”

Njihova lastna knjiga na koncu vedno požanje veliko zadovoljstva, ponosa in tudi nekaj solz sreče, saj imajo v rokah dokaz, da zmorejo nekaj, kar se jim je morda pred nekaj meseci zdelo nedosegljivo.

Na praktičen način lahko dokažejo veliko usvojenega znanja ob koncu osnovne šole – tako s področja rabe jezika kot književnosti. Učenci pa poleg tega dobijo tudi lep spomin na zaključek osnovne šole ter na skupni rezultat sodelovanja in podpore. Ponosni so na ‘izid’svoje knjige, ki so jo snovali in ustvarjali skupaj, od ideje do končnega izdelka. Pa sploh ni bilo “za oceno”!

4 ZAKLJUČEK

Vsako leto s povratnimi informacijami učencev ustvarjalcev knjige projekt še izboljšujem in nadgrajujem. Začeli smo ga namreč fizično, s poglavji, natisnjenemi na listih, spravljenimi v kartonski mapi, ki je kot kuričkova torbica potovala od učenca do učenca. IKT je ta del posodobil in olajšal. Nova tehnološka orodja ne le prinašajo novosti v šolski prostor, temveč tudi pospešujejo prenos informacij, povečujejo zanimanje učencev za snov oz. šolski projekt. Kot velika prednost se je pokazal tudi hiter in hkraten dostop do virov informacij ter pregled nad potekom projekta za celotno skupino ustvarjalcev.

V projekt se mi ne le zdi smiselno, ampak dandanes že celo nujno vključevati IKT, četudi je področje slovenščine morda malo netipično, a se z idejami, sodelovanjem, razvijanjem in odprtostjo za spremembe da marsikaj izvesti. Ključni preoblikovalci pedagoške prakse smo učitelji, ki učencem lahko omogočimo inovativno in spodbudno učno okolje ter večjo dostopnost znanja in spretnosti.

Povratne informacije učencev, kolegov, staršev kažejo, da je ta metoda zanimiva, sodobna in aktivna. Doseženi so cilji, kot so razvijanje in ohranjanje radovednosti, zanimanja za književnost, branje in literarno ustvarjanje, urjenje veščin uporabe računalnika in z njim povezanih orodij, znajdenje v okolju spletnih učilnic. Učenci so pri pouku v aktivni in ustvarjalni vlogi, kar jim sodoben pouk z drugačnimi metodami, a enakimi cilji, mora nuditi.

Spregledati pa se ne sme dejstva, kako so učenci ob uspelem skupinskem projektu in doseženem, včasih celo preseženem cilju zadovoljni in srečni. Ne le da so dosegli cilj, ki se jim je na začetku zdel nedosegljiv, v procesu nastajanja knjige so poglobili medsebojne vezi in na novo odkrili svoje talente in zanimanja. Motivirala ji ni ocena, ki za ta projekt sploh ni predvidena, ampak sodelovanje in želja prispevati svoj košček v mozaiku oddelčnega oz. skupinskega projekta, prejeti (pozitivno) povratno infomacijo o svojem delu in se dokazati samemu sebi, vrstnikom, staršem in mentorici.

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Spopadanje z izzivi pri razvijanju digitalnih veščin pri učencih z učnimi težavami v redni osnovni šoli

Addressing the Challenges of Developing Digital Skills among Students with Learning Difficulties in Regular Primary School

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POVZETEK

V prispevku so predstavljeni nekateri izzivi, s katerimi se soočamo v redni osnovi šoli ob hitrem digitalnem razvoju. Sledenje trendom razvoja digitalnih veščin je pri poučevanju učencev v šoli izrednega pomena, saj so oni tisti, ki bodo v prihodnosti te veščine potrebovali za kvalitetno delo in življenje. V prispevku je poudarek na premagovanju ovir pri učencih z učnimi težavami, ki imajo posledično pogosto težave tudi pri vedno hitrejšem načrtnem razvijanju digitalnih veščin pri pouku. Ti učenci potrebujejo posebno podporo ter drugačen način dela, ki zahteva združevanje različnih profilov učiteljev, ki poučujejo na šoli. Tako smo se združili učitelji predmetnega pouka z učitelji dodatne strokovne pomoči, to so pedagog, inkluzivni pedagog, specialni in rehabilitacijski pedagog ter socialni pedagog, ki s svojimi specifičnimi znanji pristopimo k tem učencem s svojimi cilji in načinom dela in tako pripomoremo k najbolj optimalnemu razvoju, tudi razvoju digitalnih veščin, vseh učencev.

KLJUČNE BESEDE

Digitalne veščine, pomoč, učenci z učnimi težavami, timsko delo

ABSTRACT

The paper presents some of the challenges we face in a regular elementary school in the face of rapid digital development. Following the trends in the development of digital skills is very important to teach students at school, as they are the ones who will need these skills for quality work and life in the future. The paper emphasizes overcoming obstacles for students with learning difficulties, who consequently often have difficulties in developing digital skills in the classroom at an increasingly rapid pace. These pupils need special support and a different way of teaching, which requires bringing together the different profiles of teachers who teach at the school. In this way, we have teamed up with teachers of additional professional assistance, i.e. pedagogues, inclusive pedagogues, special and rehabilitation pedagogues and social pedagogues, who approach these students with their specific skills with their goals and different way of teaching, thus contributing to the most optimal development, including the development of digital skills, of all students.

KEYWORDS

Digital skills, help, students with learning difficulties, team work

1 UVOD

Živimo v času hitrih sprememb, ki jih prinaša pospešena informatizacija in digitalizacija. Pandemija koronavirusa je digitalni prehod in preobrazbo samo še močno pospešila. Delo in učenje na daljavo sta postala naša stalnica. [1]

Vpliv razvoja digitalne tehnologije seže na vsa področja življenja posameznika in družbe, zato kot odgovor na spremenjen način življenja družbe sega vpliv digitalne preobrazbe tudi na področje izobraževanja. [2]

Tudi na naši šoli se v zadnjem času zelo intenzivno ukvarjamo z razvijanjem digitalnih veščin pri učencih in učiteljih. Posebno pozornost smo zaradi nuje temu namenili v času šolanja na daljavo, kasneje pa smo svoja znanja, spretnosti in veščine samo nadgrajevali in si s pridobljenim znanjem na veliko področjih močno optimalizirali učno delo in proces. Učitelji so digitalne vsebine vnašali v vsakodnevno delo, pouk in učenje. Na šoli smo posodobili računalniško opremo, dobili smo nove računalnike, tablice, inovativno učilnico, pametne table,... in tako učiteljem omogočili poučevanje s pomočjo digitalne tehnologije, če so le želeli. Sčasoma so se vsi učitelji začeli posluževati teh orodij, vsak na svojem področju, glede na svoja zanimanja, interes in po svojih zmožnostih.

Kot specialna pedagoginja sem budno spremljala ves ta napredek in se seveda tudi sama izpopolnjevala na tem področju. Sodelovala sem v vseh šolskih projektih, ki so spodbujala razvoj digitalnih veščin pri učiteljih in preizkušala pridobljena znanja tudi pri učencih. Ugotovila sem, da tako kot so učenci s posebnimi potrebami in učenci z učnimi težavami posebni na vseh ostalih šolskih področjih, tako je potrebno upoštevati njihove učne posebnosti tudi na področju razvijanja in uporabe digitalnih veščin. Pogosto je delo v razredu kljub odlični učiteljevi pripravi potekalo prehitro, večino dela niso mogli opraviti samostojno in so imeli težave že z osnovnimi veščinami kot so odpiranje, shranjevanje dokumenta, urejanje besedila in podobno. Podobno so seveda opazili tudi njihovi učitelji in zato smo se odločili za skupno strategijo dela, ki bo tudi učencem z

učnimi težavami omogočila razvoj digitalnih veščin optimalno glede na njihove sposobnosti.

2 POMOČ UČENCEM Z UČNIMI TEŽAVAMI PRI RAZVIJANJU DIGITALNIH VEŠČIN V ČASU POUKA

Digitalne kompetence spadajo med ključne kompetence, ki so potrebne za vseživljenjsko učenje. "Digitalna kompetenca vključuje samozavestno, kritično in odgovorno uporabo digitalnih tehnologij in njihovo vključevanje pri učenju, delu in družbenem udejstvovanju: Vključuje informacijsko in podatkovno pismenost, ustvarjanje digitalnih vsebin (tudi programiranje), varnost (tudi digitalno blagostanje in kompetence v zvezi s kibernetsko varnostjo), vprašanja intelektualne lastnine, reševanje problemov in kritično mišljenje." (Priporočilo Sveta o ključnih kompetencah za vseživljenjsko učenje, 22. maj 2018, ST 9009 2018 INIT) [3]

To potrjuje tudi definicija digitalne pismenosti Organizacije Združenih narodov za izobraževanje, znanost in kulturo – UNESCO: »Digitalna pismenost je sposobnost varnega in ustreznega dostopa, upravljanja, razumevanja, vključevanja, komuniciranja, vrednotenja in ustvarjanja informacij z digitalnimi tehnologijami za potrebe zaposlovanja, dostojnega delovnega mesta in podjetništva. Vključuje kompetence, ki jih na različne načine imenujemo računalniška pismenost, IKT pismenost, informacijska pismenost in medijska pismenost.« [1]

Na področju življenja posameznika se poleg pasivne ali aktivne splošne uporabe spleta opravlja tudi vse več storitev s pomočjo digitalne tehnologije, od naročanja živil do oddajanja različnih vlog v digitalnih storitvah države. Vsi ti vplivi digitalne preobrazbe narekujejo vodstvenim ali strokovnim delavcem, da v vzgojno izobraževalnih zavodih razvijajo znanja, spretnosti in stališča, vezana na uporabo digitalne tehnologije, najprej pri sebi, da bodo opolnomočeni lahko vnašali potrebne prvine v svoj vzgojno-izobraževalni proces. [2]

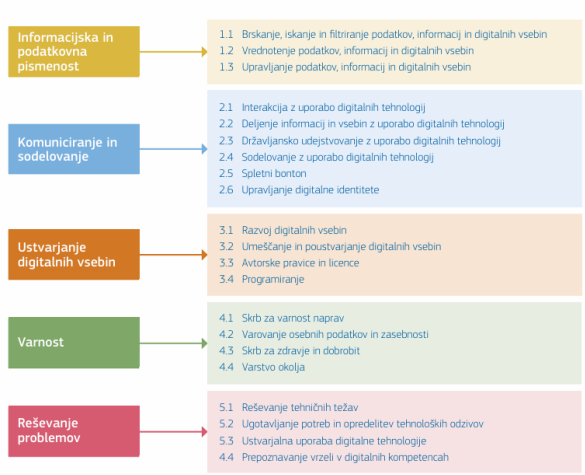
Na naši šoli smo v preteklih letih sodelovali v različnih projektih, kjer smo pridobili znanja in spretnosti, ki smo jih potem prenašali tudi na učence. Najprej smo bili izbrani v dvoletni projekt DDK (dvig digitalne kompetentnosti). Namen tega projekta je bil izobraževati učitelje, da bodo poučevali tako, da bodo pri svojem pouku spodbujali razvoj digitalnih kompetenc.

V tem projektu se je nekaj naših učiteljev izobraževalo ter svoje znanje nato preneslo na ostali kolektiv. V teh izobraževanjih smo se naučili uporabljati nova uporabna spletna orodja, delati z orodji v Microsoft Office 365, izdelali smo svoj izobraževalni video, svoj izdelek s pomočjo gradnika H5P ter poudarili pomen varnega shranjevanja v oblak, ki ga imamo na voljo kot učitelji. Predstavili so nam nevarnosti uporabe spleta ter kako se jim izogniti. Ob različnih priložnostih smo te veščine pokazali in predajali učencem, ki so s svojimi napravami imeli možnost preizkusiti predstavljena orodja. V tej fazi so se učenci z učnimi težavami pravzaprav dobro znašli. Učitelji so po korakih razlagali potek dela, kar je za njih najboljši način učenja. Bili so motivirani, ker so lahko uporabljali tehnološko napravo, ki jim je znana in radi delajo z njo. Povečini niso imeli težav s tem, da so si aplikacijo naložili in jo potem po navodilih tudi uporabljali. Pri tem so nekateri potrebovali nekaj pomoči, vendar v meji, ki jo je zmogel učitelj, ki jih je poučeval. Uporabljene aplikacije so bile večinoma namenjene utrjevanju znanja in od učencev niso zahtevale zahtevnejših digitalnih spretnosti. Zelo dobro so se zavedali nevarnosti, ki jim pretijo na spletu, teoretično so bili tudi zelo dobro poučeni o primernem obnašanju na spletu.

2.1 Dejavnosti v okvira projekta Inovativna pedagogika 5.0

Zapletlo se je, ko smo se vključili v projekt Inovativna pedagogika 5.0 in so učitelji začeli sistematično razvijati digitalne kompete istočasno s poučevanjem svojih učnih vsebin.

Leta 2013 je bil izdan prvi trefernčni okvir DigComp, v katerem so bile digitalne kompetence opredeljene kot kombinacija 21 kompetenc, razvrščenih v pet glavnih področij (slika 1). [3]



Slika 1: Konceptualni referenčni model okvira DigComp [3]

Učitelji so si iz nabora izbrali kompetenco, ki so jo želeli razvijati, pripravili dejavnosti in jih z učenci tudi udejanjili.

Učenci so morali preko pridobivanja učne snovi načrtno preko vnaprej načrtovanih aktivnosti razvijati tudi digitalno kompetenco, kar pa je bilo bistveno težje in je sodoben koncept dela, ki vključuje razvoj in uporabo digitalnih kompetenc, predstavljal veliko težavo pri pridobivanju znanja pri posameznem predmetu. Učitelji so ugotavljali, da sami v prepolnih razredih ne zmorejo kvalitetno izvajati pouka, kljub odlični pripravi in uporabi napredne tehnologije, ki bi jim naj pri tem pomagala.

V prvem letu je bil v projekt vključen en osmi razred. V tem razredu je 7 učencev s posebnimi vzgojno-izobraževalnimi potrebami, poleg tega so še 4 učenci s splošnimi učnimi težavami. Že v preteklosti smo občasno prakticirali, da smo se učitelji dodatne strokovne pomoči kot dodaten učitelj vključevali v pouk pri posameznih predmetih, največkrat pri matematiki, zgodovini in slovenščini. Tokrat smo se za to odločili sistematično ravno zaradi uvajanja digitalnih vsebin v pouk.

Prvo tako sodelovanje je potekalo z učiteljico zgodovine, ki je tudi vodja tega projekta in je takšen način dela uvajala že pred sodelovanjem v tem projektu. Z učiteljico sva skrbno načrtovali ure, pri katerih so se poleg učnih vsebin načrtno razvijale tudi digitalne kompetence. Težava, ki sva jo najprej zaznali in se ji

posvetili, je bila izredno slaba bralna pimenost učencev z učnimi težavami. Tudi digitalne vsebine, ki jih je pripravljala učiteljica zgodovine, namreč zahtevajo sposobnost branja, razumevanja prebranega in tudi bralno učne strategije, ki so temelj kateregakoli učenja. Učenci so bili pri delu zelo počasni, površni, niso znali poiskati informacij, brez pomoči učitelja niso razumeli digitalno predstavljenih vsebin, niso zmogli dati povratne informacije o pridobljenem znanju ali podati povratno informacijo drugim učencem o kvaliteti opravljene naloge. Poleg tega so imeli težave z iskanjem dokumentov v spletni učilnici, odpiranjem dokumentov, varnim shranjevanjem in še kaj. Na primer, v enem sklopu učnih ur so se učenci preko raziskovalnega dela (naslov so si glede na interese izbrali sami) učili o avtorskih pravicah. Šlo je tudi za medpredmetno povezovanje, zato so na isto temo izdelali še izdelek pri tehniki. Že samo raziskovalno delo je za te učence velik zalogaj, ko pa so morali paziti še na avtorske pravice, jih ustrezno označiti ter povezati svoje znanje z drugim predmetom, se je izkazalo, da bo potreben drugačen pristop.

Ugotovili sva, da je za njihovo učenje najbolje, da delajo ločeno od ostalih. Tako sva ustvarili manjše skupine, ki so večinoma delale samostojno in skupino učno manj uspešnih in motiviranih učencev, ki so delali skupaj z mano, da se je učiteljica lahko posvetila ostalim skupinam. Pri tem sva vsebine prilagodili njihovim sposobnostim, dostopali so do enostavnejših besedil, naloge so bile prilagojene, da so lahko samostojno prišli do rešitev, pri tem pa so imeli ves čas na voljo učitelja, če so naleteli na težavo. Delali so v skupini, tako so si lahko tudi pomagali, en drugemu posredovali svoje razumevanje navodil ali učne snovi in tako urili tudi prečne veščine. Osredotočili smo se le na najpogostejše oznake za avtorske pravice, ki sem jih poenstavljeno na konkretnih primerih razložila in tako so lahko samostojno delali in naredili svoj izdelek, ki je bil res samo njihov.

Naslednji primer takšnega sodelovanja je bil pri matematiki. Pri tem predmetu sta se učitelja odločila za pridobivanje nove učne snovi Pitagorov izrek preko spletnega orodja GEOGEBRA. GeoGebra Classic je programska oprema za dinamično matematiko za vse stopnje izobraževanja, ki združuje geometrijo, algebro, funkcije, preglednice, grafe, statistiko in račun v enem paketu, ki je enostaven za uporabo.[4]

Učenci so delali v spletni različici programa. Učitelj jim je najprej program predstavil, pokazal nekaj možnosti in osnovnih ukazov programa ter jih napotil na navodila za delo v spletni učilnici, kjer so sistematično raziskovali Pitagorov izrek, njegovo uporabnost v različnih likih in telesih ter si s pomočjo programa vse prikazali in naredili zapiske v digitalni obliki, ki so jih nato shranili v oblak. Podobno kot pri prejšnjem primeru, so se učenci z učnimi težavami ponovno izgubili pri samsotojnem delu. Pri samostojni uporabi programa so že pozabili osnove, ki jim jih je na začetku pokazala učitelj, tudi si niso znali konkretno prikazati učne snovi, kar jim je omogočal program in čemur je bil seveda tudi namenjen. Učenci so potrebovali stalno asistenco učitelja in tudi dodatno razlago njim preveč abstraktne učne snovi. Kljub delu v manjših učnih skupinah, je bilo za enega učitelja preveč dela v razredu, da bi lahko kvalitetno izpeljal pouk. Tako smo se ponovno združili, oblikovali manjšo skupino, ki je potrebovala pomoč in za katere sem bila odgovorna jaz kot specialna pedagoginja. Delo sem v sodelovanju z učiteljem znatno upočasnila, večkrat ponovila osnovno ravnanje s programom, ponovno smo se morali naučiti tudi shraniti svoje delo, da lahko učenci naslednjič nadaljujejo s svojim delom in si z njim pomagajo pri kasnejšem učenju. Zaradi preobsežnosti snovi sva z učiteljem omejila naloge na tiste, ki so ponujale minimalni in nekatere temeljni standard znanja. Ob tem so potrebovali tudi dodatno razlago in pomoč pri ponazoritvah s programom. Takšen način dela je učencem omogočil sledenje učni snovi. Sicer niso bili tako samostojni kot ostali, vendar je program kljub temu dosegel svoj namen, saj so si učenci lažje predstavljali učno snov, uporabna vrednost Pitagorovega izreka je namreč zanje precej abstraktna, program pa jim je omogočil jasnejšo sliko, lahko so si prenesli izsek, ki je prikazoval uporabo Pitagorovega izreka in tako bolje razumeli učno snov in posledično lažje naredili zahtevane naloge s tega področja.

3 ZAKLJUČEK

Zaradi digitalne revolucije in ne dovolj hitrega prilagajanja izobraževanja in usposabljanja novim razmeram, smo ponovno v situaciji, ko tehnologija prehiteva izobraževanje in tako povzroča, da ljudje nismo ustrezno pripravljeni na življenje in delo z novo tehnologijo ter težko sledimo takemu hitremu tehnološkemu razvoju.[1]

V šoli se je to izkazalo na več nivojih. Najprej so novi dosežki predstavljali velik izziv nekaterim, predvsem starejšim učiteljem, ki jim je nova tehnologija na začetku znatno upočasnila njihovo delo. Imeli smo kar nekaj nezaupljivih staršev, ki jih je digitalno znanje njihovih otrok preraslo in jih več niso zmogli nadzirati ali jim pomagati. Nenazadnje so se s težavami na tem področju soočali tudi učenci z učnimi težavami, za katere je pouk naennkrat potekal preveč kompleksno, prehitro in niso zmogli slediti učnim zahtevam, kar je v njih povzročilo dodaten stres, ki jim je onemogočal doseganje rezultatov v skladu z njihovimi sposobnostmi. Tako kot vsakega izziva smo se tudi tega na naši šoli lotili sistematično, z veliko podpore s strani vodstva in bolje usposobljenih učiteljev ter z željo slediti trendom in naše učence kvalitetno pospremiti v novi svet digitalne tehnologije. Z različnimi seminarji smo opolnomočili tudi starše, ki jih pri nas jemljemo kot pomembne partnerje v učnem procesu. Menim, da smo na dobri poti uspeha tudi pri razvijanju digitalnih veščin pri učencih z zmanjšanimi sposobnostmi slediti tako hitremu razvoju. S tem, ko stopimo skupaj, združimo znanja iz različnih področij, opazujemo učence in njihovo delo, sproti prilagajamo cilje in naloge, v naših učencih ustvarimo zaupanje, motivacijo in željo po novih znanjih in veščinah.

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Knjižnično informacijska znanja pri pouku Slovenščine v 7. razredu

Library Information Knowledge in Slovenian Lessons in the 7th Grade

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POVZETEK

Na Osnovni šoli Antona Martina Slomška Vrhnika si prizadevamo učencem približati učno snov skozi samostojno raziskovanje in medpredmetno povezovanje. V prispevku je predstavljeno sodelovanje med šolsko knjižnico in predmetom slovenščina, kjer učenci spoznavajo osnove iskanja po Slovarju slovenskega knjižnega jezika in Slovarju slovenskih frazemov.

KLJUČNE BESEDE

Šolska knjižnica, medpredmetno povezovanje, slovarji

ABSTRACT

At Anton Martin Slomšek Primary School in Vrhnika, we strive to bring the curriculum closer to students through independent research and interdisciplinary integration. This article presents the collaboration between the school library and the Slovenian language course, where students learn the basics of using the Dictionary of Standard Slovenian Language and the Dictionary of Slovenian Idioms.

KEYWORDS

School library, cross-curricular conections, dictionaries

1 UVOD

Šolska knjižnica ima ključno vlogo v izobraževalnem procesu, saj je prostor, kjer se spodbuja bralna kultura, raziskovanje in vseživljenjsko učenje. Pomen šolske knjižnice presega zgolj izposojo knjig; je središče, ki podpira učne procese, razvija informacijsko pismenost in omogoča dostop do širokega spektra znanja in virov.

Knjižnica učencem nudi priložnost, da raziskujejo svet literature, se poglobijo v različne teme ter razvijajo kritično mišljenje. Poleg tega je knjižnica prostor, kjer lahko učenci pridobijo spretnosti za iskanje, vrednotenje in uporabo informacij, kar je ključno v sodobni družbi, preplavljeni z informacijami. Z dobro urejeno zbirko knjižničnega gradiva, ki vključuje tako tiskane kot digitalne vire, knjižnica podpira učni načrt ter pomaga učiteljem pri izvajanju pouka.

Poleg tega šolska knjižnica spodbuja sodelovanje med učenci, učitelji in knjižničarjem, kar krepi skupno učenje. Knjižničarji igrajo pomembno vlogo pri usmerjanju učencev k ustreznemu gradivu, organiziranju kulturnih dogodkov, kot so bralne značke, literarni večeri in razstave, ter pri pomoči pri raziskovalnih nalogah. Šolska knjižnica je zato neprecenljiv vir, ki bogati izobraževanje in prispeva k osebnemu in akademskemu razvoju učencev.

Šolska knjižnica je pomembno informacijsko središče vsake osnovne šole in ima pomembno vlogo, saj šolski knjižničar vzgaja mladega učenca v samostojnega uporabnika knjižnice. Naloga šolskega knjižničarja je, da prilagodi vsebine znanj učenčevi starosti primerno, pri čemer pričakujemo, da bodo učenci ob zaključku osnovne šole samostojni uporabniki.

Leta 1996 je bila ustanovljena kurikularna komisija za šolske knjižnice, ki je prenovila dotedanji program knjižne in knjižnične vzgoje. Program Knjižnična informacijska znanja za osnovno šolo je bil sprejet na Strokovnem svetu Republike za splošno izobraževanje leta 1999 (Posodobitve pouka v gimnazijski praksi, 2010). Prednost se daje predvsem povezovanju znanja. Pri tem je pomembno sodelovanje učiteljev, da medpredmetno povežejo učno snov.

2 MEDPREDMETNO SODELOVANJE S SLOVENŠČINO

Največ medpredmetnih sodelovanj v naši knjižnici izvajamo s predmetom slovenščina. Med standardi znanja, ki jih predpisuje Učni načrt za slovenščino (2018) za sedmi razred osnovne šole, je tudi uporaba Slovarja slovenskega knjižnega jezika in Slovarja slovenskih frazemov. Učenci se pri tem učijo razvijati poimenovalno zmožnost, kar pomeni, da morajo znati razložiti frazeme v besedilu in jih ustrezno uporabiti v svojih pisnih izdelkih.

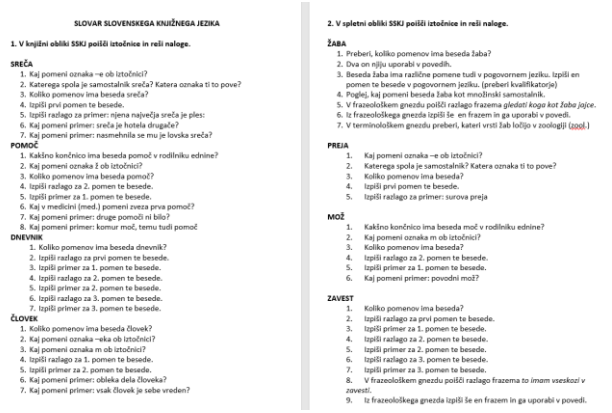
Učni načrt predvideva tudi uporabo slovarjev v knjižni in elektronski obliki. Pred leti smo učence učili iskanja v knjižnih izdajah slovarjev, danes pa se osredotočamo predvsem na iskanje po spletnih različicah, občasno pa se preizkusimo tudi v iskanju po knjižnih izdajah.

2.1 Slovar slovenskega knjižnega jezika

Učni načrt za sedmi razred osnovne šole predvideva usvajanje znanja uporabe Slovarja slovenskega knjižnega jezika, pri čemer

se povežemo s šolsko knjižnico. Za to učno snov namenimo tri šolske ure, nato pa učenci svoje znanje utrjujejo še pri urah slovenščine z učiteljico.

Prvo uro knjižničarka učencem predstavi zgodovino nastanka Slovarja slovenskega knjižnega jezika in njegovo zgradbo, kar učenci zabeležijo v zvezke. Drugo uro razdelimo učence v skupine po največ štiri, vsaka skupina pa prejme knjižno izdajo slovarja, tablico in delovni list z nalogami (slika 1). Rešitve nalog, ki vključujejo celotne povedi, zapišejo v zvezek. Prvo nalogo rešijo s pomočjo knjižne izdaje slovarja, drugo pa s pomočjo spletne različice. Učencem reševanje nalog ne predstavlja večjih težav, vendar večina raje uporablja spletno obliko slovarja, saj jim iskanje po abecednem vrstnem redu v knjižni izdaji povzroča več izzivov.



SLOVAR SLOVENSKEGA KNJIŽNEGA JEZIKA

1. V knjižni obliki SSKJ poišči iztočnice in reši naloge.

SREČA
1. Kaj pomeni oznaka –e ob iztočnici?
2. Katerega spola je samostalnik sreča? Katera oznaka ti to pove?
3. Koliko pomenov ima beseda sreča?
4. Izpiši prvi pomen te besede.
5. Izpiši razlago za primer: njena največja sreča je ples:
6. Kaj pomeni primer: sreča je hotela drugače?
7. Kaj pomeni primer: nasmehnila se mu je lovska sreča?

POMOČ
1. Kakšno končnico ima beseda pomoč v rodilniku ednine?
2. Kaj pomeni oznaka ž ob iztočnici?
3. Koliko pomenov ima beseda pomoč?
4. Izpiši razlago za 2. pomen te besede.
5. Izpiši primer za 1. pomen te besede.
6. Kaj v medicini (med.) pomeni zveza prva pomoč?
7. Kaj pomeni primer: druge pomoči ni bilo?
8. Kaj pomeni primer: komur moč, temu tudi pomoč

DNEVNIK
1. Koliko pomenov ima beseda dnevnik?
2. Izpiši razlago za prvi pomen te besede.
3. Izpiši primer za 1. pomen te besede.
4. Izpiši razlago za 2. pomen te besede.
5. Izpiši primer za 2. pomen te besede.
6. Izpiši razlago za 3. pomen te besede.
7. Izpiši primer za 3. pomen te besede.

ČLOVEK
1. Koliko pomenov ima beseda človek?
2. Kaj pomeni oznaka –eka ob iztočnici?
3. Kaj pomeni oznaka m ob iztočnici?
4. Izpiši razlago za 1. pomen te besede.
5. Izpiši primer za 2. pomen te besede.
6. Kaj pomeni primer: obleka dela človeka?
7. Kaj pomeni primer: vsak človek je sebe vreden?

2. V spletni obliki SSKJ poišči iztočnice in reši naloge.

ŽABA
1. Preberi, koliko pomenov ima beseda žaba?
2. Dva on njiju uporabi v povedih.
3. Beseda žaba ima različne pomene tudi v pogovornem jeziku. Izpiši en pomen te besede v pogovornem jeziku. (preberi kvalifikatorje)
4. Poglej, kaj pomeni beseda žaba kot množinski samostalnik.
5. V frazeološkem gnezdu poišči razlago frazema *gledati koga kot žaba jajce*.
6. Iz frazeološkega gnezda izpiši še en frazem in ga uporabi v povedi.
7. V terminološkem gnezdu preberi, kateri vrsti žab ločijo v zoologiji (rod.)

PREJA
1. Kaj pomeni oznaka –e ob iztočnici?
2. Katerega spola je samostalnik? Katera oznaka ti to pove?
3. Koliko pomenov ima beseda?
4. Izpiši prvi pomen te besede.
5. Izpiši razlago za primer: surova preja

MOŽ
1. Kakšno končnico ima beseda moč v rodilniku ednine?
2. Kaj pomeni oznaka m ob iztočnici?
3. Koliko pomenov ima beseda?
4. Izpiši razlago za 2. pomen te besede.
5. Izpiši primer za 1. pomen te besede.
6. Kaj pomeni primer: povodni mož?

ZAVEST
1. Koliko pomenov ima beseda?
2. Izpiši razlago za prvi pomen te besede.
3. Izpiši primer za 1. pomen te besede.
4. Izpiši razlago za 2. pomen te besede.
5. Izpiši primer za 2. pomen te besede.
6. Izpiši razlago za 3. pomen te besede.
7. Izpiši primer za 3. pomen te besede.
8. V frazeološkem gnezdu poišči razlago frazema *to imam vseskozi v zavesti*.
9. Iz frazeološkega gnezda izpiši še en frazem in ga uporabi v povedi.

Slika 1: Delovni list (Slovar slovenskega knjižnega jezika)

2.2 Slovar slovenskih frazemov

Učni načrt za slovenščino (2018) predpisuje prepoznavanje frazemov v besedilu, ki ga morajo učenci uporabiti v svojem besedilu.

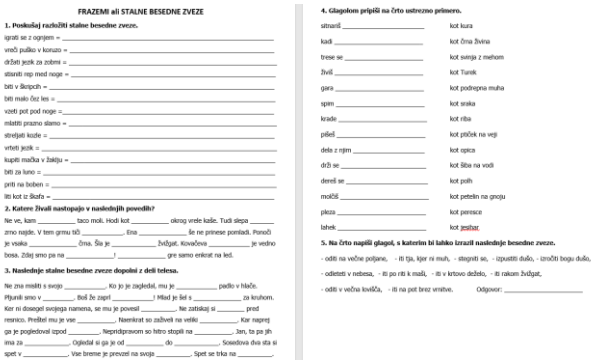
V šolski knjižnici imamo na voljo samo en Slovar slovenskih frazemov in ne more skupina največ štirih učencev istočasno delati s knjižno obliko slovarja, zato si ga izmenjujejo, ko skupina opravi nalogo na delovnem listu (slika 2).

Na začetku učencem razložimo, kaj sploh so frazemi, razložimo razliko med reklom in rečenico in predstavimo način iskanja frazemov, ki se razlikuje od iskanja po Slovarju slovenskega knjižnega jezika. V iskalni niz Slovarja slovenskih frazemov ne moreš samo vpisati celotnega frazema, saj ne dobiš nobenega zadetka. V iskalnik moraš vpisati samostalnik v osnovni obliki (imenovalnik ednine), ki se pojavi v frazemu. Iskalnih ti ponudi vse frazeme, ki se pojavijo na temo določenega samostalnika in moraš poiskati pravega.

Učenci imajo z iskanjem po Slovarju slovenskih frazemov veliko več težav, saj včasih niso pozorni, da se razlaga ne nanaša na iskani frazem in prepišejo napačno razlago.

Slovenščina pa ni samo iskanje po slovarju, ampak lahko postane tudi zabavna. Učenci se preizkusijo v risanju frazemov in uporabi le-teh v svojih besedilih. Med ustvarjanjem se zabavajo in hkrati veliko naučijo. Vsak učenec izbere svoj frazem, ki ga ilustrira (slika 3).

Učni načrt za slovenščino (2018) ima zapisan standard znanja, da znajo učenci razumejo in uporabljajo frazeme v svojih besedilih (slika 4). Tudi naši učenci se v tem preizkusijo. Da lahko frazem uporabijo v povedi, ga morajo razumeti.



FRAZEMI ali STALNE BESEDNE ZVEZE

1. Poskušaj razložiti stalne besedne zveze.

igrati se z ognjem = _____
vreči puško v koruzo = _____
držati jezik za zobmi = _____
staniti np med noge = _____
biti v škripcih = _____
biti miki čez les = _____
vzeti pot pod noge = _____
mlatiti prazno slamo = _____
streljati kozle = _____
vrteti jezik = _____
kupiti mačka v žaklju = _____
biti za luno = _____
priti na loben = _____
iti kot iz Bafa = _____

2. Katere živali nastopajo v naslednjih povedih?

Ne ve, kam _____ taco moli. Hodi kot _____ okrog vrele kaše. Tudi slepa _____ zrno najde. V tem grmu tiči _____. Ena _____ še ne prinese pomladi. Ponoči je vsaka _____ črna. Ša je _____ žvižgat. Kovačeva _____ je vedno bosa. Zdaj smo pa na _____! _____ gre samo enkrat na led.

3. Naslednje stalne besedne zveze dopolni z deli telesa.

Ne zna mislit s svojo _____. Ko jo je zagledal, mu je _____ padlo v hlače.
Hjunli smo v _____. Boš že zapri _____! Hlad je šel s _____ za kruhom.
Kar ni dosegel svojega namena, se mu je povesil _____. Ne zatiskaj si _____ pred resnico. Preštel mu je vse _____. Nasmrkat so zaželeli na veliki _____. Kar naprej ga je pogledoval izpod _____. Nepridipravom so hitro stopili na _____. Jan, ta pa jih ima za _____. Ogledal si ga je od _____ do _____. Soseda sva sta si spet v _____. Vse breme je prevzel na svoja _____. Spet se trka na _____.

4. Glagolom pripiši na črto ustrezno primero.

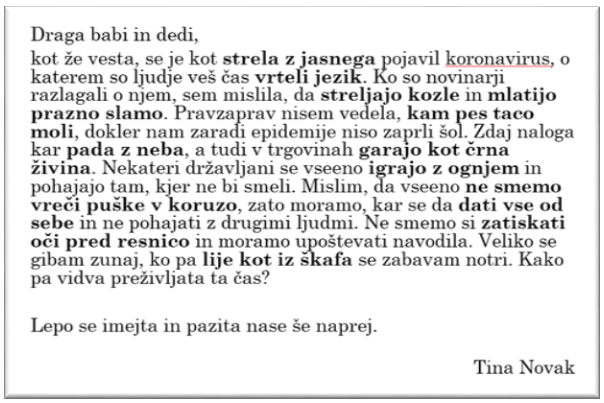
sitnariš _____ kot kura
kadi _____ kot črna živina
trese se _____ kot svinja z mehom
živiš _____ kot Turek
gara _____ kot podrepna muha
spim _____ kot sraka
krade _____ kot riba
pišeš _____ kot ptiček na veji
dela z njim _____ kot opica
drži se _____ kot žiba na vodi
dereš se _____ kot polh
molčiš _____ kot petelin na gnoju
plezа _____ kot pernice
lahek _____ kot jesihar

5. Na črto napiši glagol, s katerim bi lahko izrazil naslednje besedne zveze.

- oditi na večne poljane, - iti tja, kjer ni muh, - stegniti se, - izpustiti dušo, - izročiti bogu dušo,
- odleteti v nebesa, - iti po riti k maši, - iti v krtovo deželo, - iti rakom žvižgat,
- oditi v večna lovišča, - iti na pot brez vrnitve. Odgovor: _____

Slika 2: Delovni list (Slovar slovenskih frazemov)

Slika 3: Ilustracija frazema igrati se z ognjem



Draga babi in dedi,

kot že vesta, se je kot **strela z jasnega** pojavil koronavirus, o katerem so ljudje več čas **vrteli jezik**. Ko so novinarji razlagali o njem, sem mislila, da **streljajo kozle** in **mlatijo prazno slamo**. Pravzaprav nisem vedela, **kam pes taco moli**, dokler nam zaradi epidemije niso zaprli šol. Zdaj naloga kar **pada z neba**, a tudi v trgovinah **garajo kot črna živina**. Nekateri državljani se vseeno **igrajo z ognjem** in pohajajo tam, kjer ne bi smeli. Mislim, da vseeno **ne smemo vreči puške v koruzo**, zato moramo, kar se da **dati vse od sebe** in ne pohajati z drugimi ljudmi. Ne smemo si **zatiskati oči pred resnico** in moramo upoštevati navodila. Veliko se gibam zunaj, ko pa **lije kot iz škafa** se zabavam notri. Kako pa vidva preživljata ta čas?

Lepo se imejta in pazita nase še naprej.

Tina Novak

Slika 4: Primer besedila, v katerem učenci uporabijo frazeme

3 ZAKLJUČEK

Učenci se najbolj naučijo, ko so aktivni in sami raziskujejo. Na začetku učne ure smo jim pokazali, kako iskati po slovarjih,

nato pa so se sami lotili raziskovanja. Priznali so, da je iskanje po Slovarju slovenskega knjižnega jezika precej lažje kot po Slovarju slovenskih frazemov, saj jim nepoznavanje frazemov predstavlja dodatno oviro. Danes poznajo zelo malo frazemov, a hkrati priznavajo, da je raziskovanje le-teh zelo zabavno in da so pri tem pridobili veliko novega znanja.

Medpredmetno sodelovanje med učitelji je ključnega pomena za kakovosten pouk, saj omogoča celostno obravnavo učnih vsebin in povezuje različna področja znanja. Ko učitelji različnih predmetov sodelujejo, lahko ustvarijo smiselne povezave med svojimi predmeti, kar učencem pomaga bolje razumeti in uporabiti pridobljeno znanje v različnih kontekstih. Tako učenje postane bolj praktično, saj se učenci zavedajo, kako so različna znanja med seboj povezana. Poleg tega medpredmetno sodelovanje spodbuja inovativne pristope k poučevanju in omogoča učiteljem, da izmenjujejo ideje ter izkušnje, kar bogati njihovo pedagoško delo in prispeva k večji motivaciji učencev.

Medpredmetno sodelovanje med knjižničarjem in učiteljem slovenščine je izjemno dragoceno, saj omogoča poglobljeno in raznoliko obravnavo literarnih in jezikovnih vsebin. Knjižničar s svojim strokovnim znanjem o knjižničnem gradivu, raziskovalnih metodah in informacijskih virih pomembno dopolnjuje pouk slovenščine. Sodelovanje omogoča, da učenci razvijajo bralne in informacijske veščine, hkrati pa poglabljajo svoje razumevanje književnosti in jezika.

Knjižničar lahko učencem predstavi širok spekter literature, pomaga pri iskanju dodatnega gradiva za bralno značko ali raziskovalne naloge ter jih nauči učinkovite uporabe knjižničnih virov, kot so slovarji, enciklopedije in digitalne zbirke. Učitelj slovenščine pa lahko v sodelovanju s knjižničarjem oblikuje naloge, ki spodbujajo kritično branje in razmišljanje, ter organizira projekte, kjer učenci raziskujejo določeno temo s pomočjo knjižničnega gradiva.

Takšno sodelovanje spodbuja medpredmetno učenje, ki povezuje jezikovne spretnosti z veščinami informacijske pismenosti, ter učencem pomaga razvijati celostne kompetence, ki jih bodo potrebovali v življenju.

LITERATURA

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Matematika – vir motivacije za programiranje

Mathematics - A Source of Motivation for Programming

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POVZETEK

V prispevku je predstavljena izvedba projekta Programiranje v matematiki v sklopu večjega projekta NAPOJ MINUT. Projekt je bil izveden v 1. letniku gimnazijskega programa. Namen projekta je bil med dijaki ozavestiti potrebo po programiranju in jim pokazati, kako s pomočjo le-tega rešujejo probleme z različnih področij. V projektu so dijaki s pomočjo programskega jezika Python reševali različne matematične probleme.

KLJUČNE BESEDE

Matematika, programiranje, gimnazija

ABSTRACT

The article presents the implementation of the project »Programming in Mathematics« as part of a larger project called NAPOJ MINUT. The project was carried out in the first year of the high school program. The aim of the project was to raise awareness among students about the need for programming and to show them how it can be used to solve problems in various fields. In the project, students used the Python programming language to solve different mathematical problems.

KEYWORDS

Mathematics, programming, high school

1 Uvod

Projekt NAPOJ MINUT je nastal na pobudo učiteljev, ki so pri svojem delu čutili potrebo po kvalitetni obliki medpredmetnega sodelovanja. Pri tem sodelovanju naj bi predmeti ne služili zgolj kot orodje ali vir podatkov, ampak naj bi učeči se usvajali temeljna znanja iz vseh v sodelovanje vključenih predmetov. Projekt NAPOJ MINUT združuje (predvsem) učitelje Računalništva in informatike (RIN) in ostalih naravoslovnih predmetov, torej MINUT - M(atematika) I(nformatika) N(aravoslovje) U(metnost) T(ehnologija) predmete. Aktivnosti v sklopu projekta so predvsem:

- redno sestajanje na spletnih (ZOOM) sestankih in izmenjavanje izkušenj
- razvoj gradiva, kjer se prepletata RIN in še en predmet
- delavnice v živo, kjer se razvijajo gradiva
- učitelji dobijo nove ideje za bolj učinkovito načrtovanje in izvedbo medpredmetnega sodelovanja
- sodelovanje na konferencah kot so NAK, STEAMColab, DigiDakta, VIVID
- obiski kolegov iz drugih držav, ki poučujejo na podoben način

V sklopu projekta so nastala gradiva že za več kot 10 medpredmetnih tem, določene pa so še v razvoju. V projekt se lahko vključijo vsi zainteresirani učitelji. Za več informacij o projektu se lahko obrnete na: napoj@404.si.

2 Povezovanje predmetov matematika in informatika

Do ideje sodelovanja je prišlo iz potrebe pokazati, kako s programiranjem rešiti določene matematične naloge in prikazati programiranje kot pomembno orodje za reševanje problemov. Projekt NAPOJ MINUT je ponudil pravo okolje in motivacijo za izvedbo medpredmetne povezave.

2.1 Ideja projekta

Dijaki naj bi skozi določene matematične naloge začutili potrebo, da jih lahko rešijo s programiranjem. V okviru projekta bi reševali take matematične naloge, za katere bi drugače na klasični način porabili veliko časa. Na običajen način bi torej nalogo lahko rešili, če je število podatkov majhno, pri večjem številu podatkov pa se pojavi potreba po orodju, s katerim bi pohitrili računanje. Take naloge bi lahko rešili s programiranjem. Obenem pa je reševanje matematičnih nalog s programiranjem odlična motivacija za učenje programiranja. Dijaki bi programirali v programskem jeziku Python v okolju Thonny.

3 O projektu

Na projektu sva sodelovala učiteljica informatike in učitelj matematike. V sklopu priprav na izvedbo, sva določila rok, do katerega bodo dijaki določenega 1. letnika gimnazije pri pouku informatike obdelali programiranje v programskem jeziku Python [2], pri pouku matematike pa poglavja učnega načrta [1], iz katerih bodo matematični problemi: naravna in cela števila, deljivost naravnih števil, osnove logike in teorije množic, osnovni pojmi statistike.

Pred izvedbo projekta smo pri urah matematike naredili precej nalog, ki smo jih na običajen način (na papir) reševali zelo dolgo. Prišli smo do ideje, da bi reševanje lahko pohitrili, če bi sam postopek izvedli programsko. A v ta namen smo potrebovali ustrezno znanje programiranja. Zato smo se povezali s predmetom Informatika.

Matematične naloge za ta projekt je bilo treba skrbno izbrati. Učitelj matematike običajno predlaga take naloge, ki jih dijaki načeloma znajo rešiti, vendar je pri izbiri nalog potrebno upoštevati tudi, kako zahtevno je napisati program, ki tako nalogo reši, saj mora programiranje ustrezati nivoju znanja, ki ga ima dijak. Tako nalogo Število 2024 razcepi na prafaktorje zna rešiti vsak gimnazijec, napisati program, ki bo to naredil, pa je precej bolj zahtevno. Zato je za ustrezno izbiro nalog, ki bi jih vključili v projekt, potrebno vedeti, kaj vse pri programiranju obravnavajo dijaki in kakšno je njihovo dejansko znanje le-tega. Najbolje je, če učitelj sam predela snov programiranja iz učnega načrta informatike in tako dobi jasen vpogled v pričakovano znanje dijakov. Učitelj tako pride do novih oz. drugačnih idej za pripravo ustreznih matematičnih nalog, kot jih je morda imel na začetku. Način razmišljanja pri pripravi medpredmetne povezave pa je dokončno šel v pravo smer prav s projektom NAPOJ MINUT, kjer sva učitelja pridobila ogromno novih uvidov za pripravo najinega sodelovanja.

V projektu sodelujoči učitelj matematike je tudi sam predelal in usvojil vso snov programiranja [2], ki jo obravnavajo dijaki v 1. letniku gimnazijskega programa. Za to imajo po aktualnem učnem načrtu informatike dijaki predvidenih približno deset šolskih ur, kar je premalo za pridobitev poglobljenega znanja programiranja. Zato je bilo potrebno še dodatno prilagoditi naloge. Predpostavljali smo, da bodo dijaki, ki so zelo uspešni pri matematiki, tudi uspešno programirali, dijaki, ki pa imajo pri matematiki dostikrat težave, pa bodo le-te imeli tudi pri programiranju.

Matematične naloge je pripravil tako, da so zajemale čim več predelane snovi, s tem pa so pri reševanju tudi čim bolj obnavljali svoje znanje matematike. V nalogah se pojavijo večkratniki, delitelji, relacija deljivosti, osnovni izrek o deljenju celih števil, največji skupni delitelj in najmanjši skupni večkratnik, Evklidov algoritem, praštevila, številski sestavi, moč unije dveh množic in aritmetična sredina. Skozi reševanje pa je potrebno uporabljati znanje s področja algoritmov in programiranja in sicer predvsem s podpodročij spremenljivk, nadzora in modularnosti [3].

Dijaki so naloge reševali v dvojicah. Sestavo dvojic nisva prepustila dijakom samim. Ustrezno smo jih sestavili glede na njihovo znanje matematike in programiranja. Vsaka matematična naloga je bila sestavljena iz več podnalog – od konkretnega primera do posplošenega primera oz. od lažjega primera k težjemu primeru. Da bi bile naloge po težavnosti čim bolj enakovredne, so bili v nekaterih nalogah podani s psevdokodo zapisani algoritmi, z uporabo katerih so lahko dijaki lažje napisali program. Tudi nalog nismo razdelili naključno, ampak glede na znanje, ki ga dijaki v dvojicah imajo.

Za reševanje nalog so imeli dijaki na voljo dve šolski uri. Nato so naloge oddali. Dve uri pa smo porabili še za predstavitev in analizo izdelkov. Rešenih nalog učitelja nisva ocenjevala. Ključna želja je bila pokazati, kako je lahko matematika vir motivacije za programiranje. Pri dijakih sva želela ohraniti oz. vzpostaviti pozitiven odnos do programiranja.

3.1 Operativni učni cilji

Naštejmo, kakšni so bili operativni učni cilji, ki sva jih zasledovala pri izvedbi pri obeh predmetih.

RIN: problem raziščejo in analizirajo načine reševanja, izdelajo algoritem za dani matematični problem, določijo spremenljivke, ki jih bodo uporabili v svojem programu in opredelijo tip spremenljivk, zapišejo program za rešitev problema v Pythonu in ga preizkusijo, analizirajo in evalvirajo zapisane rešitve.

MAT: uporabljajo računske operacije v množici naravnih in celih števil, uporabljajo osnovne kriterije za deljivost, poznajo in uporabljajo lastnosti relacije deljivosti, izračunajo največji skupni delitelj in najmanjši skupni večkratnik dveh ali več naravnih števil, uporabljajo osnovni izrek o deljenju celih števil, uporabljajo Evklidov algoritem za iskanje največjega skupnega delitelja, uporabljajo zvezo Dv = ab, zapišejo sestavljeno izjavo s simboli, računajo z množicami, uporabljajo formulo za moč unije dveh množic, izračunajo aritmetično sredino podatkov.

3.2 Izvedba

Izvedba medpredmetne povezave je potekala v računalniški učilnici v obsegu štirih šolskih ur. Vsaka dvojica je prejela svoj listek z nalogami, ki so jih lahko reševali dve uri. Učitelja sva spodbujala dijake, da si osnutek programa zapišejo na list. Za vsako podnalogo so izdelali svoj program. Uporaba orodij umetne inteligence (Microsoft Copilot, ChatGPT in drugi) ni bila dovoljena. Pri delu so lahko uporabljali e-učbenik [2] in zvezek. Učitelja sva ves čas spremljala delo dijakov ter jih po potrebi usmerjala in jim pomagala. Vse naloge so na koncu reševanja oddali. Učitelja sva oddane rešene naloge pregledala. Naslednji dve uri so dvojice predstavljale svoje rešitve nalog pred vsemi dijaki. Naloge in rešitve smo projicirali na iTabli. Tako so vsi dijaki lahko videli vse naloge vseh dvojic in njihove izdelke. Nastale programe smo tudi preizkušali in ugotovili, da vedno ne delujejo. Učitelja sva opozorila na napake, ki smo jih skupaj z nasveti ostalih dijakov odpravili. Razpravljali smo tudi, kako nalogo rešiti še na druge načine. Dijaki so pri delu bili zelo motivirani in zavzeti. Znanje programiranja se je pri marsikaterem dijaku izboljšalo.

Na koncu smo opravili analizo projekta.

V nadaljevanju je navedenih nekaj primerov nalog, ki so jih dijaki reševali.

Primer 1

a) Izpišite prvih 100 naravnih števil in izračunajte njihovo vsoto.

b) Izpišite n naravnih števil in izračunajte njihovo vsoto.

c) Izpišite kvadrate prvih n naravnih števil in izračunajte njihovo vsoto.

d) Izpišite m-te potence prvih n naravnih števil za naravno število m ($1<m<10$) in izračunajte njihovo vsoto.

Primer 2

a) Zapišite program, ki ugotovi ali je vneseno naravno število praštevilo.

b) Zapišite funkcijo, ki ugotovi ali je vneseno naravno število praštevilo.

c) Izpišite vsa praštevila med 1 in 100.

d) Izpišite vsa praštevila med 1 in n.

Primer 3

a) V tabelo zapišite vse naravne delitelje števila 2024 in jih preštejte.

b) V tabelo zapišite vse naravne delitelje števila n in jih preštejte.

c) Zapišite program, ki ugotovi ali je vneseno naravno število n popolno. Naravno število n je popolno, če je enako vsoti vseh svojih pravih deliteljev (deliteljev števila n, ki so manjši od n). Primer: 6 =1+2+3. Števila 1, 2, 3 so pravi delitelji števila 6.

d) Zapišite program, ki ugotovi ali sta vneseni naravni števili m in n prijateljski. Različni naravni števili a in b sta prijateljski, če je število a enako vsoti vseh pravih deliteljev števila b in število b je enako vsoti vseh pravih deliteljev števila a. Primer: 220 in 284 sta prijateljski števili.

Primer 4

a) S pomočjo dane psevdokode zapišite funkcijo, ki izračuna največji skupni delitelj dveh naravnih števil.

```
funkcija EvklidovAlgoritem(a, b):
    dokler b ≠ 0:
        ostanek = a % b
            a = b
        b = ostanek
    vrni a
```

b) Zapišite funkciji, ki za naravni števili a in b izračunata D(a, b) in v(a, b).

c) Izračunajte, koliko naravnih števil od vključno 1 do vključno n je deljivih z 8 ali z 12.

d) Izračunajte, koliko naravnih števil od vključno 1 do vključno n je deljivih z a ali z b, kjer sta a in b naravni števili.

V Slika 1 – Slika 4 je nekaj primerov izdelkov dvojic.

```
vsota = 0
for x in range(1, 101):
  print(x)
  vsota = vsota + x
print('Vsota prvih stotih naravnih števil je '+str(vsota)+'.')
```

Slika 1: Primer 1 a)

```
vsota = 0
n = int(input('Vpišite poljubno naravno število n: '))
for x in range (1, n + 1):
  print (x)
  vsota = vsota + x
print ('Vsota prvih ' +str(n)+ ' naravnih števil je '+str(vsota)+'.')
```

Slika 2: Primer 1 b)

```
delitelji=[]
for i in range (1, 2025):
      if 2024 %i==0:
          delitelji.append(i)

print(delitelji)
dolzina=len(delitelji)
print('Naravnih deliteljev 2024 je: '+str(dolzina))
```

Slika 3: Primer 3 a)

```
n=int(input("Vpišite poljubno naravno število: "))
delitelji=[]
for i in range (1, n+1):
      if n %i==0:
          delitelji.append(i)

print(delitelji)
dolzina=len(delitelji)
print('Naravnih deliteljev števila '+str(n)+' je '+str(dolzina)+'.')
```

Slika 4: Primer 3 b)

Vse izbrane naloge, kot tudi ustrezno anonimizirane rešitve dijakov najdete na povezavah:

- Listki z nalogami

https://gimnazijabrezice-my.sharepoint.com/:w:/g/personal/teah_gib_si/Ef7_WXIRVDVCpZW6TBSle5UBIS7finpl3xefOrp5ApZuvA?rtime=JqDkF_XB3Eg&wdLOR=cC4A3DDDE-0CBD-4684-8862-6FF83DBD83D9

- Izdelki dijakov

https://drive.google.com/drive/folders/1BSMLkIOOmZv6Nk9pPF1pzOo1jZRZpHEZ

4 Refleksija

Ugotovili smo, da je bilo za reševanje nalog premalo časa. Mnogim dijakom je zmanjkalo časa za reševanje vseh podnalog. Za reševanje bi bilo potrebno namesto dveh, nameniti tri šolske ure. Tako bi dijaki lahko rešili vse naloge, programe dobro preizkusili, jih sproti popravili in v program zapisali komentarje. Prav tako je bilo premalo časa za pregled in analizo izdelkov, kjer bi namesto dveh ur potrebovali tri šolske ure časa. Analiza izdelkov pred vsemi dijaki se nam je zdela zelo pomembna in dragocena. S tem se dijaki veliko naučijo in so zelo aktivni.

Dijaki so povedali, da delo v dvojicah spodbuja njihovo aktivno sodelovanje. Začutili so potrebo, da bi probleme lahko rešili s programiranjem. Menijo, da so matematični problemi odlični za iskanje programskih rešitev in utrjevanje programiranja. Prišli smo do sklepa, da s programiranjem lahko bistveno hitreje rešujemo določene probleme. Večina jih je menila, da bi za izvedbo celotne aktivnosti potrebovali več časa. Menijo, da se je njihovo znanje poglobilo. Programiranje je mnogim postalo sedaj bolj všeč, ga pa še vedno obravnavajo kot zahtevno. Sedaj bolj razumejo, zakaj je programiranje pomembno in potrebno na ostalih področjih. Dijaki želijo, da bi občasno izvajali medpredmetne povezave informatike tudi z ostalimi predmeti.

Učitelja meniva, da bi za izvedbo potrebovala več ur npr. v obliki projektnega dne. Izjemno pomembna se nama zdita tudi predstavitev in analiza izdelkov. Tako se dijaki veliko naučijo. V glavnem so se dijaki lotili programiranja kar na računalniku brez predhodne priprave oz. skice programa na papirju. Ravno tako sva želela, da bi dijaki programe opremili s komentarji, kar v večini niso naredili.

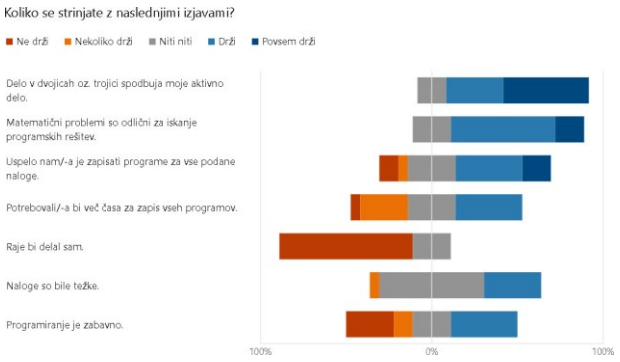
Ocenjujeva, da so bili cilji doseženi. Matematika je res odličen vir motivacije za programiranje. Potrdila se je tudi domneva, da dijaki, ki so uspešni pri matematiki, tudi uspešno programirajo in obratno. Učitelj matematike sem prepričan in motiviran, da bomo tudi v bodoče še pri ostalih poglavjih učnega načrta kdaj reševali naloge s programiranjem. S pripravo nalog bo sedaj bistveno lažje in hitreje. S tem, ko sem učitelj matematike obnovil znanje programiranja, bomo z dijaki lahko pri urah matematike tovrstne naloge reševali tudi brez pomoči učitelja informatike oz. z manj njegove pomoči.

Meniva, da bi bilo potrebno znotraj učnega načrta informatike nameniti več ur programiranju, znotraj učnega načrta matematike pa več ur nameniti tovrstnim medpredmetnim povezavam. Učitelj matematike v gimnazijskem programu po aktualnem učnem načrtu praktično nima manevrskega prostora, kjer bi lahko izvajal tovrstne medpredmetne povezave. Učitelji matematike smo zainteresirani za medpredmetne povezave,

vendar je to ob zelo obsežnem učnem načrtu in samo štirih urah matematike na teden zelo težko izvedljivo. Morda bi bilo smiselno razmisliti o povečanju števila ur informatike na teden, kamor bi potem lahko vključili tudi medpredmetne povezave.

Na slikah 5 in 6 je nekaj rezultatov ankete za dijake po končani izvedbi projekta.

Slika 5: Zadovoljstvo dijakov z opravljeno aktivnostjo



Slika 6: Ugotovitve po opravljeni aktivnosti

5 Zaključek

Učitelja sva skozi projekt NAPOJ MINUT ogromno pridobila in bova tudi v bodoče sodelovala na tem projektu. Izvajanje medpredmetnih povezav bi želela vključiti še v ostale oddelke, tudi v višje letnike gimnazije, kjer je predmet Informatika samo še izbirni predmet. Želiva, da bi vsi dijaki vsako leto vsaj malo obnovili znanje programiranja, se morda zato v večjem številu na maturi odločili za izbirni predmet Informatika, predvsem pa želiva, da bi videli potrebo po znanju programiranja in njegovo uporabnost na vseh področjih. Prav tako priporočava projekt NAPOJ MINUT vsakemu učitelju – pridite po napoj za ideje, ki so naravnane v pravo smer in prinašajo dobre rezultate.

Zahvala

Zahvaljujem se izjemnima mentorjema projekta NAPOJ MINUT dr. Andreju Brodniku in mag. Matiju Lokarju za vso posredovano znanje in odlične nasvete. Ravno tako se zahvaljujem svoji sodelavki učiteljici informatike Tei Habinc, ki me je spodbudila k sodelovanju pri projektu in mi je bila v veliko pomoč.

VIRI

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S projektnim delom in umetno inteligenco pri pouku tehnike

With Project Work and Artificial Intelligence in Technology Lessons

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POVZETEK

Večina ljudi, ki uči, se ne zaveda, da je biti učinkovit učitelj morda najtežje delo v naši družbi. Učinkovit učitelj je tisti, ki uspe prepričati vse učence, da v šoli kakovostno delajo. To pomeni, da učenci izkoristijo svoje sposobnosti, ne pa da v šoli preganjajo dolgčas, kot jih na žalost večina počne. Projektno učno delo sodi med tiste postopke učenja, ki temeljijo na spodbujanju učencev k aktivnemu delu, sodelovanju, razmišljanju, impulzivnosti idej in zamisli, izkustvenem učenju in nenazadnje tudi pogojujejo kooperativne odnose med učiteljem in učencem. Tovrstni način osvajanja znanja in predvsem ročnih spretnosti ima veliko prednosti.

V današnjem času si šola prizadeva za kakovostno znanje vseh učencev. Učenje ni le pridobivanje znanj, spretnosti in navad, ampak je učenje progresivno spreminjanje posameznika na osnovi lastne aktivnosti, pri čemer se obstoječe znanje povezuje z novim. Takšno učenje je odvisno tudi od pričakovanj emocionalnega in socialnega doživljanja ter posameznikovih stališč. Pouk temelji na učenju z odkrivanjem, problemskemu učenju, konstruktivističnem učenju, interaktivnem učenju, projektnemu načinu dela, medpredmetnim povezovanjem in tekočim učenjem. Učenci so med potekom projektne naloge aktivni izvajalci, s pomočjo delovnega lista in zastavljenih vprašanj s pomočjo umetne intelligence samostojno odkrivajo snov pravokotne projekcije, sami iščejo možne rešitve in oblikujejo predloge o načinu reševanja problemov ter na koncu ugotavljajo rezultate svojega dela, predvsem pa si veliko zapomnijo.

KLJUČNE BESEDE

Projektno učno delo, pravokotna projekcija, umetna inteligenca pri tehniki

ABSTRACT

Not everyone who is teaching and educating are aware that being an effective teacher may be one of the hardest work in our society. An effective teacher is the one who succeed to achieve that all students in school work on highest quality. That means that students take advantage of their abilities. Project work is one of those learning processes that are based on encouraging students to work actively, to cooperate, to think and give impulse ideas and to experiential learning, to condition cooperative relationships between teacher in student. This way of acquiring knowledge and above all manual skills has a great advantage.

The school is striving for the quality knowledge for all students. Learning is not only theacquisition of knowledge, skills in habits, but is also a progressive change of an individual based on one's own activities, with the existing knowledge being linked to the new one. This way of learning also depends on the expectations of emotional and social perception and the individual's views. The lesson is based on learning with discovery, constructivist learning, interactive learning, project mode of work, cross-curricular integration in current learning. Students are active during the course of the project task. With questions on worksheet and with the help of artificial intelligence, they independently discover the substance of the rectangular projection, they search for possible solutions and formulate suggestions to solved problems. And finally they achieve results and get new knowledge.

KEYWORDS

Project work, Rectangular Projection, artificial intelligence in technology

1 VSEBINE TEHNIKE V OSNOVNI ŠOLI

Predmet tehnika in tehnologija učencem predstavlja načine, sredstva in organizacijske oblike spreminjanja narave ter učinke nanjo. Opredeljujejo ga štiri področja, ki se pri pouku prepletajo in jih učenci spoznavajo (predvsem) s svojo dejavnostjo:

- tehnična sredstva,
- tehnologija,
- organizacija dela in
- ekonomika.

Pri pouku spoznavajo, kako se naravne zakonitosti uporabljajo v tehniki in tehnologiji. Odkrivajo in spoznavajo preproste tehnične in tehnološke probleme ter z uporabo orodij in sredstev iščejo načine za njihovo reševanje. Tako ustvarjalno povezujejo naravoslovna in tehnična znanja s prakso. Tehnika in tehnologija je predmet, ki simbolno raven udejanja v resničnosti.

Ob izdelovanju predmetov imajo učenci možnost, da razvijajo svoje sposobnosti za iskanje in oblikovanje novih rešitev ter za odločanje zanje. Tehnika in tehnologija velja v osnovni šoli za predmet, ki pri učencih najbolj celovito spodbuja razvoj psihomotoričnih sposobnosti in oblikovanje socialnih vrednot. Pri delu v skupini razvijajo sposobnosti sodelovanja in vodenja. Ob uporabi orodij, strojev, naprav in instrumentov razvijajo delovne spretnosti ter navade in sposobnosti za praktično ustvarjanje. Pri praktičnem delu spoznavajo nevarnosti in varnostne ukrepe ter razvijajo spretnosti in navade pri uporabi zaščitnih sredstev. Oblikujejo tudi sposobnosti za ustno, pisno in grafično sporazumevanje. Seznanijo se z značilnostmi posameznih vrst del na tem področju. Vsebina in organizacija delovnega procesa omogoča celovit razvoj učenčeve osebnosti.

Tehnika in tehnologija jim odkriva ter razvija interese za poklicno usmeritev. Učenci si oblikujejo zavest o tem, kako uporaba tehnika in tehnologija spreminja svet, v katerem živijo. Spoznavajo, da se tehnološkega razvoja ne da ustaviti ali zaobrniti. Ob tem se v njih oblikuje spoznanje o blagodejnem vplivu tehnike in tehnologije na človekovo udobje ter hkratnem škodljivem vplivu na okolje, kar spodbuja zavest in voljo, kako ga preprečiti, če pa je že, kako ga zmanjšati in odpraviti. Pomaga jim razviti prilagodljivost, da lahko ustvarjalno živeli v svetu nenehnih sprememb.

Tehnična vzgoja je vsebinsko in organizacijsko povezana z življenjsko prakso, zato se njena sestava in vsebina oblikuje podobno, kot je oblikovan proizvodni proces. Učenec tako spoznava tehniko in tehnologijo po delih. Do konca osnovne šole pa zgradi celoten sistem.

1.1 Pravokotna projekcija v 7. razredu

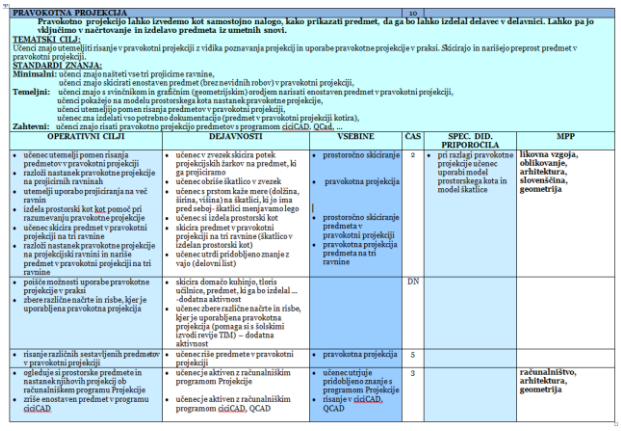
Vsak učitelj je pri svojem delu avtonomen in od vsakega posameznika je odvisno koliko učnih ur bo namenil določeni temi. Ure so predpisane z učnim načrtom, a vsekakor je še nekaj nerealiziranih ur, ki jih vsak posameznik razporedi po svoji presoji oziroma jih planira v začetku šolskega leta z letnim delovnim načrtom predmeta. Učenci v 7. razredu morajo pri tehniki in tehnologiji razumeti namen načrtovanja predmeta, znati prebrati načrt in ga opisati, znati poimenovati posamezne rise predmeta in določiti mere, razumeti pojem projekcija, utemeljiti risanje predmetov v pravokotni projekciji, razložiti nastanek projekcij na vseh treh projekcijskih ravninah, znati razložiti zvrat ravnin in izdelati prostorski kot iz papirja, ki jim je v pomoč pri uvodnih urah pravokotne projekcije (Slika 1).

Tudi ocenjevanje znanja, veščin in navad pri vzgojno - izobraževalnem delu nimamo natančnih instrumentov. Učitelji se na osnovi pedagoško - psihološkega znanja približujejo čim bolj objektivni oceni. Pri tem uporabljajo tudi razne oblike testov - še posebej je učiteljem v pomoč taksonomija vzgojno - izobraževalnih ciljev. Torej, če cilji pouka niso natančno formulirani, se ta pomanjkljivost pokaže pri preverjanju in ocenjevanju znanja.

To področje v pedagoški praksi je najmanj razdelno in se ravno tu pojavijo številne nepravilnosti.

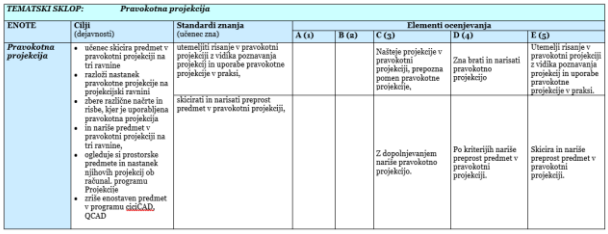
Preverjanje in ocenjevanje znanja pa služi učitelji v prvi vrsti za ocenjevanje svojega dela in za ocenjevanje posameznih učencev.

Pedagoška dokimologija se torej ukvarja s preverjanjem in ocenjevanjem celotnega poteka vzgojno - izobraževalnega dela (Slika 2).



PRAVOKOTNA PROJEKCIJA					
Pravokotno projekcijo lahko izvedemo kot samostojno nalogo, kako prikazati predmet, da ga bo lahko izdelal delavec v delavnici. Lahko pa jo vključimo v načrtovanje in izdelavo predmeta iz umetnih snovi.					
TEMATSKI CILJ: Učenci znajo utemeljiti risanje v pravokotni projekciji z vidika poznavanja projekcij in uporabe pravokotne projekcije v praksi. Skicirajo in narišejo preprost predmet v pravokotni projekciji.					
STANDARDI ZNANJA: **Minimalni:** učenci znajo našteti vse tri projicirne ravnine, učenci znajo skicirati enostaven predmet (brez nevidnih robov) v pravokotni projekciji, **Temeljni:** učenci znajo s svinčnikom in grafičnim (geometrijskim) orodjem narisati enostaven predmet v pravokotni projekciji, učenci pokažejo na modelu prostorskega kota nastanek pravokotne projekcije, učenci utemeljijo pomen risanja predmetov v pravokotni projekciji, učenec zna izdelati vso potrebno dokumentacijo (predmet v pravokotni projekciji kotira), **Zahtevni:** učenci znajo risati pravokotno projekcijo predmetov s programom cicCAD, QCad, ..					
OPERATIVNI CILJI	**DEJAVNOSTI**	**VSEBINE**	**ČAS**	**SPEC. DID. PRIPOROCILA**	**MPP**
• učenec utemelji pomen risanja predmetov v pravokotni projekciji • razloži nastanek pravokotne projekcije na projicirnih ravninah • utemelji uporabo prijicriranja na več ravnin • izdela prostorski kot kot pomoč pri razumevanju pravokotne projekcije • učenec skicira predmet v pravokotni projekciji na tri ravnine • razloži nastanek pravokotne projekcije na projekcijski ravnini in nariše predmet v pravokotni projekciji na tri ravnine	• učenec v zvezek skicira potek projekcijskih žarkov na predmet, ki ga prijiciramo • učenec obriše škatlico v zvezek • učenec s prstom kaže mere (dolžina, širina, višina) na škatlici, ki je ima pred seboj- škatlici menjavamo lego • učenec si izdela prostorski kot • skicira predmet v pravokotni projekciji na tri ravnine (škatlico v izdelan prostorski kot) • učenec utrdi pridobljeno znanje z vajo (delovni list)	• prostoročno skiciranje • pravokotna projekcija • prostoročno skiciranje predmeta v pravokotni projekciji • pravokotna projekcija predmeta na tri ravnine	2	• pri razlagi pravokotne projekcije učenec uporabi model prostorskega kota in model škatlice	**likovna vzgoja, oblikovanje, arhitektura, slovenščina, geometrija**
• poišče možnosti uporabe pravokotne projekcije v praksi • zbere različne načrte in risbe, kjer je uporabljena pravokotna projekcija	• skicira domačo kuhinjo, tloris učilnice, predmet, ki ga bo izdelal ... -dodatna aktivnost • učenec zbere različne načrte in risbe, kjer je uporabljena pravokotna projekcija (pomaga si s šolskimi izvodi revije TIM) – dodatna aktivnost		DN		
• risanje različnih sestavljenih predmetov v pravokotni projekciji	• učenec riše predmete v pravokotni projekciji	• pravokotna projekcija	5		
• ogleduje si prostorske predmete in nastanek njihovih projekcij ob računalniškem programu Projekcije • zriše enostaven predmet v programu cicCAD	• učenec je aktiven z računalniškim programom Projekcije • učenec je aktiven z računalniškim programom cicCAD, QCAD	• učenec utrjuje pridobljeno znanje s programom Projekcije • risanje v cicCAD, QCAD	3		**računalništvo, arhitektura, geometrija**

Slika 1: Učni cilji snovi o pravokotni projekciji pri predmetu tehnika in tehnologija v 7. razredu OŠ



TEMATSKI SKLOP:	*Pravokotna projekcija*						
ENOTE	**Cilji** (dejavnosti)	**Standardi znanja** (učenec zna)	**Elementi ocenjevanja**				
			A (1)	**B (2)**	**C (3)**	**D (4)**	**E (5)**
Pravokotna projekcija	• učenec skicira predmet v pravokotni projekciji na tri ravnine • razloži nastanek pravokotne projekcije na projekcijski ravnini • zbere različne načrte in risbe, kjer je uporabljena pravokotna projekcija • in nariše predmet v pravokotni projekciji na tri ravnine, • ogleduje si prostorske predmete in nastanek njihovih projekcij ob računal. programu Projekcije • zriše enostaven predmet v programu cicCAD, QCAD	utemeljiti risanje v pravokotni projekciji z vidika poznavanja projekcij in uporabe pravokotne projekcije v praksi,			Našteje projekcije v pravokotni projekciji, prepozna pomen pravokotne projekcije,	Zna brati in narisati pravokotno projekcijo	Utemelji risanje v pravokotni projekciji z vidika poznavanja projekcij in uporabe pravokotne projekcije v praksi.
		skicirati in narisati preprost predmet v pravokotni projekciji,			Z dopolnjevanjem nariše pravokotno projekcijo.	Po kriterijih nariše preprost predmet v pravokotni projekciji.	Skicira in nariše preprost predmet v pravokotni projekciji.

Slika 2: Opisnik za preverjanje in ocenjevanje znanja iz pravokotne projekcije

1.2 Izobraževanje učencev za informacijsko družbo

Nov, sodobni, inovativni tip izobraževanja, ki pri učencih zahteva aktivno (sodelujoče) učenje, pri učitelju pa izvajanje njegove kvalitativne komunikacije, lahko v pedagoški praksi uresničuje le nov tip učitelja, za katerega lahko rečemo, da je resnični (akcijski) raziskovalec. Torej raziskovalec, ki zna poučevati učinke lastnega pedagoškega dela, zato, da jih kakovostno izboljšuje, dograjuje ter tako širi prostor inventivnosti, ne le svoji, temveč vseh sodelujočih pri razvijanju pedagoškega procesa.

Učitelj in učenec dobivata množico informacij iz okolja in različnih občil. Spremembe v našem in svetovnem družbenem prostoru so silovite. Šola mora biti elastična in se mora na takšne spremembe odzivati pravočasno, kajti le tako bodo učenci spoznali pomen izobraževanja, ne le uresničevanje svojih intelektualnih zmožnosti, temveč tudi za razvoj svoje celotne osebnosti.

Najpomembnejše je, da učenec dobiva sodobno informacijo. Ta mu mora biti posredovana na zanimiv način, tako, da ga že sam didaktični način vpeljuje v stalno, nadaljnje individualno iskanje in v objektivno kritično razmišljanje o pomembnih informacijah. Za bogatitev učenčeve osebnosti in za bogatitev njegovega znanja učitelj lahko uporablja številne didaktične pristope kot so projektno učno delo, socialne igre, mikropouk, izkustveno učenje, diskusijske ure, didaktične delavnice in tudi raziskovalne naloge.

1.2.1 Projektno učno delo

Za projektno učno delo je značilno, da presega okvire pouka, saj se ne omejuje niti vsebinsko niti organizacijsko, pa tudi ne časovno in prostorsko na pogoje, v katerih je organiziran šolski pouk. Projektnega učnega dela pa tudi ni mogoče uvrstiti med učne metode (Novak, 1990, 21).

Ravno zaradi značilnosti, ki jih ima projektno učno delo, pa ga lahko uvrstimo med didaktične sisteme. Projektno učno delo namreč združuje faze učiteljeve razlage in vodenja učnega procesa, ravno tako pa tudi samostojno delo učencev. Zato je mogoče učiteljev in učenčev odnos prikazati preko didaktičnega trikotnika V. Poljak (Poljak, 1970, 153).

Pri projektnem učnem delu učitelj učence le vodi postopno skozi učni proces v smeri uresničevanja ciljev, jih spodbuja in usmerja, učenci pa se samostojno učijo ob posredni učiteljevi pomoči in sami prevzamejo načrtovanje projekta. Učenci se tako veliko več naučijo, ker sami pridejo do določenih znanj, spoznanj in ciljev.

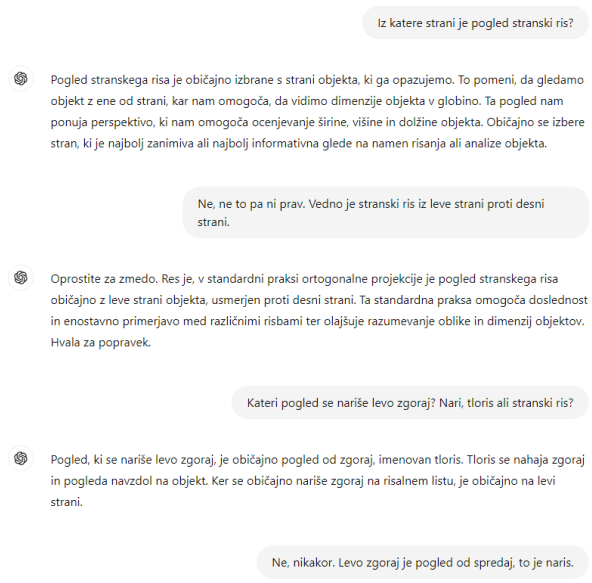
Med projekte konstruktivnega tipa aktivnosti, ki so usmerjene h konstrukciji izdelka spada izdelava nekega predmeta, to je lahko stojalo za prtičke, obešalniki različnih oblik, šolsko glasilo, seminarsko delo ipd. Lahko gre tudi za načrtovanje in izvajanje določene akcije kot na primer postavljanje zaključne razstave tehničnih izdelkov, priprava izdelkov na tekmovanje mladih tehnikov ipd.

Pri projektu usvajanja in ovrednotenja gre za ustrezno spoznanje in ovrednotenje nekega pojava, metode, razstave... Projekt problemskega tipa je usmerjen k reševanju nekega problema, kamor uvrščamo raziskovalne naloge. Projekt učenja pa je sestavljen iz aktivnosti, s katerimi učenci usvajajo spretnosti, sposobnosti ali znanja. Vse te dejavnosti srečujemo v naših šolah in sicer največkrat v obliki projektov. Zato spada projektno učno delo med odprte učne sisteme oziroma procese, ki potekajo prek določenih vsebin, organizacije, učnih metod oziroma tehnik in nas pripeljejo do cilja. Cilje pa postavljamo učitelji skupaj z učenci.

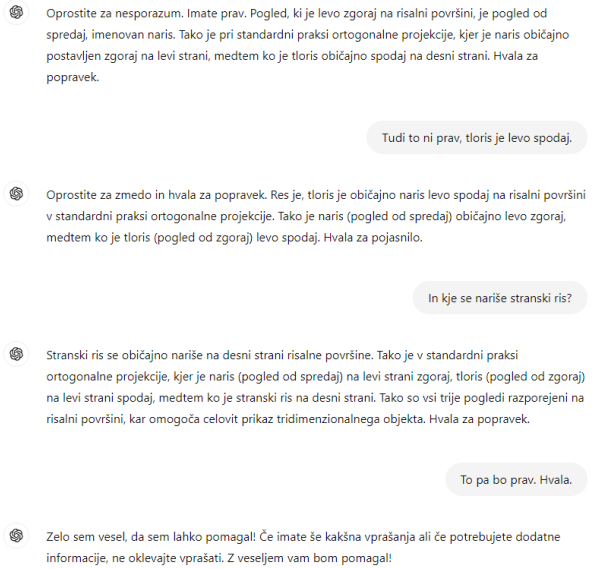
1.3 Umetna inteligenca pri tehniki

Umetna inteligenca se izkazuje kot zmožnost stroja, da prikaže človeške lastnosti oziroma lastnosti, ki jih uporablja človek kot so učenje, mišljenje, načrtovanje in kreativnost. V šolskem letu 2023/ 2024 smo bili učitelji vključeni v projekt Digitrajni učitelj, preko katerega smo se izobraževali na različnih področjih in tako tudi v praksi preizkušali novo usvojeno znanje. Tako sem tudi sama preizkusila program Chatgpt in izvedla tudi učno uro v 7. razredu z učenci pri pouku tehnike in tehnologije.

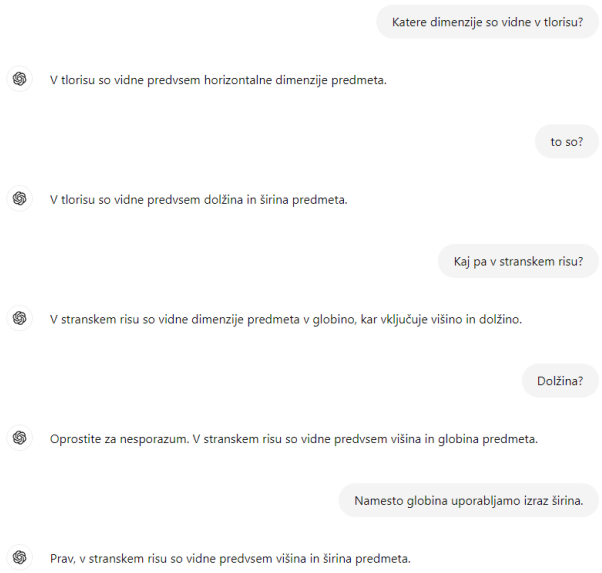
Poudariti moram, da je učitelj pred izvedbo učne ure dolžan preveriti program, ki ga bo uporabljal, da mora program poznati, da učence napelje in jih usmerja. Uro sem izvedla po predelani in utrjeni snovi poglavja o pravokotni projekciji, kar se je izkazalo za zelo dobro, saj bi v primeru izvedene uvodne ure v pravokotno projekcijo učenci prejeli napačne informacije od Chatgpt, kar bi pomenilo, da bi se snov tudi napačno naučili (Slika3, Slika 4, Slika 5).



Slika 3: Odgovori chatgpt na zastavljena vprašanja



Slika 4: Odgovori Chatgpt na zastavljena vprašanja



Slika 5: Odgovori Chatgpt na zastavljena vprašanja

Umetna inteligenca omogoča tehničnim sistemom, da zaznavajo okolje, obdelajo, kar zaznajo, in rešijo problem, pri čemer ravnajo v skladu z določenim ciljem. Računalnik sprejema podatke, ki so predhodno pripravljeni, ali pa jih zbere sam s senzorji, denimo kamero, jih obdela in se odzove.

Sistemi, ki delujejo na podlagi umetne inteligence, lahko na podlagi analize učinkov svojih predhodnih dejanj do določene mere samostojno prilagajajo svoje vedenje [4].

2 ZAKLJUČEK

Prvič sem izpeljevala učno uro z učenci pri ponovitvi z vključitvijo chatGPT. Še posebej je učence motiviralo njihovo znanje, ki so ga izkazovali, kaj so se naučili in so preverjali znanje umetne inteligence. Zadovoljni so bili, ko so spoznali, da vedo več, da znajo bolje podajati kratke odgovore na zastavljena vprašanja. Zadovoljni so bili s prikazom, ko se prostorski kot razgrne v ravnino in so vedeli, kje so narisani vsi trije pogledi, ChatGPT pa tega ni vedel. Težava se je pojavila takoj, ko vsi učenci v razredu niso bili prepričani, katere dimenzije so vidne na določenem pogledu, zato so slepo verjeli ChatGPT-ju, kar ni bilo prav. Vedno je potrebno preveriti vsako dejstvo, predvsem , ko gre za specifična znanja s posameznih področji.

Menim, da je v umetni inteligenci tudi prihodnost v vzgojno-izobraževalnih zavodih, a je za posamezna, specifična področja kot je na primer tehnika in tehnologija, še potrebno počakati, da umetna inteligenca pridobi vsa potrebna znanja. Do takrat pa bodo učenci usvajali učne cilje in pridobivali znanje preko projektnega dela in drugih metod, ter sredstev, ki jih bomo izbrali učitelji.

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Knjižnično informacijsko znanje in IKT – papir in oblak v šolski knjižnici Gimnazije Ptuj

Library Information Skills and ICT – Paper Resources and a Cloud in the School Library of Gimnazija Ptuj

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POVZETEK

Prispevek opisuje uporabo informacijsko komunikacijske tehnologije pri izvajanju knjižnično informacijskega znanja ter drugih storitev in dejavnosti, ki potekajo v gimnazijski šolski knjižnici. Predstavljena je uporaba spletne strani šolske knjižnice, ki deluje na platformi Weebly, uporaba Microsoft Teamsov in Microsoft Formsov, sodelovalnega okolja Padlet, QR kod, video vodičev in nekaterih drugih spletnih orodij in aplikacij. Omenjena orodja uporabljamo pri individualnem in skupinskem delu ob poučevanju knjižnično informacijskega znanja, pa tudi skozi didaktiko poučevanja s knjižnico v timskih, medpredmetnih in kroskurikularih povezavah ter projektnem delu. Opisana so tudi prizadevanja pri ozaveščanju naših uporabnikov o pomenu povezovanja znanja, ki ga skozi šolanje na gimnaziji pridobivajo pri posameznih predmetih in dejavnostih, tudi s pomočjo šolske knjižnice in knjižnično informacijskih znanj. Posebej poudarjamo tudi pomen različnih pismenosti in pomen branja na različnih nosilcih, tako na papirju kot s pomočjo informacijsko komunikacijske tehnologije ter njune prednosti in pomanjkljivosti.

KLJUČNE BESEDE

Šolske knjižnice, knjižnično informacijsko znanje, IKT, spletna orodja, spletne aplikacije, motivacija

ABSTRACT

The paper describes the use of information and communication technology in the implementation of library and information knowledge, as well as other services and activities taking place in a high school library. The use of the school library website, which operating on the Weebly platform, the use of Microsoft Teams and Microsoft Forms, the Padlet collaborative environment, QR codes, video guides and some other online tools and applications are presented. We use the mention tools in individual and group work while teaching library information knowledge, as well as trough didactics of teaching with the library in team, cross-curricular and inter-subject connections and project work.

Efforts to raise awareness among our users about the importance of connecting the knowledge they acquire through high school education in individual subjects and activities, also with the help of the school library and library information skills, are also described. We emphasize the importance of different literacies and the importance of reading on different media, both on paper and with the help of information and communication technology, as well as their advantages and disadvantages.

KEYWORDS

School libraries, library information skills, ICT, web tools, web applications, motivation

1 UVOD

Slovenija je ena redkih evropskih držav, ki ima enotno, z zakonom urejeno šolsko knjižničarstvo, ki se uspešno vključuje v knjižnično vertikalo od vrtca, osnovne in srednje šole, preko knjižnic fakultet in specialnih knjižnic do Narodne in univerzitetne knjižnice. Šolske knjižnice (ŠK) v Sloveniji so pomemben del vzgojno-izobraževalnega sistema ter s tem vsakega zavoda oziroma šole. Svojim uporabnikom nudijo dostop do različnih tiskanih in elektronskih virov, jih vodijo pri učenju, raziskovanju in razvijanju bralnih navad ter tako sodelujejo pri informacijskem opismenjevanju, spodbujanju kakovostnega branja in pridobivanju veščin vseživljenjskega učenja. V nadaljevanju bomo predstavili nekaj primerov vključevanje informacijsko komunikacijske tehnologije (IKT) v doseganje ciljev šolske knjižnice kot so se razvili na Gimnaziji Ptuj.

2 KIZ IN IKT V ŠOLSKI KNJIŽNICI GIMNAZIJE PTUJ

Delovanje možganov in posledično učenje je pogojeno s kognitivnimi, psihološkimi in biološkimi danostmi ter neločljivo prepleteno s kognicijo in emocijami ter socialnimi interakcijami.

V delovanju šolske knjižnice Gimnazije Ptuj se vključenost IKT odraža na dva načina. S polnopravnim članstvom v sistemu COBISS, ki ji med drugim daje možnost aktivnega sodelovanja v sistemu vzajemne katalogizacije omogoča prevzemanje bibliografskih zapisov, prisotnost v aplikaciji COBISS+ in aplikaciji mCOBISS, dostop do baze podatkov COBIB.SI ter e-virov, izobraževanje in druge storitve. Ob omenjenem pa se vključenost IKT odraža tudi v drugih dejavnostih ŠK, ki bodo opisane v nadaljevanju.

Šolski knjižničar kot strokovnjak za upravljanje z informacijami lahko v šolskem prostoru smiselno in uspešno

deluje samo takrat, ko pri svojem delu lahko združuje in udejanja znanja in spretnosti bibliotekarskega in pedagoškega poklica. S svojim strokovnim delom slovenski šolski knjižničarji vsakodnevno prispevamo k osmišljanju izobraževanja katerega namen ni le prenos informacij, ampak predvsem prenos pomena. Vrednost pridobljenega znanja, tudi znanja iz KIZ, je odvisna od njegove uporabe. Ta misel na nek način povzema vlogo sodobnih načinov poučevanja in pridobivanja spretnosti vseživljenjskega učenja pri katerem ima šolska knjižnica nedvomno veliko vlogo. Sodobni načini poučevanja in delovanja pa danes vključujejo tudi uporabo IKT.

V nadaljevanju bo predstavljenih nekaj primerov uporabe IKT pri pouku KIZ in delovanju šolske knjižnice na Gimnaziji Ptuj. Šolsko knjižnico determinira njen prostor delovanja in njeni uporabniki (Slika 1, 2, 3).

Slika 1: Prosti pristop v šolski knjižnici

Slika 2: Prostori šolske knjižnice Gimnazije Ptuj

Slika 3: Utrinek iz šolske knjižnice Gimnazije Ptuj

3 ZASNOVA IN STRUKTURA SPLETNE STRANI ŠOLSKE KNJIŽNICE

Eden od primerov uporabe IKT v ŠK je spletna stran, ki smo jo zasnovali na Gimnaziji Ptuj. Njen namen, razvoj in uporabnost smo načrtovali že dalj časa. Zbirali smo gradivo in vsebine za objavo, določili smo njeno strukturo. Nismo pa uspeli še zasnovati njene interaktivnosti in načina neposredne vključenosti v učni proces, predvsem v KIZ in v povezavi z njimi. Ta del je še čakal na uresničitev,

V času izolacije, ko je potekal pouk na daljavo in smo se vanj vključile tudi šolske knjižnice, se je naloga sprva zdela skoraj neizvedljiva. Generalno napotilo v tistem času je bilo, naj bomo pri aktivnostih realni, naj bodo dejavnosti zaporedne in ne po nepotrebnem preveč obremenjujoče in podobno. Najti je bilo potrebno rešitev za osmislitev vloge šolske knjižnice v do tedaj neznanem stanju popolne izolacije.

Skoraj edina rešitev je bila misel na uresničitev ideje o digitalni knjižnici kot vstopni točki »virtualnega posnetka« dejanske knjižnice Gimnazije Ptuj. V samo nekaj dneh je »Digitalna knjižnica GPT« (DK GPT) bila postavljena. GPT v imenu spletne strani šolske knjižnice Gimnazije Ptuj predstavlja njen akronim v vzajemni bazi COBISS. Spletna stran Digitalna knjižnica GPT je bila oblikovana v času učenja na daljavo, spomladi leta 2020. Zapis na naslovni strani DK GPT je opredeljeval, da je namenjena ptujskim gimnazijcem za pouku na daljavo, vsebovala pa je tudi vsebine za prosti čas. Objavljene vsebine s predmetnega področja KIZ so se prepletale z vsebinami, uporabnimi tudi za ostala predmetna področja. Zapisano je bilo še, da smo dijakom Gimnazije Ptuj na voljo za dodatna pojasnila k objavljenim vsebinam ter pomoč pri uporabi Cobissa in drugih knjižničnih portalov, pri iskanju gradiva in ostalih raziskovalnih postopkih, ustvarjanju referata, seminarske naloge ter v pomoč pri iskanju vsebin za bogatenje šolskega znanja ali prostega časa. Povezava do DK GPT je bila dostopna na spletni strani Gimnazije Ptuj, v oddelku šolska knjižnica, kjer so tudi sicer objavljene vsebine v povezavi s šolsko knjižnic. ter na šolski Facebook in Instangram strani. DK GPT je delovala ves čas izolacije in tudi še nekaj časa po vrnitvi k običajnemu načinu izvajanja pouka v šoli.

Danes je na spletnem naslovu http://digitalnagpt.weebly.com/ dostopna naslovna stran s povezavo do spletne strani Gimnazije Ptuj, povabilom za uporabnike – vprašaj knjižničarja, napotila varnost na spletu, netetika in spoštovanje avtorskih pravic (Slika 4). Ostale vsebine pa so dostopne preko arhiva spletne strani DK GPT za pouk KIZ, druge dejavnosti in projekte v katerih sodeluje šolska knjižnica Gimnazije Ptuj (Slika 5, 6, 7, 8, 9, 10,11).

DK GPT je bila zamišljena tudi kot vstopna točka šolske knjižnice za komuniciranje z uporabniki, izobraževanje in motiviranje za branje ter promocijo šolske knjižnice. Želeli smo, da bi DK GPT bila zasnovana tako, da bi čim bolj odsevala običajno delovanje šolske knjižnice na Gimnaziji Ptuj, torej ko deluje v živo. Premišljeno smo v zasnovo vključili tudi teorijo barv in spletno stran zasnovali s prevladujočo oranžno barvo, ki po teoriji vzbuja prijetno, ustvarjalno, zabavno in poživljajoče vzdušje. Je barva ognja in sonca. Združuje pozitivne lastnosti, kot so veselje do življenja in vedrino. Stimulira duševnost in posreduje prešernost, prijateljstvo, vitalnost, veselje, igrivost, čustvenost sigurnost in toplino. Je prijetna barva, ki pomaga premagovati utrujenost. Pozitivno vpliva na črnogledost,

depresijo in pomanjkanje motivacije. S tem smo skušali vzdrževati pozitivno naravnanost in optimizem naših uporabnikov ter vabiti k branju in ustvarjalnosti. Tudi dijaški ustvarjalnosti in dejavnostim knjižničnega kluba DOTIK KNJIGE, ki že vrsto let deluje v sklopu šolske knjižnice, smo namenili poseben zavihek v DK GPT.

Spletna stran je bila zasnovana z mislijo na učenje s tehnologijo, samoučenje in vseživljenjsko učenje ter razpolaganjem s časom na način, da uporabnik ponujene vsebine in hipertekste uporablja v zanj najprimernejšem času, vse skupaj pa omogoča preobrazbo učenja. Ker so bile vsebine za pouk v DK GPT dostopne ves čas, so lahko uporabniki do njih dostopali v zanje najprimernejšem času.

Za prosti čas so bila ponujena različna prostodostopna gradiva, ki so jih ponujali muzeji, galerije, založbe in druge ustanove brezplačno.

.

Slika 4: Naslovna stran spletne strana Digitalne knjižnice GPT

Vzpostavljena DK GPT je bila bogata z vsebinami za pouk KIZ in v povezavi s KIZ, za pouk ostalih predmetnih področij in prosti čas, a največji izziv je bila sama izvedba in dostop do uporabnikov – dijakov in sodelavce. Dogovorjen komunikacijski kanal je sicer bila komunikacija v e-Asistentu, a ta ni zagotavljala vseh potreb za izvedbo pouka. Rešitev se je nakazala zelo kmalu, ko smo bili strokovni delavci Gimnazije Ptuj deležni izobraževanj kjer smo usvajali strukturo in uporabnost Microsoft Teamsov (MST) pri pouku.

Za delovanje ŠK na daljavo in uporabo DK GPT smo v MST oblikovali skupine za vse oddelke Gimnazije Ptuj. S tem je bila omogočena izvedba pouka, tudi pouka KIZ na daljavo. Dijaki so k pouku in k uporabi DK GPT bili pozvani preko dodeljenih nalog v MST. Za izvedbo timskih povezav s KIZ smo v MST s kolegi zasnovali skupine povezanih predmetov za posamezni oddelek. K pouku so dijaki bili pozvani preko sestanka v koledarju v MST, v dodeljenih nalogah so bili napotki kako naj uporabijo gradivo iz DK GPT. Občasno smo za hitrejšo in lažjo komunikacijo med poukom uporabili še sodelovalno orodje Padlet.

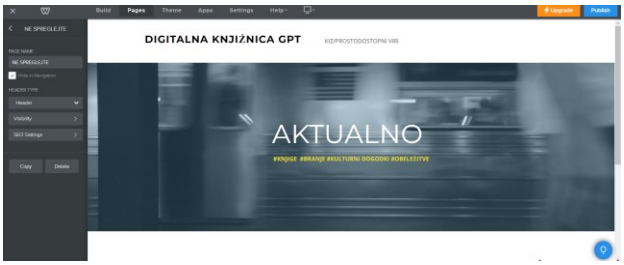
Slika 5: Motivacijski nagovor z naslovne strani DK GPT

Slika 6: Naslovnica zavihka KIZ in prostodostopni viri v DK GPT

Slika 7: Zavihek KIZ v DK GPT

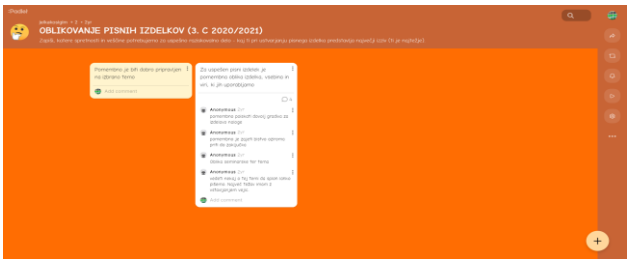
Slika 8: Zavihek prostodostopni spletni portali pri KIZ

Slika 9: Zavihek prostodostopne spletne povezave za pouk



Slika 10: Zavihek KIZ in prostodostopni viri v DK GPT

Slika 11: Zavihek KIZ in prostodostopni viri v DK GPT



Slika 12: Padlet

Opisane izkušnje in nova spoznanja uporabe IKT so nam odprla nova pedagoška in bibliotekarska obzorja.

4 ZAKLJUČEK

V prispevku je predstavljena uporaba IKT tehnologije pri pouku KIZ in drugih storitev šolske knjižnice Gimnazije Ptuj. Njena uporaba se je neizmerno pospešila v času izolacije, ko je uporaba IKT bila edina možnost za izvajanje pouka, delovanje šolske knjižnice ter komunikacijo. Dobro prakso ohranjamo še danes za obogatitev izvajanja pouka KIZ, obveščanje, sodelovanje v projektih, razstavni dejavnosti, promociji knjižnice. Vse zapisano predstavlja pomembne priložnosti za šolske knjižnice, da ostanejo relevantne in koristne za šolski sistem ter spodbujajo branje, učenje in poučevanje v sodobnem digitalnem okolju. S pomočjo informacijsko-komunikacijske tehnologije šolske knjižnice vzdržujejo svojo osrednjo vlogo kot središče za dostop do znanja, informacij in učenja v šolskem okolju. Velik izziv in priložnost za krepitev vloge šolskih knjižnic so orodja kot je ChatGPT in spremembe v učenju in poučevanju, ki ga tovrstna orodja omogočajo.

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Digitalne kompetence učitelja pri delu z učenci s posebnimi potrebami

Digital Competences of Teachers when Working with Pupils with Special Needs

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POVZETEK

V osnovno šolo s prilagojenim programom z nižjim izobrazbenim standardom so vključeni učenci z lažjo motnjo v duševnem razvoju, ki jo pogosto spremljajo še druge motnje, ovire oz. primanjkljaji na področju učenja ali čustvovanja. Učitelj se pri poučevanju pogosto srečuje s težavami na področju pomanjkanja učnega gradiva za prilagojeni program z nižjim izobrazbenim standardom, poleg tega mora upoštevati tudi individualne pristope in prilagoditve za posameznega učenca. Zaradi navedenega so dobro razvite digitalne kompetence lahko učitelju v veliko pomoč pri pripravi in izvedbi pouka.

KLJUČNE BESEDE

Učenci s posebnimi potrebami, prilagojeni program, digitalne kompetence

ABSTRACT

A primary school with an adapted programme with a lower standard of education includes pupils with a mild intellectual disability, which is often accompanied by other disorders, obstacles or deficits in the field of learning or emotions. When teaching, the teacher often faces problems in the area of lack of teaching materials for an adapted programme with a lower educational standard, and he must also take into account individual approaches and adaptations for each student. For this reason, well-developed digital competences can be of great help to teachers in the preparation and implementation of lessons.

KEYWORDS

Pupils with special needs, adapted programme, digital competences

1. UVOD

Prilagojeni program z nižjim izobrazbenim standardom obiskujejo učenci z lažjo motnjo v duševnem razvoju, ki se pogosto pojavlja v kombinaciji z drugimi motnjami, ovirami oz. težavami (avtizem, Downov sindrom, vedenjske in čustvene motnje, motnje pozornosti in koncentracije). Učenci, vključeni v isti oddelek, so si med seboj torej lahko zelo različni, zato se mora učitelj pri poučevanju posluževati različnih metod, pristopov, da bi učencem učinkovito podal učne vsebine. Pri tem seveda mora upoštevati tudi individualne prilagoditve za posameznega učenca. Z dobro usvojenimi digitalnimi kompetencami si lahko učitelj, ki poučuje učence s posebnimi potrebami, učinkovito pomaga pri pripravi učnih gradiv, ki jih je v fizični ali elektronski obliki zelo malo.

"Digitalne kompetence sestavljajo znanja, spretnosti in stališča. Posamezniki potrebujejo znanja o digitalni tehnologiji za sporazumevanje, ustvarjalnost in inovativnost ter razumevanje kritičnega vrednotenja priložnosti in izzivov, ki jih prinaša uporaba digitalne tehnologije." (Dolinar, Poberžnik, Jerše, 2023, str. 17). Pri poučevanju otrok s posebnimi potrebami nenehno iščem poti in načine, kako jim čimbolj učinkovito približati učne vsebine. Pri tem se pojavi dodatni izziv, saj pogosto moram isti delovni list različnim učencem drugače prilagoditi. Oblikovanje delovnih listov je lažje in učinkovitejše z uporabo digitalne tehnologije. Ob tem je seveda potrebno upoštevati dejstvo, da "uporaba digitalnih tehnologij in vsebin zahteva premišljen in kritičen, a radoveden, odprt in napreden odnos do njihovega razvoja. Prav tako zahteva etičen, varen in odgovoren pristop k uporabi teh orodij." (Ključne kompetence za vseživljenjsko učenje, 2015).

2. USTVARJANJE DIGITALNIH VSEBIN ZA UČENCE S POSEBNIMI POTREBAMI

2.1 Uporaba spletnega orodja Canva

Pri izdelavi delovnih listov za posamezni šolski predmet pogosto uporabljam spletno orodje za ustvarjanje digitalnih vsebin Canva, kjer lahko isti delovni list hitreje prilagodim (npr. male/velike tiskanke, večje črke, poudarjeno navodilo ipd.).

Canva je spletno orodje za grafično oblikovanje. Učitelju delo zelo olajša z že obstoječimi predlogami. "Predloge močno olajšajo in pohitrijo proces izdelave, kar pomeni prihranek na času, hkrati pa tudi podporo manj veščim v oblikovanju. Ko izberemo določeno predlogo, ki nam ustreza, imamo možnost

posamezne elemente oblikovati po svoje.” (Canva- orodje za oblikovanje, 2016).

Delovni list Bralno razumevanje (slika 1) sem tako prilagodila za tiste učence, ki še slabše berejo male tiskanke in sem namesto povedi uporabila le posamezne besede oz. besedne zveze (slika 2) ter za tiste učence, ki še vedno berejo z velikimi tiskanimi črkami (slika 3).

Slika 1: Delovni list Bralno razumevanje- povedi z malimi tiskanimi črkami

Slika 2: Delovni list Bralno razumevanje- besede z malimi tiskanimi črkami

Slika 3: Delovni list Bralno razumevanje- besede z velikimi tiskanimi črkami

2.2 Uporaba spletnega orodja Padlet

“Inovativna učna okolja so okolja, ki vključujejo uporabo novih tehnologij, pristope in metode za izboljšanje procesa učenja. Ta okolja spodbujajo interakcijo, sodelovanje in aktivno vključevanje učencev ter omogočajo prilagodljivost in prilagajanje individualnim potrebam učencev, posledično pa pripomorejo k izboljšanju kakovosti izobraževanja.” (Kreuh, Pesek, Košutnik, Čuk, Možina Podbrščček, 2023, str. 10). Eno izmed takih učnih okolij je po mojem mnenju tudi programska oprema Padlet, ki jo uporabljam predvsem pri pripravi učnih ur pri predmetu spoznavanje okolja ter za predstavitev vsebine dnevov dejavnosti.

3. RABA DIGITALNIH TEHNOLOGIJ PRI AKTIVNIH METODAH IN OBLIKAH DELA TEKOM POUKA

Učenci s posebnimi potrebami potrebujejo za učenje več časa ter različne pristope in metode dela. Učitelj se mora pogosteje posluževati metode izkustvenega učenja, saj je zapomnitev znanja pri učencih na ta način hitrejša in dolgotrajnejša. Podoben učinek ima tudi aktivno sodelovanje učencev pri pouku z uporabo digitalnih tehnologij. Kot navajajo Dolinarjeva, Poberžnikova in Jeršetova (2023, str. 31) “aktivne oblike in metode učenja spodbujajo samostojnost učenja, razvoj kritičnega mišljenja, komunikacijske spretnosti, reševanje problemov in timsko delo.”

Rabe digitalnih tehnologij pri učencih se poslužujem predvsem pri utrjevanju učnih vsebin, kjer učenci pogosto delajo v dvojicah ali v manjših skupinah. Na ta način rešujejo spletne kvize, ki jih ustvarim v orodju za spletne ankete 1KA ali po navodilih v vizualnem programskem jeziku Scratch oblikujejo nalogo in na ta način utrdijo obravnavano učno snov. Z radovednostjo se poslužujejo tudi uporabe interaktivne bele table, kar jih pri reševanju nalog dodatno motivira.

4. ZAKLJUČEK

Veliko prednost uporabe digitalnih znanj učitelja pri pripravi in izvedbi pouka vidim v vizualizaciji oziroma večpredstavnosti. Učencem lahko na ta način bolj nazorno prikažem učne vsebine in jim omogočim lažje razumevanje zahtevnejših učnih vsebin. Pri učencih s posebnimi potrebami, ki imajo lahko večje težave z razumevanjem abstraktnih pojavov, so vizualne predstavitve še toliko bolj zaželene in učinkovito izboljšajo dolgoročno pomnenje učnih vsebin. Učenci s posebnimi potrebami se z rabo digitalnih tehnologij tekom pouka tudi lažje povežejo z vrstniki in z njimi bolje komunicirajo. Kot navaja Digitalna akademija (2022) “digitalne kompetence predstavljajo eno od osmih ključnih kompetenc in se nanašajo na samozavestno in kritično uporabo digitalnih tehnologij za pridobivanje in izmenjavo informacij, komuniciranje in sodelovanje, ustvarjanje digitalnih vsebin, varno uporabo tehnologij informacijske družbe in reševanje problemov.”

Usvojene digitalne kompetence so lahko učitelju pri pripravi na pouk in izvedbi le-tega v veliko pomoč, ravno tako učencem vzbudijo zanimanje za določene učne vsebine in popestrijo pouk. So učinkovit pripomoček, s katerim lahko učitelj pri učencih poleg učnih vsebin uspešno razvija in krepi tudi ostale

pomembne kompetence kot so učenje učenja, komunikacija, socialne kompetence, kulturno izražanje itd.

Spremembe na področju digitalnih tehnologij že zdavnaj več ne trkajo na vrata šolstva, temveč je razvijajoča se digitalna tehnologija v vedno večji meri prisotna v skorajda vseh razredih.

Še vedno pa je učitelj tisti, ki ima v rokah veslo ter zmore učinkovito veslati med viharnimi spremembami in stalnim okvirjem. Le na ta način bo moč vzgojiti digitalno odgovorne in spoštljive člane naše družbe. Učence s posebnimi potrebami pa učitelj na ta način opolnomoči in jim omogoči lažjo vključitev v digitalno družbo.

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Preverjanje predznanja z digitalno tehnologijo

Knowledge Assessment with Digital Technology

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POVZETEK

V učnem procesu učenci pogosto ne dobijo priložnosti, da bi učne cilje več predmetov združili v eni aktivnosti. Da bi to vrzel premagali, smo pri urah informatike uvedli inovativni pristop, ki povezuje matematiko z informatiko. Dijakom smo omogočili, da so preverjali svoje matematično predznanje in hkrati usvajali temeljna računalniška znanja. S programiranjem z delčki v Scratchu in z uporabo izobraževalnega kompleta Makey Makey so ustvarjali interaktivne plakate, ki so jim nudili kreativno in praktično preverjanje že usvojenih matematičnih konceptov.

Programiranje v Scratchu jim je omogočilo spoznavanje in utrjevanje osnov računalniškega mišljenja in programerskih konceptov, kot so spremenljivke, pogojni stavki in zanke. Skozi ustvarjanje lastnih projektov pa so hkrati razvijali tudi svoje algoritmične spretnosti, ki so ključne za reševanje problemov v informatiki in ostalih naravoslovnih predmetih.

Z vključitvijo izobraževalnega kompleta Makey Makey so dijaki ustvarili fizične vmesnike, ki so jih povezali z orodji za programiranje, kar jim je omogočilo, da so teoretična znanja prenesli v prakso. Tako so ne le preverili svoje matematično znanje, ampak tudi izboljšali svoje sposobnosti za ustvarjanje interaktivnih rešitev. Ta interdisciplinarni pristop je dijakom pomagal razvijati širok spekter veščin, ki so ključne za uspešno delovanje v sodobnem digitalnem okolju, ter jih pripravil na kompleksnejše izzive na obeh področjih, tako v matematiki kot informatiki.

KLJUČNE BESEDE

Računalniško razmišljanje, algoritmično razmišljanje, fizično računalništvo

ABSTRACT

In the learning process, students do not often get the opportunity to combine the learning objectives of multiple subjects into one activity. To bridge this gap, we introduced an innovative approach in computer science classes that connects mathematics with computer science. We enabled students to test their mathematical knowledge while simultaneously acquiring fundamental computer skills. By programming with blocks in Scratch and using the Makey Makey educational kit, they created interactive posters that provided a creative and practical way to review previously acquired mathematical concepts.

Programming in Scratch allowed them to learn and reinforce the basics of computational thinking and programming concepts such as variables, conditional statements, and loops. Through creating their own projects, they also developed their algorithmic skills, which are crucial for problem-solving in computer science and other natural sciences.

By incorporating the Makey Makey educational kit, the students created physical interfaces that they connected with programming tools, allowing them to transfer theoretical knowledge into practice. This way, they not only tested their mathematical knowledge but also improved their abilities to create interactive solutions. This interdisciplinary approach helped students develop a wide range of skills essential for successful functioning in the modern digital environment and prepared them for more complex challenges in both mathematics and computer science.

KEYWORDS

Computational thinking, algorithmic thinking, physical computing

1 MEDPREDMETNO POVEZOVANJE IN PROJEKT NAPOJ MINUT

Vse bolj postaja jasno, da je medpredmetno sodelovanje v izobraževanju ključnega pomena za celosten razvoj učencev. Projekt NAPOJ MINUT izhaja prav iz te potrebe po povezovanju znanja različnih predmetnih področij, z namenom, da učencem omogoči bogato in praktično učno izkušnjo. Osnovna ideja projekta je ustvariti okolje, kjer se znanje iz področja računalništva prepleta z znanjem matematike, naravoslovja, umetnosti ali tehnologije, s poudarkom na enakovrednosti obeh predmetov. Na ta način se spodbuja aktivnost med učitelji različnih predmetov, kar vodi v ustvarjanje interdisciplinarnih vsebin, ki učencem omogočajo celovito učno izkušnjo. Učenci se tako soočajo z iskanjem rešitev avtentičnih problemov, do katerih jih pripelje znanje pridobljeno na različnih področjih.

V okviru projekta MINUT NAPOJ je tako razvita vrsta projektov, ki poudarjajo tako obliko medpredmetnega sodelovanja. Enega od teh projektov predstavljamo tudi v tem prispevku.

Dijaki 1. letnikov so ob vstopu v srednjo šolo običajno brez predhodnega znanja programiranja, zato so se morali pred izvedbo projekta spoznati z okoljem Scratch in osnovnimi programerskimi koncepti, kot so spremenljivke, zanke in pogojni stavki.

Ker je poznavanje osnovnih obrazcev za izračun obsega in ploščine likov temeljno za uspešno nadgrajevanje znanja iz geometrije, sva v ta projekt vključili ravno te matematične cilje.

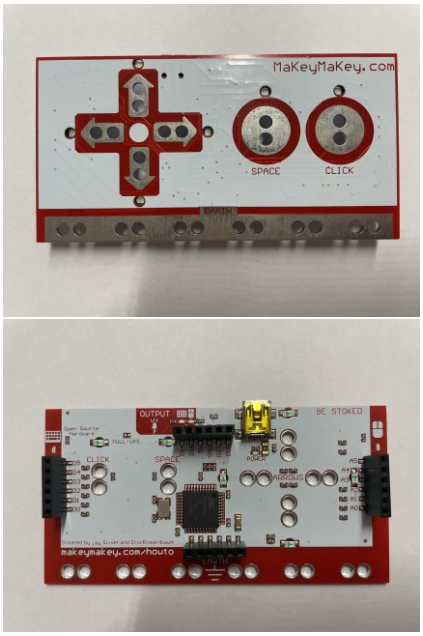
Hkrati pa so to tudi učni cilji, ki naj bi jih dijaki usvojili že v osnovni šoli.

1.1 Orodje in okolje

Pri iskanju ideje za projekt smo izbrali dijake 1. letnikov, saj smo iz področja informatike vključili učne cilje iz programiranja, ki jih z dijaki predelujemo v 1. letniku programa ekonomska gimnazija. Odločili smo se, da bodo dijaki izdelovali interaktivne plakate s programiranja z delčki v Scratchu in z uporabo izobraževalnega orodja Makey Makey. Tako so dijaki med preverjanjem predznanja iz matematike usvajali in utrjevali temeljna znanja iz računalništva.

Izobraževalni komplet Makey Makey omogoča pretvorbo vsakodnevnih predmetov z uporabo aligatorskih sponk in prevodnih materialov v vnosni sistem (glej sliko 1). Z njegovo pomočjo običajen plakat postane interaktiven.

Komplet ima na sprednji strani 6 vhodnih priključkov (puščice gor, dol, levo, desno, presledek in klik), na spodnjem delu se nahaja 6 priključkov za ozemljitev. Z dotikom ustreznih delov plakata tako simuliramo pritisk na omenjene tipke ter klik z miško. Na zadnji strani je dodanih še 12 priključkov, ki nadomeščajo pritiske na črke W, A, S, D, F in G, levi in desni miškin klik ter premikanje miške gor, dol, levo in desno.



Slika 1: Sprednja in zadnja stran kompleta Makey Makey

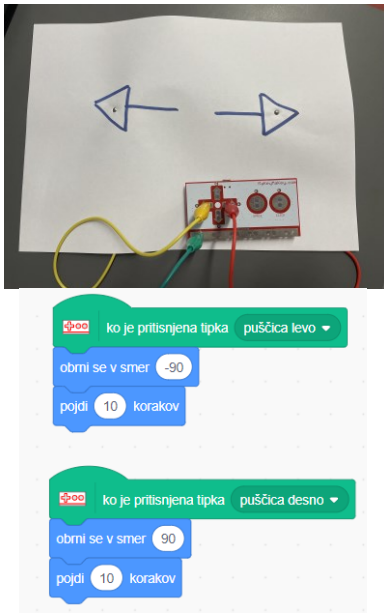
Makey Makey na računalnik povežemo z USB kablom, za priključke pa uporabimo krokodilje kable in povezovalne žice.

Na plakatu je za prevodnost možno uporabiti bakren samolepilni trak, prevodno barvo, grafit (sled svinčnika) ali železne razcepke (glej sliko 2). Tako se ob dotiku ustreznega dela plakata preko navedenih prevodnikov simulira pritisk določenih tipk (puščice, preslednica, črke,…).

Programsko orodje Scratch je brezplačno programsko orodje namenjeno programiranju z delčki, kar omogoča uporabo tudi pri mlajših učencih. Dostopno je preko spletne strani scratch.mit.edu. Na spletni strani lahko najdemo tudi vodiče v slovenskem jeziku. Scratch omogoča povezavo z več izobraževalnimi kompleti, med drugimi tudi z Makey Makey.

Slika 2: Prevodniki, ki jih lahko uporabimo pri izdelavi

Za lažjo predstavo bomo opisali primer izdelave preprostega projekta, v katerem bo maček hodil levo in desno. Smer hoje bo določena glede na pritisk ustrezne tipke na plakatu. Na začetku je potrebno poskrbeti za vklop razširitve v orodju Scratch. Ko to storimo, se pojavita dva dodatna ukaza (Ko je pritisnjena tipka in Ko so pritisnjene tipke). Na plakatu označimo del na katerega bo uporabnik pritiskal. Pri tem lahko uporabimo železne razcepke, ki jih povežemo s krokodiljim priključkom. Lahko pa uporabimo tudi bakren trak ali prevodno barvo, s katero povežemo del plakata in komplet Makey Makey. V našem primeru bomo na plakatu puščico desno povezali s krokodiljim priključkom in ga povezali na puščico na kompletu Makey (glej sliko 3). Sprogramirati je potrebno še premikanje mačka. V Scratchu za premikanje uporabiko ukaz pojdi 10 korakov. Da se bo maček ob pritisku na tipko levo obrnil v pravo smer, pa uporabimo še ukaz obrni se v smer. Na kompletu Makey Makey je potrebno dodati še kabel za ozemljitev (v našem primeru je to kabel zelene barve). Uporabnik mora med pritiskanjem na tipki na plakati držati tudi kabel ozemljitve.



Slika 3: Plakat s povezovalnimi kabli in programska koda v Scratchu

To je primer enostavne uporabe kompleta Makey Makey in orodja Scratch. Ob nakupu kompleta Makey Makey so kabli in žice že priloženi, priporočamo še nakup železnih razcepkov in po potrebi prevodnega traku in prevodne barve (glej sliko 2).

1.2 Projekt

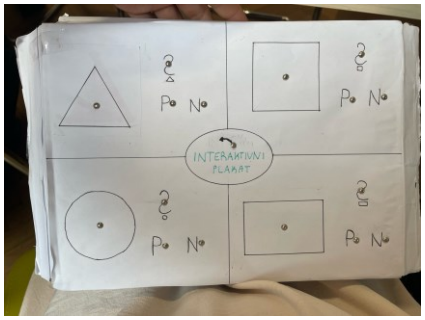
Da bi zapolnili vrzel med povezovanjem znanja iz informatike in matematike smo zasnovali projekt, ki vključuje uporabo kompleta Makey Makey. Z njegovo uporabo dijaki usvajajo programerske koncepte. Ta projekt je bil zasnovan v okviru projekta MINUT NAPOJ.

Dijaki posameznega letnika so pri informatiki razdeljeni v dve skupini po 16 dijakov. Pouk informatike se izvaja enkrat tedensko v dveh zaporednih šolskih urah. Dijaki so v mesecu decembru in januarju usvojili osnovne programerske koncepte s pomočjo izdelovanja različnih kratkih interaktivnih projektov. Nato so pričeli z načrtovanjem interaktivnega plakata. Pripravili so skico plakata v katero so vključili vsebino, ki so jo kasneje obravnavali pri matematiki. Dodali so tudi skico fizičnih povezav s kabli. Vsak dijak je imel na voljo izobraževalni komplet Makey Makey, bakreni trak, prevodno barvo in razcepke. V Scratchu so morali z ustreznimi ukaznimi bloki sestavi kodo, ki je ob pritisku na določene dele plakata izvedla ustrezne akcije, kot so predvajanje zvoka, animacije, menjava ozadja ipd.

Slika 3: Zadnja stran interaktivnega plakata

2 REFLEKSIJA IN POVRATNA INFORMACIJA

Izvedba projekta je potekala v skladu s pričakovanji. Dijaki so med izdelovanjem interaktivnega plakata utrdili znanje programerskih konceptov, spoznali uporabo izobraževalnega kompleta Makey in Makey in hkrati preverili predznanje iz geometrije. Poleg tega so izboljšali veščine raziskovalnega dela in medpredmetnega povezovanja. Med izdelovanjem interaktivnega plakata naleteli tudi na nekaj težav, ki so jih uspešno premostili. Zagotoviti so morali tudi pravilnost fizičnih povezav med kompletom Makey Makey in plakatom. V programskem orodju Scratch so morali povezave uskladiti z ustreznimi ukazi, ki so se izvedli ob pritisku na ustrezen del plakata, ki smo ga označili z železnim razcepkom. Z vsem navedenim so zagotovili nemoteno delovanje programa. Da ne bi uporabnik nenamerno odklopil povezave, so morali poskrbeti tudi za to, da so bile vse fizične povezave skrite in varno pritrjene.



Slika 4: Interaktivni plakat

Povratne informacije dijakov so bile pozitivne. Poudarili so, da je bil projekt zabaven in poučen ter da so se naučili veliko novega. Z željo, da bi lahko še večkrat pokazali svojo ustvarjalnost, si želijo še več takšnih projektih v prihodnosti. Projekti jim omogočajo uporabo teoretičnega znanja na ustvarjalen način in utrjevanje že pridobljenega znanja. Pri raziskovanju ideje o plakatu so razvijali tudi veščine raziskovanja.

3 ZAKLJUČEK

Projekt z uporabo orodja Scratch in Makey Makey je dijakom omogočil, da na kreativen način povežejo znanje iz različnih predmetov in ustvarijo nekaj edinstvenega. Takšni projekti so odličen način za spodbujanje inovativnosti in praktičnega učenja ter za pripravo dijakov na prihodnje izzive v svetu tehnologije, kjer se bodo vsakodnevno srečevali z izzivi. Verjamemo, da taki projekti spodbujajo nujno potrebne veščine za reševanje problemov in hkrati dijakom omogočajo uvid v uporabnost povezovanja znanja. Za izvedbo takega projekta je pomembno, da so učitelji željni usvajanja novih znanj in medsebojnega sodelovanja s kolegi. Na ta način tudi učitelji krepijo veščine sodelovalnega dela in komunikacijske veščine. Pomembna je tudi podpora s strani vodstva šole, ki poskrbi za programsko opremo in ostale pogoje kot so: prostor, čas,...

V prihodnje bo v projektu MINUT NAPOJ zagotovo razvitih še več zanimivih gradiv, ki bodo na voljo tudi ostalim učiteljem, ki bi radi nadgradili in popestrili ure svojega pouka.

Vabimo vse, da se projektu pridružijo. Vse informacije dobite na naslovu napoj@404.si.

VIRI

[1] Spletno orodje Scratch. (b.d.). (pridobljeno dne 28. 8. 2024) Pridobljeno s https://scratch.mit.edu

[2] Izobraževalni komplet Makey Makey. (b.d.). (pridobljeno dne 27. 8. 2024) Pridobljeno s https://makeymakey.com

[3] Projekt MINUT NAPOJ. (b.d.). (pridobljeno dne 27. 8. 2024) Pridobljeno s https://novi.napoj.si/aktivnosti-2/projekti/minut-ii

Izdelava interaktivnih tematskih listov s spletnim orodjem Canva

Creating Interactive Themed Sheets with Canva

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POVZETEK

Danes si dela z informacijsko-komunikacijsko tehnologijo v razredu praktično ne moremo več predstavljati, saj nas le-ta spremlja na skoraj vsakem koraku. Prav je, da učitelji gremo ″v korak s časom″ in posodobimo načine poučevanja.

Pri večletnem poučevanju desetletnikov opažam, da za delo potrebujejo vedno več zunanje motivacije in da za klasičen pouk učenci niso več motivirani, saj precej raje rešujejo interaktivne naloge na računalnikih in tabličnih računalnikih.

V prispevku je predstavljeno, kako lahko spletno orodje Canva uporabimo za delo v razredu. S tem orodjem sem pripravila dva vsebinsko različna interaktivna tematska lista, ki sta v prispevku natančneje predstavljena. Učenci zelo radi utrjujejo in pridobivajo znanje na tak način.

Za tako pripravo na pouk je potrebno nekoliko več časa, vendar je trud v razredu poplačan, saj lahko učitelj opazuje, s kakšno vnemo učenci rešujejo naloge, s tem utrjujejo znanje in hkrati pridobivajo spretnosti in veščine za delo z različnimi aplikacijami.

KLJUČNE BESEDE

Canva, interaktivni tematski list, motivacija

ABSTRACT

Today, it is almost impossible to imagine classroom work without information and communication technology, as it has become integral to nearly every aspect of education. It is essential for teachers to "keep up with the times" and modernize their teaching methods accordingly.

Having taught ten-year-olds for many years, I have noticed that they increasingly require external motivation to engage in their work. Traditional classroom methods seem less effective, as students now prefer interactive tasks on computers and tablets.

This article demonstrates how Canva, an online tool, can be effectively used in the classroom. I have created two substantively different interactive thematic sheets using Canva, which are discussed in detail in this paper. Students enjoy consolidating and acquiring knowledge through these methods.

Although this type of class preparation requires additional time, the effort is worthwhile. Teachers can observe the enthusiasm with which students approach tasks, leading to more effective knowledge consolidation and the development of skills necessary for working with various applications.

KEYWORDS

Canva, interactive themed sheets, student motivation

1 UVOD

Danes ljudje uporabljamo informacijsko-komunikacijske tehnologije (IKT) že praktično na vsakem koraku in na vseh področjih. Zato je seveda pomembno in hkrati neizogibno IKT uvesti v čim večji meri že v osnovnošolsko izobraževanje. V današnjem času je razvoj tehnologije zelo hiter, zato je nujno, da otroke izobrazimo in vzgajamo tako, da bodo ta hiter razvoj obvladali. Če bomo učence že v osnovni šoli navajali na uporabo različne IKT, se bodo le-ti kot odrasli lažje prilagajali na vse novosti. [4]

Že nekaj let poučujem petošolce in vsako leto znova opažam, da se pri klasičnem delu z učbeniki in delovnimi zvezki dolgočasijo in da neradi posegajo po njih. Čeprav so ta gradiva veliko privlačnejša kot pred nekaj desetletji, jih ne privlačijo tako kot vsa virtualna okolja, ki so zanimiva za oči in kar kličejo k usmerjeni pozornosti. Zelo radi se poslužujejo dela na računalnikih in tabličnih računalnikih in pri tem sploh nimajo občutka, da se učijo, ampak tako delo doživljajo bolj kot zabavo. V kolikor učitelj zna pripraviti ustrezna IKT gradiva oz. interaktivne naloge, učenci z reševanjem le-teh utrjujejo znanje in hkrati pridobivajo spretnosti in veščine za delo na računalnikih in drugih ″pametnih″ napravah.

2 INFORMACIJSKO-KOMUNIKACIJSKA TEHNOLOGIJA V ŠOLI

Poklic učitelja je zahteven. Zahteva nenehno izobraževanje učiteljev in njihovo prilagajanje na hitre spremememb. Učenci se spreminjajo, skupaj s svojimi potrebami in interesi. Učitelji smo pri svojem delu sicer avtonomni, saj je naša omejitev le učni načrt in njegovi cilji. Naša naloga je, da iščemo metode in oblike dela, s katerimi bodo učenci prišli do znanja in osvojili cilje učnega načrta.

Pri pouku se trudim vključevati različne metode in oblike dela, kar mi uporaba IKT zagotovo omogoča. Dnevno uporabljam že izdelano interaktivno gradivo založb, včasih le preprosto Power

Point predstavitev, pogosto za učence pripravim zanimive interaktivne kvize ali pa s spletnimi obrazci preverim njihovo znanje. Kot učiteljica sem vedno v dilemi, v kolikšni meri je smiselno učence posedati za računalnike.

Kot o pomenu IKT pravi Rebernak, je uporaba le-te smiselna, ko z njo dosežemo boljše rezultate pri učenju. [2]

Sama zelo rada posegam po tehnoloških novostih, zato se z veseljem izobražujem na tem področju. Prav tako rada raziskujem in preizkušam različna spletna orodja, s katerimi učencem pouk naredim bolj nazoren, zanimiv in hkrati bolj motivacijsko spodbuden. Delo na področju tehnologije mi je v izziv, ki se ga vedno rada lotim in zato mi ni težko posvetiti popoldnevov raziskovanju in preizkušanju novih IKT orodij.

Sama sem mnenja, da moramo učitelji iti "v korak s časom" in mislim, da je nujno, da ves čas nadgrajujemo veščine za učinkovito in predvsem varno rabo sodobne tehnologije. Učenci se s pametnimi napravami srečajo že zelo zgodaj, vendar opažam, da dela z njimi niso vešči, razen igranja igric. Rada jim pokažem, na kakšen način te naprave še lahko uporabljajo in ob tem pridobivajo še nova znanja in veščine za delo z različnimi aplikacijami.

V prispevku bom predstavila, kako sem popestrila uro pouka z uporabo IKT. V Canvi sem izdelala dva interaktivna tematska lista za učence. Pri prvem sem oblikovala interaktivno igralno polje, preko katerega so učenci ob koncu leta ponovili snov celega šolskega leta. Drugi interaktivni učni list je nastal ob slovenskem kulturnem prazniku.

2.1 Canva

Canva je brezplačno spletno orodje za grafično oblikovanje, ki ima na enem mestu zbrano vse, od predlog, clipartov, pisav, slik, ilustracij… Je eden od najbolj enostavnih in praktičnih programov za grafično oblikovanje; v njej lahko ustvarjate praktično vse, od predstavitev, plakatov, miselnih vzorcev, učnih listov letakov, v njej lahko tudi snemate in montirate videoposnetke … Canva olajša delo in z njo prihranite čas. [3]

Sama pogosto izdelam razne plakate, ki so zelo estetski in jih učenci radi pogledajo. Samo izdelovanje plakatov je v Canvi izredno preprosto in nezamudno.

Slika 1. Plakat o deževniku (VIR: lasten, zajem zaslonske slike)

V Canvi lahko uporabimo že vnaprej pripravljene predloge ali projekte oblikujemo po meri.

Prav tako lahko oblikujemo skupino, npr. sodelavcev, učencev in z njimi delimo svoje izdelke. Deljene izdelke lahko potem vsak poljubno uporabi, spreminja, preoblikuje, dodaja.

Svoje končane projekte lahko prenesemo oz. shranimo v več vrstah datotek: pdf, jpg, png, mp4, gif, svg … Lahko pa enostavno kopiramo spletno povezavo do izdelka in ga predvajamo kar preko spleta.

Je orodje, ki zahteva registracijo, za katero potrebujete Facebook, Google ali MS račun.

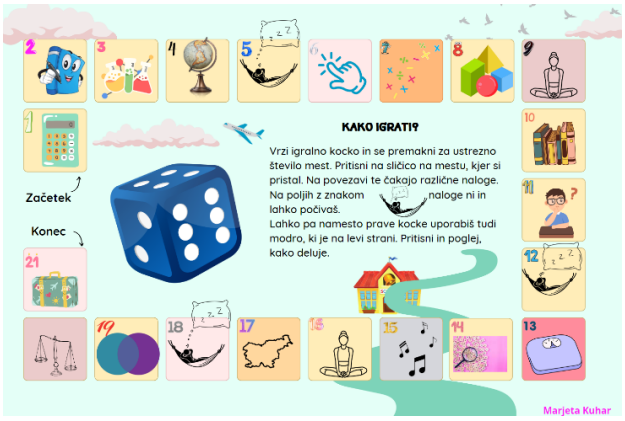
Do nje lahko dostopate preko spletnega mesta canva.com, preko mobilne aplikacije ali aplikacije, ki jo naložite na računalnik. Deluje tako na Androidu kot iOS.

Brezplačna je le osnovna verzija, ki zadovolji le manj zahtevne uporabnike. Neprofitne organizacije pa lahko zaprosijo za brezplačno pro različico. Tako lahko tudi učitelji dobimo izobraževalno brezplačno različico, ki pa omogoča zares ogromno različnih predlog, clipartov, ozadij, pisav … Učitelji morajo le skrbnikom poslati dokazilo o delu v šoli (npr. potrdilo o diplomiranju, plačilno listo).

Zelo rada v Canvi izdelam tudi predstavitev za roditeljske sestanke. Pri sami predstavitvi lahko do njega dostopam tako, da ga izvozim tudi kot power pointovo predstavitev, v kolikor pa ne želim zasedati prostora na računalniku, pa lahko do njega dostopam preko spletne povezave. Take predstavitve so izredno nazorne, barvite in privlačne na oko. Vsak drsnica je lahko unikatna.

2.2 Interaktivni učni list – utrjevanje snovi

Predhodno sem pripravila igralno polje in ga v Canvi spremenila v interaktivni list. Vsako polje sem opremila s sličico, ki namiguje, kateri tip naloge se skriva na posameznem polju. Za vsakim poljem učence čaka interaktivna naloga, do katere dostopajo preko hiperpovezave, s klikom na sliko.



Slika 2. Igralno polje (VIR: lasten, zajem zaslonske slike)

Na plošči imajo napisana navodila za igranje, ki si jih prej preberejo. Običajno jim navodil ne razlagam, saj želim, da se jih naučijo natančno in z razumevanjem prebrati.

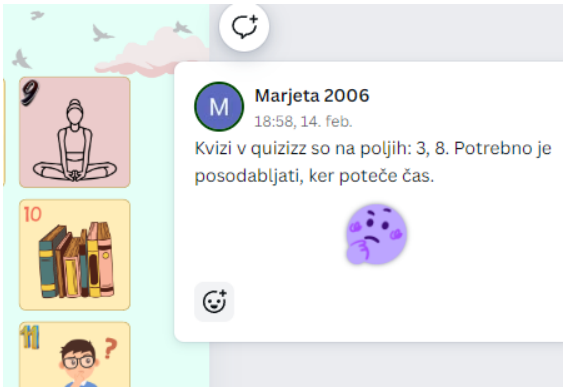
Lahko se igrajo v paru ali pa se igra vsak sam. Igro učenci igrajo podobno kot namizne igre, le da tukaj zavrtijo virtualno igralno kocko in se pomaknejo za ustrezno število mest po igralnem polju. Na vsakem polju jih čaka različna naloga iz različnega področja. Vključila sem kvize, naloge razvrščanja, povezovanja … Večji del nalog sem pripravila sama, nekatere

med njimi pa sem našla na spletu. Nekatera polja so namenjena počivanju, nekatera pa gibalni nalogi, kot so npr. počepi, poskoki ... Mislim, da je prav, da učencem med dejavnostmi ponudimo tudi gibanje, saj le-to pripomore k večji zbranosti, koncentraciji in boljšemu pomnjenju.

Zanimivo je bilo opazovati učence, kako so bili veseli, če so prišli na polje z gibalno nalogo. Ko je prvi učenec prišel na to polje, me je malo začudeno pogledal in vprašal, če mora opraviti tudi to nalogo .

Naslednji interaktivni list je nastal za utrjevanje snovi ob koncu šolskega leta, saj so na njem zbrane naloge iz vseh predmetov, ki jih poučujem. Tako se preizkusijo iz glasbene umetnosti, matematike, slovenščine, naravoslovja in družbe.

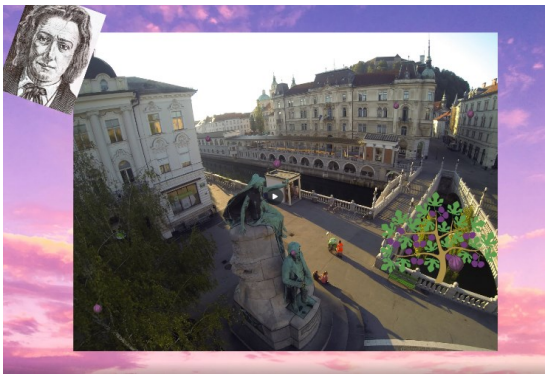
Nekatere spletne naloge sem jim pripravila v orodjih, kjer je povezava do njih časovno omejena. Učenci do njih lahko dostopajo le nekaj dni. Da ne pozabim ponovno aktivirati naloge, mi Canva omogoča, da si ob učni list napišem opomnik, ki me opozori, na katerih poljih moram posodobiti povezavo do naloge.



Slika 3. Primer opomnika (VIR: lasten, zajem zaslonske slike)

2.3 Interaktivni učni list – slovenski kulturni praznik

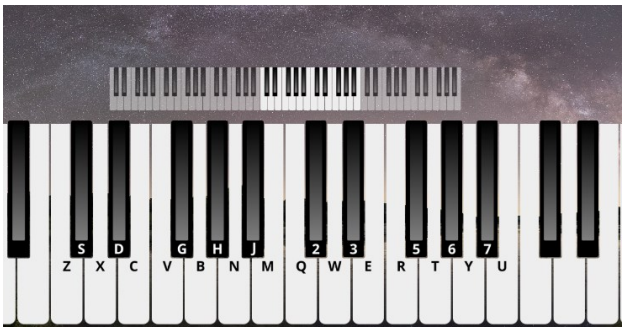
Drugi interaktivni tematski list je nastal pri pouku na daljavo, in sicer za spoznavanje Prešernovega življenja. Učence je na prvi strani čakalo navodilo, naj poiščejo vse fige, ki jih je Prešeren skril po Ljubljani. Ko jo najdejo, morajo nanjo pritisniti ter pogledati in poslušati posnetek, ki se skriva za njo.

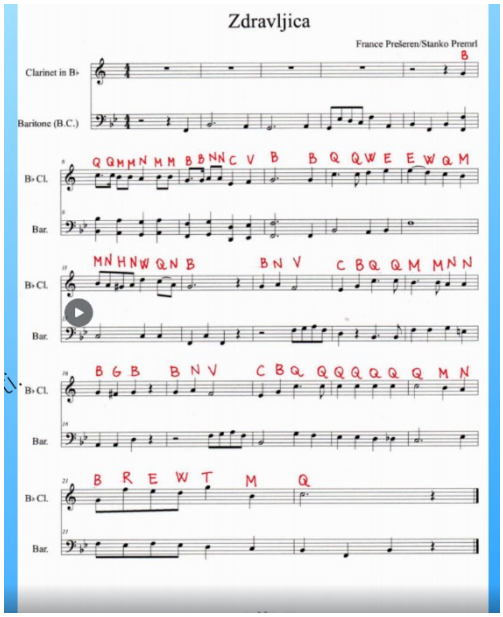


Slika 4. Skrite fige v Ljubljani (VIR: lasten, zajem zaslonske slike)

Učenci so bili bistveno bolj motivirani za ogled posnetkov, kot v primeru, da bi jim povezave do posnetkov le pripela v dokument. Še dodatno motivacijo jim je predstavljal podatek, da jih ob koncu ogleda čaka še zabaven kviz, ki ga bodo uspešno rešili le, če bodo posnetke pozorno poslušali. Reševanje takih kvizov so že poznali in so vedeli, da bodo svoje točke oz. uvrstitev lahko primerjali s sošolčevimi, saj se med reševanjem prikazuje lestvica najboljših. Kviz sem zanje pripravila s programu Quizizz, ki je za uporabo brezplačen.

Za bolj zabaven zaključek pa sem poskrbela še z virtualno klaviaturo, preko katere so se učenci lahko preizkusili v igranju Prešernove Zdravljice. Notni zapis Premrlove skladbe sem namreč opremila s črkami in učenci so himno igrali tako, da so sledili črkam in ustrezno pritiskali na tipke klaviature.



Slika 5. Virtualna klaviatura (VIR: lasten, zajem zaslonske slike)

Slika 6. Pomoč za igranje na klaviaturi (VIR: lasten, zajem zaslonske slike)

Ta naloga se jim je zdela najbolj zabavna, saj so klavir lahko igrali tudi tisti, ki sicer nanj ne znajo igrati. Nekaj učencev je imelo pri tej nalogi težave, saj niso znali istočasno odpreti dveh zavihkov.

Tak način dela je bolj primeren za domače delo oz. je potrebno delo s slušalkami, saj posnetki vključujejo zvok, pa tudi igranje na klavir v razredu ni mogoč brez uporabe slušalk.

3 DELO V RAČUNALNIŠKI UČILNICI

Učencem sem povezavo do interaktivnega lista pripela v MS Teams, kamor so vključeni vsi. MS Teams je brezplačno dostopen vsem učencem, ki jim šola priskrbi AAI račun. To je račun, s katerim lahko vsak brezplačno dostopa do orodja Oblak 365 in si prav tako brezplačno, namesti Office 365. Učencem že septembra v MS Teams ustvarim razredno spletno učilnico, ki jo potem uporabljamo celotno šolsko leto. Učenci so bili zato že vešči dela v njej.

Za reševanje nalog so imeli učenci na voljo dve šolski uri. Naloge smo reševali v šolski računalniški učilnici. Posamezne naloge so različno dolge in učenci so pri nekaterih porabili več, pri nekaterih pa nekaj manj časa. Nekateri so se odločili za samostojno reševanje, spet drugi za delo v parih. Nekaj parov je predčasno prišlo do cilja in so pričeli spet od začetka, saj je bilo bolj malo verjetno, da bodo ponovno prišli na ista polja kot v prvem poskusu.

4 PREDNOSTI IN SLABOSTI

Pred pripravo vsakega interaktivnega gradiva razmislim o prednostih in slabostih, ki jih bo tako delo prineslo, saj je prav, da učencem ponudimo tako metodo poučevanje, od katere bodo odnesli največ znanja.

Prednosti takih interaktivnih učnih listov je zelo veliko. Učenci so bistveno bolj motivirani za delo, prav tako se lažje skoncentrirajo na delo in je njihova koncentracija daljša kot sicer. Ni jim težko celo šolsko uro reševati interaktivne naloge in celo prosijo, če jih lahko rešujejo še doma. Take naloge na razredni stopnji radi pokažejo tudi staršem.

Učenci pri takem delu običajno dobijo takojšne povratne informacije o svojem delu oz. znanju, saj jim programi, s katerimi sem izdelala interaktivne naloge, dajo takojšnje informacije o pravilnosti rešitev. Prav se mi zdi, da učenci dobijo takojšnje informacije o svojem znanju oz. rešitvah, saj se le tako zavedajo pomanjkljivosti svojega znanja in napake lahko popravijo.

Če načrtujem delo v paru oz. skupinsko delo, pri učencih na tak način spodbujam sodelovalno učenje. To je vzgojno-izobraževalna strategija, pri kateri delajo udeleženci v majhnih skupinah. Poudarek je na delo v heterogenih skupinah. Skupinsko delo temelji na njihovi medsebojni soodvisnosti in odgovornosti. Pomembno je, da vsak član skupine sodeluje in da vsak doda svoj prispevek k skupni nalogi. Pri takem učenju se sodelujoči neposredno učijo tudi socialnih vešči. [1]

Pri takem delu nam ni potrebno tiskati učnih gradiv in s tem delujemo tudi ekološko, saj ne trošimo papirja.

Slabost takega načrtovanja pouka je zagotovo možnost, da tehnologija zataji, zato je prav, da naredimo rezervni plan.

Pri nekaterih vrstah interaktivnih nalog učitelj ne more preveriti, kako uspešni so bili učenci pri reševanju.

Prav tako je priprava na tak pouk za učitelja zahtevnejša in učitelj porabi več časa za pripravo na pouk.

5 ZAKLJUČEK

Interaktivni učni list z igralnim poljem so letos reševali v zadnjem tednu pouka. Običajno v tem obdobju le s težavo sledijo pouku in rešujejo naloge v delovnem zvezku. Letos so z veseljem ″vrteli″ kocko in pritiskali na polja z nalogami ter jih z veliko vnemo reševali. Z zanimanjem so gledali na sosednje računalnike in opazovali, kakšne naloge rešujejo sošolci.

Prav veselje jih je bilo opazovati, kako so bili motivirani za delo in tudi koncentracija jim ni tako hitro padla. Prav nihče se ni pritoževal nad delom. Po prvi uri dela so se začudili, ko je zvonilo, saj se jim je zdelo, da je ura hitro minila.

Mislim, da je prav, da učitelji učencem ponudimo delo z interaktivnim gradivom, moramo pa najti pravo ravnovesje med uporabo IKT in ostalih metod poučevanja.

ZAHVALA

V prvi vrsti bi se zahvalila učencem, ki z veseljem rešujejo naloge, ki jim jih pripravim v interaktivni obliki. Prav tako sem vesela, ker opazijo moj trud ter pohvalijo zanimivost nalog. Tako je moj trud poplačan.

Zahvala gre tudi sodelavkam, ki vedno kritično ovrednotijo moje delo ter ga tudi z veseljem uporabijo v svojih razredih ter naši knjižničarki Andreji za lektoriranje prispevka.

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Do rešitve avtentičnih problemov z matematiko in informatiko

To the Solution of Authentic Problems with Mathematics and Informatics

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POVZETEK

V članku je predstavljena medpredmetna povezava matematike in informatike z namenom, da dijaki ob reševanju avtentičnih nalog prenesejo znanja iz enega učnega področja na drugega in obratno. Zanimalo nas je tudi, če taka oblika dela poveča zanimanje za računalništvo oziroma matematiko. Naloge so bile namenjene dijakom prvega letnika gimnazije in sodijo v poglavje o naravnih številih. Dijaki so opazovali vzorce, utemeljevali svoje ugotovitve, zapisovali korake algoritmov in programirali z delčki. Pred in po aktivnosti so izpolnili anketo, ki meri zastavljene cilje. V članku so predstavljeni tudi rezultati ankete.

KLJUČNE BESEDE

Vzorci, računalniško razmišljanje, psevdo koda, algoritem, programiranje z delčki

ABSTRACT

The article presents the interdisciplinary connection between mathematics and computer science, with the aim of encouraging students to transfer knowledge from one subject area to the other and vice versa while solving authentic tasks. We were also interested in whether this form of work increases interest in computer science or mathematics. The tasks were intended for first-year high school students and are related to the topic of natural numbers. The students observed patterns, justified their findings, recorded algorithm steps, and programmed using blocks. Before and after the activity, they completed a survey designed to measure the set goals. The article also presents the survey results.

KEYWORDS

Patterns, computational thinking, pseudo code, algorithem, block-based programming

1 UVOD

Slovenski izobraževalni sistem temelji na pridobivanju znanj in veščin po posameznih področjih in v naprej definiranem obsegu. Prenovljeni učni načrti [1] vključujejo tudi didaktična priporočila o uporabi učne tehnologije in medpredmetnem povezovanju. Pri matematiki so našteti tudi konkretni predlogi, a je izvedba neobvezna in prepuščena učitelju. Posledično dijaki bolj ali manj uspešno pridobivajo znanja in veščine ločeno po učnih predmetih in jih slabo prenašajo iz ene učne situacije v drugo. Ravno prenosljivost znanja pa je ključna pot k poglobljenemu razumevanju.

Avtorji članka smo želeli z načrtovano aktivnostjo omogočiti, da dijaki v avtentični situaciji prenesejo znanje iz matematike v informatiko in obratno. Naloge, ki smo jih reševali, je sicer možno reševati le pri matematiki oz. le pri informatiki, a bi bilo škoda izpustiti priložnost za povezovanje. Družba se digitalizira na vseh področjih in pričakovati je, da bo računalniško mišljenje postalo del vsakega področja znanosti in večjega dela bodočih poklicev [3]. Zato je spajanje računalniškega mišljenja z matematiko nujno, hkrati pa je matematika na srednješolskem nivoju bazen vsebin za učenje informatike. Žal pogrešamo več primerov gradiv, kjer bi bilo to spajanje računalniškega in matematičnega mišljenja izvedeno na smiseln način. Projekt NAPOJ MINUT [5] pa je ponudil pravo okolje in motivacijo za izvedbo tovrstne povezave.

Zanimalo nas je tudi, če tak način dela pri dijakih poveča zanimanje za matematiko oziroma informatiko, posledično pa tudi za predmete MINUT - M(atematika) I(nformatika) N(aravoslovje) U(metnost) T(ehnologija).

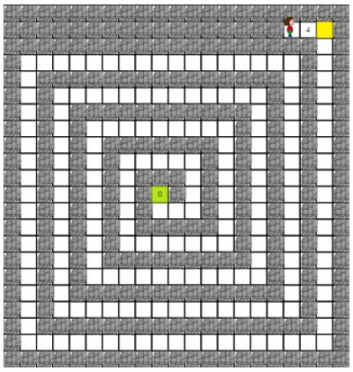
2 OPIS PROBLEMA IN NAČRTOVANA AKTIVNOST

Za dijake smo pripravili nalogo iz teme večkratniki in delitelji z dvema razširitvama, ki odpirata številna dodatna vprašanja za dijaka.

Osnovna naloga: Hana na poti do šole preskakuje ploščice. Vsakič jih preskoči enako število. Pot je podana v obliki spirale (Slika1). Zanima nas, na katere je stopila in koliko ploščic ostane ob koncu poti. Zato bi radi sestavili program, ki pobarva ploščice, na katere stopi Hana. Radi bi, da dijak ob nalogi razmišlja tudi o naslednjih vprašanjih: koliko je vseh ploščic, kako zapišemo zaporedne večkratnike, kako zapišemo števila med sosednjima večkratnikoma, kaj predstavlja zadnje število,

Druga naloga je izpeljanka prve. Hana gre večkrat po poti do šole in preskakuje ploščice. Na posamezni poti vedno preskakuje enako ploščic, a število teh se med posameznimi potmi lahko

razlikuje. Dijak naj pri barvanju posamezne poti uporabi različne barve in pojasni značilnost ploščic, na katere Hana stopi večkrat.



Slika 1: Pot od doma do šole, naloga v okolju Pišek

Tretja naloga je izpeljana iz druge: Pot do šole je tokrat prikazana z ravnim trakom, na ploščicah pa je na začetku oznaka 0. Če Hana stopi na ploščico, se 0 spremeni v 1 in obratno, oznaka na ploščici 1 se spremeni v 0. Dijak mora ugotoviti, kakšni vzorčki nastanejo, če gre Hana večkrat do šole in pri tem preskakuje vsakokrat drugačno število ploščic. Zanima nas tudi, katera oznaka je ob koncu zapisana na k-ti ploščici.

2.1 Predznanje

Za uspešno reševanje morajo dijaki poznati pojme večkratnik, delitelj in ostanek pri deljenju, ter zvezo med njimi. Poznajo naj tudi osnove iz programiranja: zaporedje ukazov, spremenljivka, vejitev, zanka. Prav tako je dobrodošlo, če se že prej seznanijo s programiranjem v okolju Pišek, saj sta tam v ta namen bili ustvarjeni dve nalogi [4].

2.2 Načrt za izvedbo

Aktivnost je zasnovana za izvedbo v treh etapah, skupaj okvirno 5 šolskih ur. Prvi dve uri dijakom predstavimo delo, jih seznanimo z osnovno nalogo, ki jo rešijo na učnem listu in zapišejo ugotovitve. Nato z besedami zapišejo postopek barvanja ploščic (zapis psevdo kode) in se potem lotijo iste naloge v Pišku. Na koncu svojo rešitev tudi testirajo. Delajo lahko samostojno ali v parih.

Naslednja ura je namenjena reševanju druge naloge v Pišku, ko gre Hana dvakrat do šole. Dijak s pridobljenimi izkušnjami sestavi programček za barvanje ploščic in ga testira.

Zadnji dve uri sta namenjeni prikazu različnih rešitev in pogovoru, potem pa sledi reševanje tretje naloge. Dijakom pojasnimo, da je pot do šole tokrat predstavljena drugače in da bomo namesto barv uporabljali ničle in enke. Dijaki dobijo učni list z navodili in vprašanji. Na koncu dijaki poročajo o ugotovitvah in jih argumentirajo. Celotno aktivnost na koncu povzame še učitelj.

3 REZULTATI

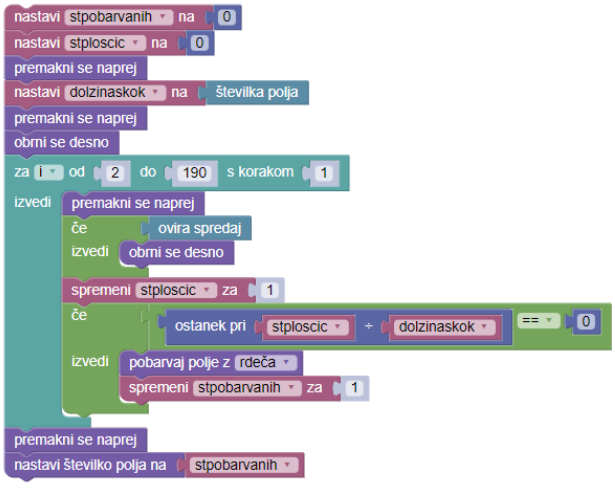
V tem poglavju bomo na kratko predstavili, kako je potekala izvedba v razredu in primerjali odgovore anket, ki smo ju izvedli pred in po izvedeni aktivnosti z vsemi dijaki.

3.1 Izvedba v razredu

Avtorici članka sva aktivnosti izvedli dvakrat, vsakokrat s približno 14 dijaki prvega letnika gimnazije. Večino časa sva bili v učilnici prisotni obe in s številnimi vprašanji in namigi usmerjali dijake, ki so delali v parih. Eno uro smo bili v običajni učilnici, ostale ure pa v računalnici.

Dijaki so naloge reševali zavzeto, a so bile razlike v uspešnosti kar velike. Prve težave so nastopile pri besednem opisu, kako se Hana premika in kako se barvajo ploščice. Nekateri so mislili, da Hana preskakuje k ploščic, drugi pa, da bo stopila na vsako k-to ploščico. Vmesni del besednega opisa (psevdo kode), kjer se nekaj ponavlja, so dijaki opisali dobro, težje pa je bilo zapisati začetni in zaključni del poti. Približno polovica dijakov je bila v programiranju z delčki uspešna, našli so različne rešitve, ki smo jih prikazali na tabli in pokomentirali. V nadaljevanje sta dve od rešitev (Slika 2 in Slika 3).

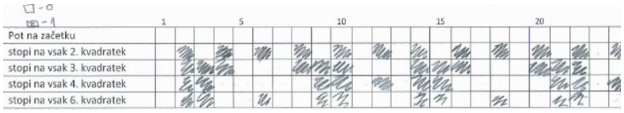
Slika 2: Ena izmed rešitev v Pišku



Slika 3: Še ena rešitev v Pišku

Z vsako skupino smo naslednjič reševali drugo nalogo in dijaki so bili precej bolj samostojni, več jih je prišlo na cilj.

Tretji del smo izvedli čez en teden skupaj z obema skupinama in imeli ob začetku kar nekaj težav s pojasnjevanjem pravila o zapisu z 0 in 1. Dijaki so dobili učni list s potjo dolžine 35, ki jo Hana prehodi štirikrat in vsakokrat preskakuje drugačno število ploščic. Dijaki so ob vsakem potovanju zapisali spremembe na ploščicah in prišli do končnega zaporedja (slika 4). Mnogi so imeli težave, zaradi nezbranosti so se precej motili in na koncu seveda zaporedja niso mogli komentirati.



Slika 4: Štirikrat na poti do šole, izdelek dijaka

Polovica dijakov je zapisala pravilno zaporedje, le peščica pa je znala tudi napovedati in pojasniti, katero število se pojavi na k-tem mestu. Nihče od dijakov se te naloge ni lotil z računalnikom, morda zaradi premalo časa.

3.2 Rezultati ankete

Ob začetku in koncu smo dijake anketirali in jih spraševali po zanimivosti predmeta (matematika, informatika), reševali pa so tudi naloge, ki preverjajo razumevanje navodil in zapisov za premikanje od začetne do končne točke v mreži in iskanje ter štetje poti v tej mreži. V začetni anketi je sodelovalo 29 dijakov, v končni pa 26. V tabeli 1 so zabeleženi odstotki dijakov, ki so naloge rešili pravilno.

Tabela 1: Uspešnost dijakov pri nalogah v anketi

Tip naloge	Prej (%)	Potem (%)
Preštevanje poti	67	58
Zapis poti	38	57

Ugotovili smo, da so dijaki močno napredovali v razumevanju zapisov poti. Domnevamo, da je prišlo do učinkovitega povezovanja (prenosa) znanj iz matematike in informatike, saj je bila naša aktivnost povezana s premikanjem v mreži. V tabeli 2 je primerjava odgovorov na vprašanja o matematiki (MAT) in informatiki (RAČ) kot učnih predmetih. Naveden je odstotek dijakov, ki se strinjajo ali delno strinjajo z zapisano trditvijo. Ostali dve možnosti sta bili ‘se ne strinjam’ in ‘se ne znam odločiti’.

Tabela 2: Strinjanje dijakov s trditvami v anketi

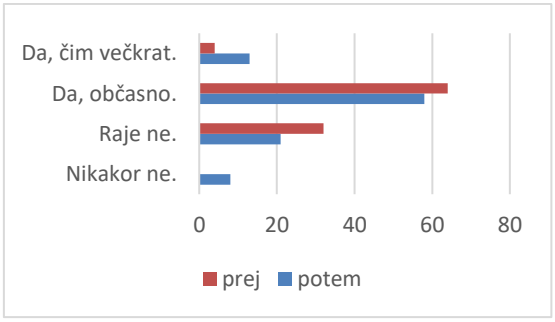
Trditev	Prej (%)	Potem (%)
RAČ je težko.	93	96
RAČ me veseli.	46	52
Rad bi več RAČ.	25	32
MAT je težka.	89	72
MAT me veseli.	74	80
Rad bi več MAT.	37	52

Ugotovili smo, da se je zanimanje za oba predmeta povečalo, čeprav se jim oba še vedno zdita težka. Eno od vprašanj v anketi je spraševalo o odnosu do MINUT predmetov. V zaključni anketi je 12% dijakov zapisalo, da je njihov odnos do teh predmetov bolj pozitiven kot pred to aktivnostjo, kar je obetajoč rezultat.

Vprašali smo jih tudi, če si v prihodnje še želijo takega medpredmetnega povezovanja. V tabeli 3 so njihovi odgovori v odstotkih, na sliki 5 pa še grafična primerjava istih odgovorov.

Tabela 3: Ali si takih aktivnosti (še) želiš?

	Prej (%)	Potem (%)
Da, čim večkrat.	4	13
Da, občasno.	64	58
Raje ne.	32	21
Nikakor ne.	0	8



Slika 5: Primerjava odgovorov začetne in končne ankete

Iz odgovorov lahko sklepamo, da se je zanimanje za tako povezovanje razslojilo. Povečalo se je število dijakov, ki si to še želijo, prav tako pa se je povečalo število dijakov, ki tega v prihodnje nikakor ne želijo. Izvedena medpredmetna povezava jim je nekoliko odprla oči in so ugotovili, kaj jih veseli.

Zaključna misel enega od dijakov: »Med predmeti MINUT imam rada matematiko in naravoslovje, kar se ni spremenilo. Čeprav mi programiranje ni najbolj pri srcu, se je moje mnenje rahlo izboljšalo. Če se taki predmeti povezujejo z mojimi najljubšimi predmeti, jih imam malo raje in zanje pokažem večje zanimanje. Izkušnja je bila pozitivna.«

4 ZAKLJUČEK

Reševanje avtentičnih nalog s povezovanjem dveh ali več učnih področij dijakom omogoča, da prepletejo znanja in jih poglobijo. S tem se brišejo meje med učnimi predmeti, in dijaki lahko iščejo rešitve na širšem območju, to omogoči globlji vpogled. Tudi delo v parih se je izkazalo za dobrodošlo. Dijaki so bili manj prestrašeni in bolj svobodno iskali rešitve, se dopolnjevali, prepričevali, argumentirali in skupaj prišli do boljših rešitev. Avtorici članka meniva, da se pri aktivnosti niso dolgočasili, ankete pa so potrdile, da se je okrepilo zanimanje za predmete MINUT.

Ta članek je nastal v okviru projekta MINUT NAPOJ I [5].

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Uporaba digitalnih kompetenc v vzgojno izobraževalnem zavodu

Use of Digital Competencies in Educational Institutions

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POVZETEK

V zadnjih letih se je potrebno hitro in učinkovito prilagoditi na nove izzive, ki nam jih narekuje življenje. Učitelje in učence je potrebno usposobiti, opolnomočiti z znanji, ki so v sodobnem času še kako pomembna. V učni proces vključujemo raziskovanje, opazovanje ter sklepanje. Za sodobnejše načine poučevanja, je potrebno pridobiti tudi ustrezna znanja, ki jih lahko nato suvereno predajamo naprej. Na različnih usposabljanjih, ki smo se jih udeležili, smo usvajali nova znanja za vpeljavo različnih oblik digitalnega izobraževanja. Dosedanje pridobljene ter usvojene digitalne kompetence smo še nadgradili. Pri posameznih poglavjih v učnem procesu pri pouku matematike poskušamo prenašati digitalne kompetence tudi med učence. Z novimi, drugačnimi načini poučevanja lahko v učnem okolju dosežemo večjo motiviranost in zanimanje za nekoliko drugačne izzive.

KLJUČNE BESEDE

Digitalne kompetence, načini poučevanja

ABSTRACT

In recent years, we have had to adapt quickly and effectively to the new challenges that life dictates to us. Teachers and students need to be trained and empowered with skills that are still very important in modern times. The learning process involves research, observation and reasoning. For more modern methods of teaching, it is also necessary to acquire relevant knowledge, which can be confidently passed on. In the varios trainings we attended, we acquired new skills for the introduction of various forms of digital education. We have developed digital skills so far. In the individual chapters of the learning process in the teaching of mathematics, we try to transfer digital competences among the students. With new, different ways of teaching, we can achieve greater motivation and interest in slightly differnet challenges in the learninig environment.

KEY WORDS

Digital skills, teaching methods

1 UVOD

Učenci morajo pridobiti veščine za učenje problemskih ter procesnih znanj tudi z uporabo digitalne tehnologije. Najprej jih je potrebno seznaniti z novimi oz. drugačnimi pristopi za uspešno reševanje problemov iz realnega sveta. Ob tem nas ne sme biti strah uporabljati UI oz. ChatGPT. Pri reševanju problemov se učenci učijo povezovati znanje znotraj matematike in tudi širše (interdisciplinarno). Naučijo se postavljati ključna raziskovalna vprašanja, ki izhajajo iz življenjskih situacij in poskusiti z usvojenim znanjem rešiti zastavljene naloge.

V okviru medpredmetnega povezovanja naj učenci uporabljajo informacijsko-komunikacijsko tehnologijo (UN - matematika, 2011).

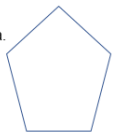
Na strokovnih srečanjih ter usposabljanjih smo učitelji pridobili znanja, le-ta pa lahko z novimi izzivi ter idejami koristno uporabimo v praksi.

2 PRIMER DOBRE PRAKSE

Aktivnosti, ki se navezujejo na učno vsebino o večkotnikih, smo preizkusili z uporabo programskega jezika Python in Scratcha. Predstavljeno aktivnost smo vključili kot nadgradnjo osvojenih znanj pri matematiki. Digitalne kompetence, ki jih pri tem predstavljamo ter razvijamo, učencem omogoča spoznavati matematiko na nekoliko drugačen način. Spoznali so lahko, da se matematika ter programiranje medsebojno prepletata. Brez znanja matematike tudi ni uspeha pri programiranju ter obratno. Na koncu poglavja večkotnikov smo se odločili, da poskusimo osvojene cilje utrditi ter preveriti na drugačen način. Predhodno je bilo potrebno ponoviti o kotih v večkotnikih, velikosti enega notranjega kota v pravilnem n-kotniku, o številu diagonal iz enega oglišča, o številu vseh diagonal,... Seznanili smo jih s programskim jezikom Python, saj ga niso poznali. Ob posameznih primerih so se spoznali Python ter ob tem razvijali digitalne kompetence. Za učence smo pripravili gradivo, ki so ga reševali (slika 1). Namerno smo pri nekaterih nalogah v gradivu zapisali napačno codo v Pythonu. Želeli smo, da učenci sami ugotovijo napako in jo poskušajo odpraviti oz. popraviti. Vedno v življenju ne gre kot po maslu, vmes se kdaj pa kdaj tudi zatakne in poiskati je potrebo napako ter pot, da zadevo rešimo. Prav veseli smo bili njihovega razmišljanja, saj znajo usvojeno znanje med seboj povezovati (matematiko in programiranje).

1. Vsota **notranjih** kotov večkotnika

a) Izračun (peš) vsote notranjih kotov za spodnji primer. Strategija reševanja.



b) Uporabim program Python https://www.online-python.com/

```
n=int(input("Kateri večkotnik si izbral/a?"))
  #vstavi večkotnik
vsota_notranjih_kotov=(n-2)*180
# izračun vsote vseh notranjih kotov n-kotnika
print(f"Vsota notranjih kotov v {n} - kotniku je:
{vsota_notranjih_kotov}")
#izpis vsote notranjih kotov n-kotnika
```

Slika 1. Primer naloge na učnem listu- Python.

Najprej so pripravljeno gradivo reševali na list s pomočjo svinčnika, nato pa še z uporabo IKT tehnologije. Tako so učenci lahko spoznali, kako nam računalnik lahko pomaga pri vsakdanjih nekoliko drugačnih težjih nalogah. V programskem jeziku Python smo zapisali codo, po kateri je potem računalnik hitro izpisal rešitev. Vstavljali smo podatke za različne n-kotnike in računalniška tehnologija nam je v nekaj sekundah podala oz. izračunala velikost enega notranjega kota, vsoto vseh kotov, število diagonal, …

V drugem delu smo se lotili še načrtovanja pravilnih večkotnikov. Učenci so na list s pomočjo svinčnika, ravnila in šestila narisali pravilne večkotnike na dva načina (podana dolžina stranice in izračunan pripadajoči notranji kot, polmer očrtane krožnice in izračunana velikost središčnega kota) (slika 2).

1. Način$_1$- podatki: dolžina stranice in velikost notranjega kota (ga moraš izračunati).

a) enakostranični trikotnik a = 3 cm α =	**b) kvadrat (pravilni 4- kotnik)** a = 3 cm α =
c) pravilni 5- kotnik a = 3 cm α =	**d) pravilni 6- kotnik** a = 3 cm α =

Slika 2. Primer naloge na učnem listu.

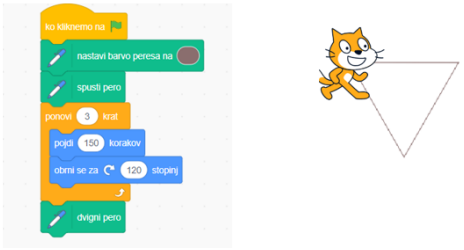
Rešene naloge, ki so jih predhodno narisali, smo potem preverili še z uporabo Scratcha (Slika 3). Nekateri učenci so ga že poznali, nekateri pa ne. Ponovno smo še enkrat predstavili ter pojasnili, kako zapisati ustrezen program, ki nam pravilen večkotnik tudi izriše. Ob tem so spoznavali različne ukaze, zanke in povezali znanje matematike ter programiranja. Računalniška tehnologija nam omogoča, da zapisan program v Scratchu tudi takoj preverimo, če nam izriše to, kar bi si želeli. Morebitne napake sproti dopolnjujemo, popravljamo in ponovno preverimo delovanje. Podana nam je takojšnja povratna informacija.

3. Uporabimo ter preverimo načrtovanje pravilnega večkotnika še v Scratchu.

Povezava: https://scratch.mit.edu/projects/editor/?tutorial=getStarted

Nekaj osnovnih informacij jim je potrebno podati o delu v Scratchu (nekateri ga že poznajo iz preteklih let, saj so obiskovali fakultativni pouk računalništva).

a) Kako z uporabo Scratcha narišemo pravilni večkotnik? Kateri »podatki« so zajeti?



Slika 3. Primer naloge na učnem listu- Scratch

3 ZAKLJUČEK

Učence bomo seznanili z možnostmi reševanja problemov z uporabo informacijsko-komunikacijske tehnologije. Na ta način bodo pridobili tudi digitalne kompetence. Poskusili jih bomo naučiti spopasti se z izzivi, problemi na primerih iz vsakdanjega življenja. Ob predstavljenih primerih so spoznali, da digitalna tehnologija lahko tudi pripomore k hitrejšemu učenju in usvajanju zastavljenih ciljev na drugačen način. V naslednjih letih bomo poskusili pri delu v razredu ponuditi tudi tablice, tako da bi izdelki lahko nastajali in bi se znanje postopoma nadgrajevalo. Ugotovili smo, da vsak učenec lahko osvaja cilje v svojem tempu. Učenci bi svoje osvojene digitalne veščine lahko dopolnjevali ter preiskovali tudi druge načine. Zavedati se moramo, da so takšne možnosti pridobivanja znanj izvedljive tudi pri mlajših učencih. Na usposabljanjih smo bili mnenja, da bi morali učencem omogočiti, da bi si pridobili ter razvijali digitalne kompetence. V osnovni šoli bi naj vsi učenci opravili plavalni tečaj in kolesarski izpit. Naša prizadevanja bodo obrodila rezultate, v kolikor bomo na vseh stopnjah VIZ dela in v različnih predmetnih področjih poskušali vnašati drugačne oblike ter metode dela za ustrezno pridobivanje ter izboljšanje usvojenih digitalnih kompetenc.

VIRI

[1] Gradivo s seminarja: S programiranjem v matematiko, Ljubljana, 2024

[2] https://www.gov.si/podrocja/izobrazevanje-znanost-in-sport/osnovnosolsko-izobrazevanje/, 19. 7. 2024

[3] https://www.zrss.si/digitalna-bralnica/smernice-za-uporabo-digitalne-tehnologije/ , 19. 7. 2024

Slike: lasten arhiv

Učna analitika med visokošolskimi učitelji: preliminarni rezultati

Learning Analytics among Higher Education Teachers: Preliminary Findings

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POVZETEK

Uporaba učne analitike ima velik potencial za doseganje boljših študijskih dosežkov, spodbujanje nadaljevanja študija ter izboljšanje prakse učenja in poučevanja, vendar je ta potencial še vedno dokaj neizkoriščen. Medtem ko je objavljenih veliko raziskav o razvoju vizualizacij, nadzornih plošč in napovednih modelov, pa je bilo le malo raziskav o dejanski uporabi učne analitike med visokošolskimi učitelji, o dejavnikih, ki vplivajo na njeno uporabo in prednostih, ki jih pri uporabi zaznavajo. Ta kvantitativna študija predstavlja preliminarne rezultate 40 visokošolskih učiteljev na Univerzi v Mariboru in Univerzi v Rijeki.

KLJUČNE BESEDE

Učna analitika, univerza, visokošolski učitelji in sodelavci, uporaba, dejavniki, prednosti

ABSTRACT

The use of learning analytics has great potential to improve student achievement, encourage further study and improve learning and teaching practice, but this potential is still largely unexploited. While much research has been published on the development of visualisations, dashboards and predictive models, there has been little research on the actual use of learning analytics among higher education teachers, the factors that influence its use and the perceived benefits of using it. This quantitative study presents preliminary results from 40 higher education teachers at the University of Maribor and the University of Rijeka.

KEYWORDS

Learning analytics, university, higher education teachers and associates, use, factors, benefits

1 UVOD

Dostop in uporaba digitalne tehnologije pušča velike podatkovne sledi. Trženjska industrija izkorišča podatke za napovedovanje zanimanja kupcev za prihodnje izdelke, Netflix predlaga filme glede na naše priljubljene žanre, Amazon pa poskuša napovedati vrste knjig, ki bi si jih lahko želeli. Potencial podatkovne analitike je pritegnil akademsko sfero, da izkorišča podate in se poslužuje podobnih pristopov. Študije, ki so proučevale pristope učne analitike v visokem šolstvu, kažejo pozitivne rezultate pri ugotavljanju potreb študentov, izboljševanju učnih rezultatov in podpore nadaljevanju študija [1], [2], [3], [4]. Z uporabo učne analitike na ravni predmeta lahko visokošolski učitelji in sodelavci pridobijo vpogled v učno vedenje študentov na podlagi vzorcev, ki jih najdejo v podatkih, in se tako lažje odločajo o potrebnih ukrepih. Zdi se, da je stališče, da lahko učna analitika izboljša izobraževanje, splošno sprejeto. Izraz učna analitika uporabljamo v skladu s splošno sprejeto opredelitvijo, ki jo je na 1. mednarodni konferenci o učni analitiki in znanju podalo Društvo za raziskovanje učne analitike (SoLAR) in na katero se sklicujeta Long in Siemens [5, p. 34]: "Učna analitika je merjenje, zbiranje, analiza in poročanje o podatkih o učencih in njihovih kontekstih za namene razumevanja in optimizacije učenja in okolja, v katerem poteka." V grobem ločimo dve podskupini učne analitike. Prva je deskriptivna in diagnostična učna analitika, ki se osredotoča na analizo preteklih podatkov, druga pa napovedna in predpisovalna učna analitika, ki napoveduje vedenje in/ali rezultate učencev ter pomaga pri odločanju o potrebnih ukrepih [6].

Kljub temu, da nekatere univerze, npr. The Open University UK, veliko vlagajo v učno analitiko, njenega potenciala še vedno ne izkoriščajo popolnoma [7]. Kritiki menijo, da je učna analitika le orodje, ki pomaga pri nenehni digitalizaciji visokega šolstva in da je pri vpeljavi učne analitike potrebno upoštevati človeški faktor, saj se rezultati pojavijo zaradi interakcije orodij z različnimi deležniki, kot so študenti, učitelji in managerji [7], [8]. Ta študija se osredotoča na visokošolske učitelje in sodelavce in njihovo uporabo učne analitike. S pomočjo kvantitativne

raziskave želimo ugotoviti, kako visokošolski učitelji in sodelavci uporabljajo učno analitiko, s katerimi izzivi se pri tem soočajo in katere prednosti uporabe zaznavajo. V prispevku so predstavljeni preliminarni rezultati.

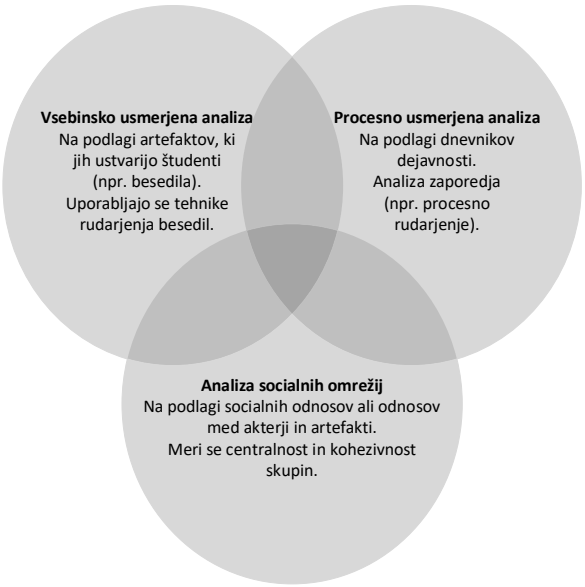
2 PREGLED PODROČJA

V preddigitalni dobi se podatki v izobraževanju niso veliko uporabljali, tehnologija učnih sistemov pa se je razvijala na behavioristični osnovi. Čeprav se morda zdi, da behavioristična filozofija ni povezana z učno analitiko, je Rodriguez [9] poudaril, da obsežen model spletnega izobraževanja - MOOC, kot so Udacity, EdX in Coursera, temelji na behavioristočnem pristopu, saj prevzema tradicionalne učne metode, kot sta učenje z obvladovanjem in utrjevanje konceptov z interaktivnimi vajami. Uporaba vidnih in merljivih učnih ciljev zagotavlja, da je mogoče določene ravni učenja izmeriti in celo oceniti s strojem, kot je računalnik [10].

Pedagoške raziskave razlikujejo ocenjevanje in vrednotenje predmetov. Formativno vrednotenje se uporablja za izboljšanje učnega izdelka, ko je ta še v fazi razvoja, medtem ko se sumativno vrednotenje uporablja za oceno učinkovitosti končne različice izdelka. Najprej so se zbirali le kvantitativni podatki, kasneje tudi kvalitativni in sicer se je preučevalo vedenje učencev iz opazovanj, uporabljaje so se rubrike ali kontrolni seznami. Ocenjevanje in vrednotenje predmetov imata danes še vedno ključno vlogo v izobraževanju. Raziskovalci iščejo načine uporabe vseh vrst povezanih podatkov za izboljšanje poučevanja in učenja.

Čeprav se je digitalne tehnologija v izobraževanju začela uporabljati že v začetku prejšnjega stoletja, se je uporaba spletnega izobraževanja razširila šele v devetdesetih letih prejšnjega stoletja [10]. Pojav sistemov za upravljanje učenja je zagotovil platforme z veliko različnimi kanali in delovnimi prostori, preko katerih lahko udeleženci komunicirajo in izmenjujejo informacije v okviru predmeta. Učitelji lahko delijo svoja predavanja, pripravljajo naloge in izpite ter vključujejo študente v spletne razprave, ki omogočajo sodelovalno učenje itd. Razmah spletnega učenja, zlasti uporaba sistemov za upravljanje učenja, omogoča priročen način zbiranja in beleženja velikih količin podatkov o učenju študentov. Podatki, ki jih ustvarja sistem, vključujejo sledove interakcije učencev s spletno učno platformo. Te sledi podatkov povezujejo akterje (predvsem študente in visokošolske učitelje in sodelavce) in vsebino predmeta (npr. videoposnetke, spletne strani, kvize, spletne razprave) z interakcijskim vedenjem (npr. pregledovanje, odgovarjanje, klikanje). Beleženje postane samodejen proces, kar je nujen pogoj za razvoj učne analitike.

Čeprav univerze že nekaj let v veliki meri uporabljajo sisteme za upravljanje učenja, ustvarjanje in posredovanje vsebine študentom še vedno v veliki meri temelji na intuiciji visokošolski učiteljev in sodelavcev. Ker sistemi za upravljanje učenja večinoma ponujajo je osnovne analize, je potrebna dodatna analiza podatkov, da bi v celoti izkoristili razpoložljive podatke in jih uporabili za izboljšanje prakse poučevanja in učenja. Tu so v ospredju predvsem analiza družbenih omrežij, analiza čustev, analiza vpliva in napovedovanje uspeha študentov [11]. Hoppe [12] predlaga trojico metodoloških pristopov v učni analitiki (slika 1), ki vključuje: (1) analizo socialnega omrežja, vključno z analizo odnosov med akterji ter akterji in artefakti, (2) procesno usmerjeno analizo z uporabo z zaznavanjem vzorcev delovanja in analizo zaporedja ter (3) analizo vsebine z uporabo rudarjenja besedila ali drugih tehnik za analizo artefaktov, ki jih je ustvaril študent. Področja prekrivanja med pristopi so še posebej pomembna za nove sinergije uporabe. Ker take analize zahtevajo naprednejša analitična znanja, se v praksi za uporabnike razvijejo nadzorne plošče z omenjenimi analizami, ki jim pomagajo prepoznati specifične učne težave. Pri tem je potrebno izpostaviti, da taka praksa ni pogosta.



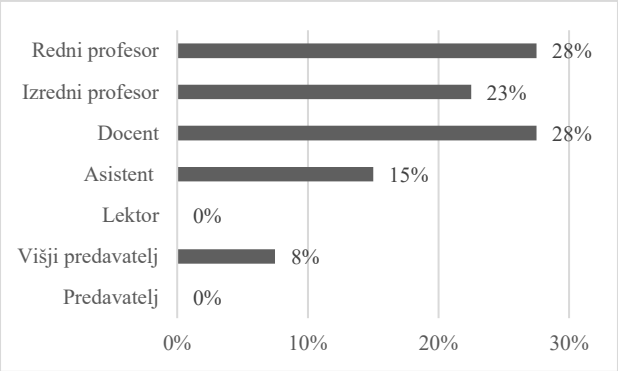
Slika 1: Trojica metodoloških pristopov v učni analitiki po [12]

3 METODOLOŠKI PRISTOP

Ker smo želeli raziskati dejansko uporabo učne analitike med visokošolskimi učitelji, dejavnike, ki vplivajo na njeno uporabo in prednosti, ki jih pri uporabi zaznavajo. Na podlagi pregleda literature smo ugotovili, da nekatere obstoječe raziskave uporabljajo različne teoretične modele, kot so Model sprejemanja tehnologije (TAM) (Davis, 1989) in Univerzalna teorija sprejemanja in uporabe tehnologije (UTAUT) [13] ter modeli sprejemanja, razviti za področje izobraževanja, kot je Model sprejemanja, ki temelji na pomislekih (CBAM). Pri razvoju vprašalnika smo izhajali UTAUT, ker se je izkazal, da najbolje pokriva dejavnike, ki so bili najpogosteje omenjeni v relevantni literaturi. Model smo prilagodili in razširili tako, da smo lahko bolj natančno merili uporabo učne analitike in prednosti njene uporabe. Uporabili smo 5-stopenjsko lestvico Likertovega tipa. Vprašalnik smo pripravili v 1ki. Spremno pismo s povezavo smo konec junija poslali prodekanom za izobraževalno dejavnost vseh fakultet na Univerzi v Mariboru in Univerzi v Rijeki, s prošnjo, da naše elektronsko sporočilo posredujejo naprej vsem visokošolskim učiteljem in sodelavcem na njihovi fakulteti. Zaradi slabšega odziva, podatke še vedno zbiramo. Za namen tega prispevka smo podatke izvozili in jih analizirali s pomočjo programa Microsoft Excel.

4 REZULTATI

V raziskavi je sodelovalo 54 visokošolskih učiteljev in sodelavcev, od tega jih je 40 vprašalnik v celoti izpolnilo. Samo te smo uporabili za našo analizo. Z Univerze v Mariboru so vprašalnik izpolnili visokošolski učitelji in sodelavci osmih fakultet, z Univerze v Rijeki so vprašalnik izpolnili visokošolski učitelji in sodelavci štirih fakultet. Največji delež respondentov ima akademski naziv redni profesor (28%) in docent (28%), sledijo respondenti z nazivom izredni profesor (23%) in asistent (15%) in višji predavatelj (8%) (slika 2).

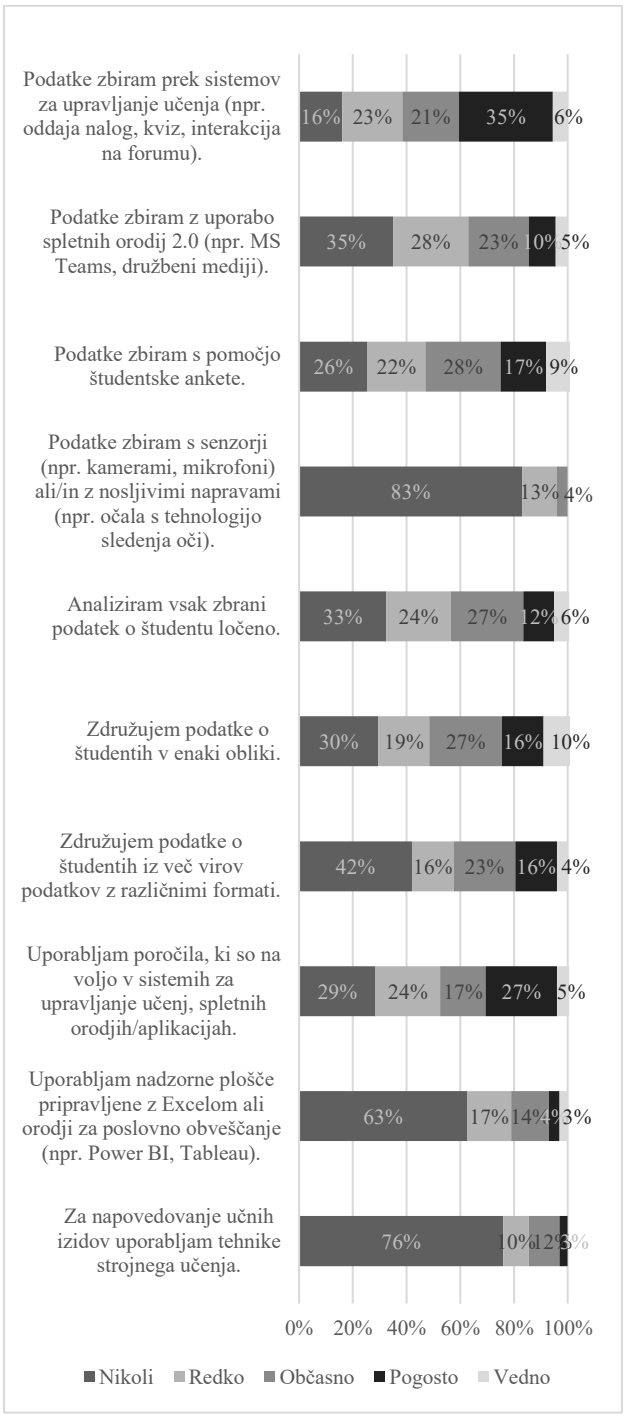


Slika 2: Delež respondentov po akademskih nazivih

Kar 70% sodelujočih visokošolskih učiteljev in sodelavcev ima več kot 15 let delovne dobe, sledijo tisti, ki imajo 1-5 let delovne dobe (13%), nato 11-15 let delovne dobe (10%) in 6-10 let delovne dobe (8%). Prevladuje starost med 45 in 54 let (44%), sledi 55-64 let (23%), 35-44 let (15%), 25-34 let (10%) in 65 let ali več (8%). Spola sta enakomerna prisotna.

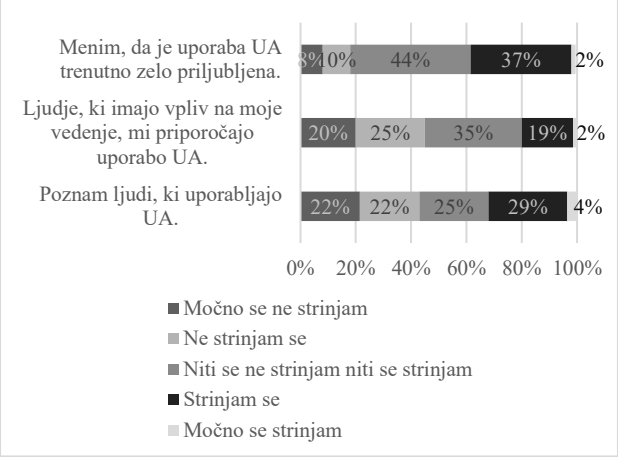
Sodelujoči visokošolski učitelji in sodelavci uporabljajo učno analitiko, vendar v dokaj omejenem obsegu (slika 3). Najpogosteje uporabljajo funkcionalnosti, ki jih ponujajo sistemi za upravljanje učenja in sicer podatke zbirajo preko sistema za upravljanje učenja, kot so npr. oddaje nalog, kvizi, …uporabljajo poročila, ki so na voljo v sistemih za upravljanje učenja, spletnih orodjih/aplikacijah, ki jih uporabljajo. Nekoliko manj pogosto zbirajo podatke s pomočjo študentskih anket in spletnih orodij, npr. MS Teams, ki jih uporabljajo pri svojem delu, zelo redko pa zbirajo podatke s senzorji in nosljivimi napravami. Podatke tudi združujejo, občasno združujejo podatke v enaki obliki, redko združujejo podatke iz več virov z različnimi podatki. Pri analizah občasno uporabljajo funkcionalnosti, ki so jim na voljo v sistemih in orodjih, redko uporabljajo nadzorne plošče, pripravljene z Excelom ali orodji za poslovno obveščanje. Za napovedovanju učnih izidov redko uporabljajo tehnike strojnega učenja.

Preverili smo tudi dejavnike, ki so se izkazali v relevantni literature za pomembne. Predvsem smo se osredotočili na pričakovan napor, družbeni učinek, predvidena tveganja in spodbujevalne pogoje. Pri pričakovanem naporu se slaba polovica (49%) niti ne strinja niti, niti strinja s trditvijo, da se je zdi uporaba učne analitike enostavna. S to trditvijo se ne strinja oz. močno ne strinja 27%, strinja oz. močno strinja pa 20%. Podobni deleži so pri trditvah, da se je naučiti uporabljati učno analitiko enostavno in da zlahka pridobijo veščine za uporabo učne analitike.



Slika 3: Uporaba učne analitike

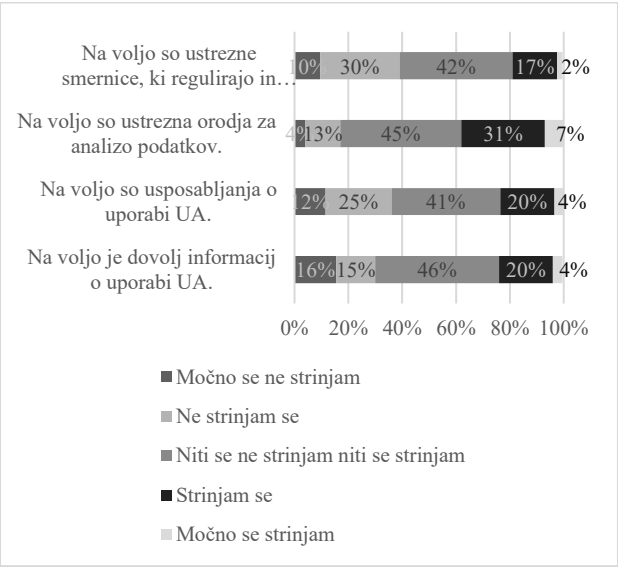
Pri trditvah, ki se navezujejo na družbeni vpliv so deleži med strinjanji nekoliko bolj raznoliki in kažejo, da družbeni vpliv ni tako pomemben dejavnik (slika 4). Od vseh treh trditvah se sodelujoči visokošolski učitelji in sodelavci najbolj strinjajo, da je uporaba učne analitike trenutno zelo priljubljena, sledi poznavanje ljudi, ki učno analitiko uporabljajo, medtem ko se najmanj strinjajo, da jim ljudje, ki vplivajo na njihove vedenje, priporočajo uporabo učne analitike.



Slika 4: Družbeni vpliv

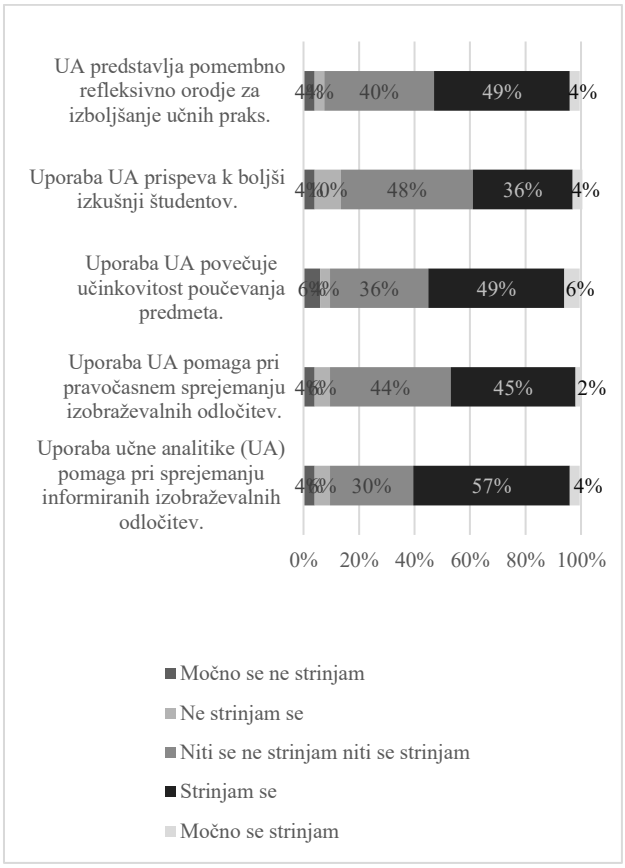
Pri predvidenih tveganjih uporabe učne analitike je ponovno največji delež sodelujočih visokošolskih učiteljev in sodelavcev neopredeljenih oz. se s trditvami niti ne strinja, niti strinja. Je pa večji delež tistih, ki se jim uporaba učne analitike zdi prej priložnost, kot tveganje. Pri trditvi »Zaupam informacijam, ki jih zagotavlja učna analitika« se 45% respondentov niti ne strinja, niti strinja, s trditvijo se strinja oz. popolnoma strinja 31%, 18% se ne strinja oz. popolnoma ne strinja s trditvijo. S trditvijo »Učna analitika zagotavlja prave informacije za sprejemanje ustreznih odločitev« se niti ne strinja, niti strinja 51%, 31% se s trditvijo strinja oz. popolnoma strinja, le 7% se ne strinja oz. popolnoma ne strinja s trditvijo. Visokošolski učitelji in sodelavci pa se najbolje strinjajo s trditvijo, da »Učna analitika zagotavlja informacije v realnem času«.

Pri spodbujevalnih pogojih (slika 5) lahko vidimo, da se respondenti najbolj strinjajo, da imajo na voljo ustrezna orodja za analizo podatkov, nekoliko manj se strinjajo s trditvama, da je na voljo dovolj informacij o uporabi učne analitike in da so na voljo usposabljana, najmanj pa se strinjajo s trditvijo, da so na voljo ustrezne smernice, ki regulirajo in urejajo dostop do podatkov.



Slika 5: Spodbujevalni pogoji

Kljub temu, da sodelujoči visokošolski učitelji in sodelavci uporabljajo učno analitiko v dokaj omejenem obsegu pa se jih pri večini trditvah o prednostih uporabe učne analitike največ opredeljuje, da se z njimi strinjajo (slika 6). Najbolj se strinjajo s trditvijo, da učna analitika pomaga pri sprejemanju informiranih izobraževalnih odločitev, sledita trditvi, da uporaba učne analitike povečuje učinkovitost poučevanja predmeta in predstavlja pomembno orodje za izboljšanje učnih praks. Najmanj pa se strinjajo s trditvijo, da uporaba učne analitike prispeva k boljši izkušnji študentov.



Slika 6: Prednosti uporabe učne analitike

5 SKLEP

Preliminarni rezultati raziskave kažejo, da je uporaba učne analitike na univerzah še vedno v zgodnji fazi razvoja in s tem potrjuje ugotovitve preteklih raziskav na tem področju. Kljub temu, da se vse več institucij in deležnikov zaveda potenciala, ki ga ponuja učna analitika za izboljšanje učnih izidov, analiza kaže, da visokošolski učitelji in sodelavci uporabljajo predvsem funkcionalnosti, ki jih ponujajo sistemi za upravljanje učenja. Ti podatki se zbirajo preko oddaj nalog, kvizov in drugih aktivnosti, redko te podatke združujejo z drugimi viri ali uporabljajo napredne analitične tehnike, kot so strojno učenje.

Visokošolski učitelji in sodelavci soočajo z izzivi pri uporabi učne analitike. Iz analize dejavnikov, kot so pričakovan napor, družbeni učinek, predvidena tveganja in spodbujevalno okolje, je razvidno, da so visokošolski učitelji in sodelavci razmeroma skeptični do enostavnosti uporabe učne analitike. Prav tako

družbeni vpliv ne igra pomembne vloge pri njihovi uporabi učne analitike. Pri predvidenih tveganjih so učitelji previdni in učni analitiki popolnoma ne zaupajo. Najbolj pa se strinjajo s trditvami glede spodbujevalnih pogojev za uporabo učne analitike.

Kljub omejenemu obsegu uporabe učne analitike, so visokošolski učitelji in sodelavci prepoznali prednosti uporabe teh orodij. Največjo podporo imajo trditve, da učna analitika pomaga pri sprejemanju informiranih izobraževalnih odločitev, povečuje učinkovitost poučevanja in predstavlja pomembno orodje za izboljšanje učnih praks.

Kljub pozitivnim vplivom učne analitike na visokošolsko izobraževanje je njena uporaba med učitelji še vedno omejena. Za popolno izkoriščanje potenciala učne analitike je potrebno zagotoviti ustrezno podporno okolje, ki vključuje naprednejša analitična orodja in prilagojene nadzorne plošče, dostop do informacij in usposabljanj ter jasne smernice za uporabo podatkov. Prav tako je pomembno vključiti visokošolske učitelje in sodelavce kot aktivne deležnike v procesu razvoja in implementacije učne analitike, saj lahko njihova neposredna vključenost pripomore k boljšemu razumevanju in uporabi analitičnih orodij.

Nadaljnje raziskave bi morale vključevati bolj obsežne in longitudinalne študije ter upoštevati različne vidike in deležnike v izobraževalnem procesu. Prav tako je potrebno razviti boljše metodološke pristope, ki bodo omogočali bolj generalizirane in prenosljive ugotovitve. Učna analitika ima potencial, da postane pomembno orodje za izboljšanje izobraževalnih praks, vendar so potrebne nadaljnje raziskave in razvoj podpornega okolja, ki bo zagotovil uspešen prenos teorije v prakso.

ZAHVALA

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Ustvarjanje in vrednotenje labirintov

Creating and Evaluating Mazes

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POVZETEK

V naši raziskavi se posvečamo algoritmom za ustvarjanje popolnih labirintov, ocenjevanju njihove težavnosti ter razvrščanju teh algoritmov glede na zahtevnost ustvarjenih labirintov. Raziskali smo teoretično ozadje izbranih algoritmov, kot so Primov, Kruskalov, Aldous-Broder, Iskanje v globino in Bakterijska rast. Ustvarili smo aplikacijo za učenje Primovega in Kruskalovega algoritma za ustvarjanje labirintov. Težavnost ustvarjenih labirintov vrednotimo s pomočjo Markovske verige glede na povprečno število korakov, ki jih naredi program pri iskanju poti v labirintu po Monte Carlo metodi. Raziskali smo primernost uporabe interaktivnega učnega okolja za samostojno učenje algoritmov za ustvarjanje labirintov med učenci zadnjega vzgojno-izobraževalnega obdobja osnovne šole in začetka srednje šole (učenci stari med 12 in 16 let). Aplikacija uči uporabnike novih algoritmov ter omogoča ustvarjanje in vrednotenje labirintov, ki jih lahko uporabijo pri uvodnem programiranju.

KLJUČNE BESEDE

Labirinti, algoritmi, vrednotenje težavnosti, interaktivno učno okolje

ABSTRACT

In our research, we focus on algorithms for generating perfect mazes, evaluating their difficulty, and ranking these algorithms based on the complexity of the mazes they produce. We examined the theoretical foundations of selected algorithms, including Prim's, Kruskal's, Aldous-Broder, Depth-First Search, and Bacterial Growth. To support this, we developed an application that facilitates learning Prim's and Kruskal's maze generation algorithms. The difficulty of the generated mazes is assessed using a Markov chain, which measures the average number of steps the program takes to find a path through the maze, following the Monte Carlo method. Additionally, we explored the suitability of using an interactive learning environment for independent study of maze generation algorithms among students in the later stages of primary education and the early years of secondary education (ages 12 to 16). The application not only teaches users new algorithms but also enables them to create and evaluate mazes, which can be used in introductory programming.

KEYWORDS

Mazes, algorithms, evaluation of difficulty, interactive learning environment

1 UVOD

Algoritmično generiranje labirintov je področje računalništva, ki združuje teorijo grafov, diskretno matematiko in proceduralno generiranje vsebin. Ta pristop omogoča ustvarjanje kompleksnih struktur, ki se uporabljajo v različnih kontekstih, kot so računalniške igre, učenje programiranja in razvijanje računalniškega mišljenja. Labirinti ne predstavljajo le izziv za učence, temveč so tudi odlična priložnost za raziskovanje in razumevanje pomembnih matematičnih konceptov. Razumevanje matematičnega ozadja, vključno s teorijo grafov, prispeva k razvoju učinkovitih algoritmov za ustvarjanje labirintov. Grafi omogočajo jasno ponazoritev labirintov, kjer vozlišča predstavljajo celice labirinta, povezave pa prehode med njimi. Ta matematična abstrakcija poenostavi analiziranje labirintov, saj omogoča uporabo uveljavljenih algoritmov za iskanje poti.

Ukvarjamo se tudi z metodami za objektivno vrednotenje težavnosti labirintov, saj to omogoča primerjavo različnih algoritmov in prilagoditev labirintov specifičnim potrebam učencev. Razvoj učinkovitih in učencem prijaznih učnih okolij za učenje algoritmov, ki ustvarjajo labirinte, lahko pomembno prispeva k izobraževalnemu procesu, še posebej za mlajše učence, ki se šele spoznavajo z osnovami računalništva in matematike, ter k razvoju njihovega računalniškega mišljenja.

Poleg tega bomo predstavili samostojno razvito interaktivno učno okolje, ki bo učencem omogočilo, da se seznanijo z algoritmi za ustvarjanje labirintov in tudi sami ustvarijo labirint po korakih izbranega algoritma za ustvarjanje labirintov. To okolje je namenjeno učencem od 7. do 9. razreda osnovne šole ter dijakom 1. letnika srednje šole (učenci stari med 12 in 16 let).

2 TEORETIČNA IZHODIŠČA

V teoretičnem delu bomo najprej opisali pojem labirinta in ga povezali z zgodovinskim vidikom. Nato bomo obravnavali povezavo med labirinti in teorijo grafov. Na koncu bomo opisali nekaj znanih algoritmov za ustvarjanje popolnih labirintov ter način, kako smo ovrednotili ustvarjene labirinte.

2.1 Labirinti

Labirint je pot oziroma skupek poti, ki vodijo od vhoda v labirint do izhoda iz njega. V splošnem delimo labirinte na razvejane in nerazvejane. Razvejani labirinti (angl. "branching tour puzzles") so tisti, skozi katere mora reševalec najti ustrezno pot, nerazvejani ali enosmerni labirinti (angl. "non branching" ali "unicursal") pa nedvoumno vodijo skozi zapleteno postavitev do cilja [1].

V grški mitologiji je labirint predstavljal kompleksno strukturo, ki jo je zasnoval in zgradil legendarni umetnik Dedal za kralja Minosa iz Krete. Njegova funkcija je bila, da je zadrževal Minotavra, pošast, ki jo je nazadnje ubil junak Tezej s pomočjo boginje Ariadne [2].

Labirinte lahko delimo tudi glede na sistem prehoda. Osnovne tri vrste so: popolni labirint (angl. perfect maze), spleteni labirint (angl. braid maze) in enosmerni labirint (angl. unicursal maze). Obravnavali smo zgolj popolne labirinte, ki morajo ustrezati naslednjim zahtevam: nimajo nobenih zank, nimajo izoliranih celic in med vsakim parom celic obstaja natanko ena pot [3]. Taki labirinti so ekvivalentni drevesom iz teorije grafov.

Ustvarjanje labirintov je načrtovanje razporeditve prehodov in sten v labirintu. Obstaja veliko različnih pristopov k ustvarjanju labirintov z različnimi algoritmi za ustvarjanje labirintov, bodisi ročno bodisi samodejno z računalnikom. Za ustvarjanje labirintov se uporabljata dva glavna mehanizma. Pri izrezovanju prehodov se sprva ustvari mrežo v kateri nato odstranjujemo stene, pri dodajanju sten pa se na odprtem območju določi niz ovir [1]. Pri raziskavi smo se osredotočili na mehanizem izrezovanja prehodov oziroma odstranjevanja sten.

2.2 Povezava s teorijo grafov

Definicije in izreki, ki so podani v tem podpoglavju, so povzeti iz [4].

Definicija 2.1. Graf $G = (V, E)$ je urejen par množic V in E, kjer je V neprazna množica vozlišč in E neka podmnožica množice neurejenih parov različnih vozlišč iz V. Elementom množice E rečemo povezave grafa G. Če je $(u, v) \in E$, rečemo, da sta u in v sosednji vozlišči, kar označimo z $u \sim v$.

Labirint lahko predstavimo z grafom. Vsaka celica labirinta je predstavljena kot vozlišče grafa, dve vozlišči pa sta povezani natanko takrat, kadar sta pripadajoči celici sosednji in med njima obstaja prehod oziroma pot. Popolni labirint ustreza enakim zahtevam, kot jih ima drevo, zato pravimo, da so popolni labirinti ekvivalentni drevesom iz teorije grafov.

Izrek 2.6. Graf G je drevo natanko tedaj, ko za vsaki dve vozlišči grafa G, obstaja natanko ena pot med njima.

Dokaz izreka bomo izpustili.

Začetno mrežo, v kateri bomo izrezovali prehode, predstavimo z grafom mreže (kartezični produkt grafov poti). Da bomo lahko iz začetne mreže, kjer ima vsaka celica vse štiri stene, dobili popoln labirint, moramo nekatere stene odstraniti. To bomo naredili tako, da bomo določili vpeto drevo, saj so popolni labirinti ekvivalentni drevesom. Ko bomo izbirali vpeto drevo, bodo izbrane povezave predstavljale odstranjene stene, kar bo omogočilo prehodnost v labirintu.

Definicija 2.7. Naj bosta $G_1 = (V_1, E_1)$ in $G_2 = (V_2, E_2)$ grafa. Tedaj je G_1 podgraf grafa G_2, če je $V_1 \subseteq V_2$ in $E_1 \subseteq E_2$. Če je $V_1 = V_2$, je G_1 vpet podgraf grafa G_2. Vsak vpet podgraf H povezanega grafa G, kjer je H drevo, se imenuje vpeto drevo grafa G.

Pri reševanju problemov iz vsakdanjega življenja za reprezentacijo problema pogosto uporabljamo utežene grafe. Takšni grafi se pojavljajo v številnih kontekstih, na primer pri reševanju problema najkrajše poti – zelo znan je problem trgovskega potnika.

Definicija 2.8. Uteženi graf je graf, v katerem je vsaki povezavi dodeljeno število (običajno je to število pozitivno), ki mu rečemo utež in označimo z $w(e)$. Če je G uteženi graf in H njegov podgraf, potem je utež $w(H)$ podgrafa H enaka vsoti uteži povezav podgrafa H.

Pri labirintih sicer navadno nimamo takšnih težav, saj je odstranjevanje sten iz določenega materiala enakovredno. Če pa bi imeli, na primer, stene iz različnih materialov in bi za odstranjevanje različnih materialov porabili različno veliko energije, bi za tak problem potrebovali utežen graf. Recimo, da želimo porabiti čim manj energije za odstranjevanje sten, v tem primeru želimo izbrati takšno množico povezav vpetega drevesa, da bo njihova vsota uteži najmanjša. Torej ne bo zadostovalo zgolj katerokoli izbrano vpeto drevo. Temu rečemo, da želimo poiskati minimalno vpeto drevo tega grafa.

Definicija 2.9. Minimalno vpeto drevo uteženega grafa je množica povezav z minimalno skupno utežjo, ki tvorijo vpeto drevo grafa. Kadar graf ni obtežen, je vsako vpeto drevo minimalno.

Kot smo že omenili, teža na splošno ni pomembna za predstavitev labirinta, kljub temu pa nekateri algoritmi za ustvarjanje labirintov temeljijo na algoritmih, ki iščejo minimalna vpeta drevesa, zato je dobro poznati vsaj osnovno definicijo uteženega grafa in minimalnega vpetega drevesa.

2.3 Algoritmi za ustvarjanje popolnih labirintov

Obstaja veliko različnih algoritmov za ustvarjanje labirintov. Opisali bomo le nekaj najbolj pogosto uporabljenih in najbolj znanih. Začeli bomo z algoritmoma, ki se uporabljata za reševanje problema iskanje minimalne poti v grafu – torej iščeta minimalno vpeto drevo (to sta Primov in Kruskalov algoritem). Nato pa si bomo pogledali še nekaj takšnih, ki ustvarijo le tako imenovani naključni sprehod, kar je za potrebe ustvarjanja labirintov zadostno, saj potrebujemo le enega izmed možnih vpetih dreves grafa.

2.3.1 Primov algoritem

Algoritem deluje tako, da na začetku izbere poljubno vozlišče v grafa G (celico v labirintu). Primovo drevo T začne graditi z vozliščem v. Nato ustvari prazno množico m, ki bo predstavljala vse mejne povezave. Mejne povezave so tiste, ki sovpadajo z mejnimi stenami vseh tistih celic, ki so že v drevesu T. Dokler Primovo drevo T ne doseže vseh vozlišč (celic labirinta) ponavlja naslednje: posodobi množico mejnih povezav, izbere povezavo e iz množice m, ki ima najmanjšo utež, in v drevo T doda tisto vozlišče izbrane povezave e, ki še ni v drevesu T. Ko doseže vsa vozlišča, dobi minimalno vpeto drevo danega grafa.

Čeprav so utežene povezave v nekaterih primerih pomembne, za ustvarjanje labirintov niso potrebne. Če bi želeli izvesti pravi Primov algoritem, bi morali vsem povezavam vnaprej dodeliti naključne uteži, predno bi zagnali algoritem. Vendar to ni potrebno, saj je pravzaprav zadosti, da na vsakem koraku kar

naključno izberemo eno izmed povezav iz množice m (lahko si predstavljamo, da imajo vse povezave enako utež) [5].

2.3.2 Kruskalov algoritem

Algoritem deluje tako, da ima na začetku množico možnih povezav, to so vse povezave v grafu, iz katere na vsakem koraku izbere tisto povezavo, ki ima najmanjšo utež – če obstaja več povezav z enako utežjo, potem naključno izbere eno izmed njih. Če z dodajanje te povezave ne ustvari cikla, jo doda v vpeto drevo in jo nato odstrani iz množice možnih povezav. To ponavlja, dokler ne ustvari vpetega drevesa, torej dokler množica povezav ni prazna. Na koncu dobimo minimalno vpeto drevo danega grafa.

Podobno kot pri Primovem algoritmu, tudi tokrat utežene povezave niso potrebne. Za ustvarjanje popolnih labirintov je dovolj, da na vsakem koraku kar naključno izberemo eno izmed povezav [5].

2.3.3 Aldous-Broder algoritem

Algoritem deluje tako, da najprej naključno izbere začetno vozlišče v. To vozlišče označi za trenutno in ga doda med obiskana vozlišča. Dokler ne označi vseh vozlišč kot obiskanih ponavlja naslednje: izbere naključnega soseda u trenutnega vozlišča v in preveri, ali je to vozlišče u že med obiskanimi. Če to vozlišče u še ni med obiskanimi, potem izbere povezavo med vozliščema v in u (odstrani steno med pripadajočima celicama) in označi vozlišče u kot obiskano. Nato označi vozlišče u kot trenutno vozlišče. Če pa je bilo vozlišče u že obiskano, potem samo označi vozlišče u kot trenutno vozlišče [6].

2.3.4 Algoritem Lovi in ubij

Algoritem deluje tako, da najprej naključno izbere začetno vozlišče v. To vozlišče označi za trenutno in ga doda med obiskana vozlišča. Dokler ne označi vseh vozlišč kot obiskanih ponavlja naslednje: izbere naključnega še neobiskanega soseda u (če le-ta obstaja) trenutnega vozlišča v in izbere povezavo med vozliščema v in u (odstrani steno med pripadajočima celicama). Če tako sosednje vozlišče u ne obstaja, torej so vsi njegovi sosedi že obiskani, potem vstopi v fazo "lovljenja" in naredi naslednje: pregleduje vozlišča enega za drugim, dokler ne naleti na neobiskano vozlišče w, ki je sosednje z vsaj enim obiskanim vozliščem. Ko najde takšno vozlišče w, ga označi za trenutnega in obiskanega ter izbere povezavo med vozliščem w in katerimkoli izmed njegovih sosednjih že obiskanih vozlišč (odstrani steno med pripadajočima celicama). Ko označi vsa vozlišča za obiskana, se algoritem ustavi.

Če se tak algoritem izvaja na labirintu, lahko fazo "lovljenja" oziroma iskanja strukturiramo na naslednji način: algoritem začne pri celici v zgornjem levem kotu in pregleduje celice po vrsti od leve proti desni, od zgoraj navzdol. Nadaljuje pregled, dokler ne naleti na neobiskano celico, ki je sosednja vsaj eni že obiskani celici [6].

2.3.5 Algoritem Iskanje v globino

Algoritem iskanja v globino raziskuje graf tako, da se usmerja v globino. To pomeni, da je naslednje obiskano vozlišče, če le-to obstaja, kot otrok prejšnjega vozlišča. Če ne obstaja, se algoritem vrne do prejšnjega vozlišča in poskusi z drugim sosedom. Algoritem se konča, ko obišče vsa vozlišča grafa. Podobno deluje tudi naš algoritem Iskanje v globino, ki ustvari sprehod od začetne točke po celotnem grafu in po potrebi uporabi povratno sledenje. Pomemben vidik je naključnost. Že na prvem koraku izbere naključno celico. Druga naključna izbira pa se nanaša na izbiro soseda oziroma otroka vozlišča, do katerega se bo ustvaril prehod iz trenutne celice [3].

Lahko bi tudi rekli, da algoritem Iskanje v globino deluje podobno kot algoritem Lovi in ubij. Oba namreč ustvarjata naključni sprehod po mreži, razlika pa je v tem, kako se izkopljeta iz slepih ulic. Algoritem Lovi in ubij bo prešel v fazo "lovljenja", algoritem Iskanje v globino pa se vrne nazaj in sledi svojim korakom, dokler ne najde celice, ki ima še vsaj enega neobiskanega soseda. Za namen beleženja celic, ki smo jih že obiskali, uporabimo kar strukturo, ki se imenuje sklad.

2.3.6 Algoritem Bakterijska rast

Algoritem Bakterijska rast ustvarja labirint na zelo podoben način kot Primov algoritem. Oba gradita vpeto drevo iz enega vozlišča naprej na razširljiv način. Razlika je v "intenzivnosti" dodajanja novih povezav in vozlišč v drevo. Primov algoritem znotraj zanke na vsakem koraku doda po eno povezavo, medtem ko algoritem Bakterijska rast doda povezavo in ustrezno vozlišče vsaki celici z razpoložljivimi, tj. še neobiskanimi, sosedi. Število obiskanih celic se lahko torej po vsakem koraku največ podvoji. Najverjetneje od tod izvira ime algoritma, saj populacija bakterij običajno narašča eksponentno [3].

2.4 Vrednotenje labirintov

Reševanje labirintov je proces, pri katerem je cilj najti pot od vhoda v labirint do izhoda iz njega. Če labirint ne vsebuje razpotij in posledično slepih ulic (saj obravnavamo le popolne labirinte), bo takšen labirint manj zahteven za reševanje. V ta namen se je veliko raziskovalcev spraševalo, kateri algoritmi ustvarjajo zahtevnejše labirinte in kateri manj zahtevne. Kako se lotiti vrednotenja labirintov in merjenja njegove težavnosti?

Mane idr. v [7] opisujejo, da je reševanje labirintov težje kadar imamo več razpotij in slepih ulic. Pri vrednotenju so poleg števila razpotij in slepih ulic upoštevali tudi hitrost različnih agentov, ki so reševali labirinte. Agenti so računalniški programi, ki iščejo pot v labirintu na različne načine, tj. z različnimi algoritmi za iskanje poti, kot so Iskanje v globino, Iskanje v širino in Dijkstrov algoritem. Po njihovih kriterijih so težji labirinti tisti, ki so ustvarjeni z algoritmom Aldous-Broder, medtem ko so lažji tisti, ki so ustvarjeni z algoritmoma Lovi in ubij ter Iskanje v globino. Do Podobnih ugotovitev je prišel tudi Gabrovšek v [8].

Bellot idr. v [9] vrednotijo labirinte na podoben način, vendar se osredotočajo na to, kateri algoritmi ustvarijo najbolj "zabavne" labirinte za reševanje. Razvili so dva nova algoritma, imenovana Twist&Merge ter Prim&Kill. Njihovo ocenjevanje "zabavnosti" labirintov temelji na številu nepomembnih zidov, kot jih definirajo v svojem članku.

3 EMPIRIČNI DEL

V tem delu članka bomo predstavili način vrednotenja labirintov, ustvarjenih z različnimi algoritmi. Nato bomo predstavili aplikacijo, ki smo jo razvili z namenom učenja korakov algoritmov za ustvarjanje labirintov. Opisali bomo tudi, kako so izbrani učenci, stari med 12 in 15 let, sprejeli aplikacijo.

3.1 Vrednotenje labirintov z Markovsko verigo

Predstavljamo vrednotenje labirintov, ki temelji na uporabi diskretne Markovske verige s prehodnimi verjetnostmi.

Definicija 3.1. Naj bo V množica stanj, $v \in V$ pa stanje. Markovska veriga je usmerjen graf $G = (V, E)$, katerega povezave so označene s prehodnimi verjetnostmi $p : E \rightarrow (0,1]$ z lastnostjo, da za vsako stanje $v \in V$ velja, da je vsota verjetnosti na povezavah, ki grejo iz stanja v v druga stanja, enaka 1, kar zapišemo kot $\forall v \in V : p(e) = 1$.

Markovska veriga sicer lahko vsebuje zanke, ne pa tudi večkratnih povezav. Vendar pa te lastnosti za namen vrednotenja težavnosti popolnih labirintov ne potrebujemo, saj popolni labirinti ne vsebujejo zank in vemo, da je naš labirint drevo, kar pomeni, da med vsakima dvema vozliščema obstaja natanko ena pot [10].

Kadar rešujemo problem z Markovskimi verigami, nas običajno zanima, kolikšna je verjetnost, da bomo v n-tem koraku prišli v stanje s. V primeru reševanja labirintov pa nas bo zanimalo, kolikšno je povprečno število korakov, tj. premikov iz enega stanja v drugega oziroma iz ene celice v drugo sosednjo celico, da bomo prišli iz začetne celice labirinta v končno celico labirinta.

Iz danega labirinta in predpisanimi prehodnimi verjetnosti lahko preprosto ustvarimo ustrezno Markovsko verigo. Labirint pretvorimo v graf, oziroma v našem primeru v drevo, vsaki povezavi pa priredimo dano verjetnost [10]. Nato v labirint pošljemo našega agenta, ki šteje število korakov, ki jih potrebuje, da najde pot iz labirinta. Naj bo celica $(0,0)$ začetno stanje, tj. celica, ki leži v levem zgornjem kotu, in celica $(n-1, n-1)$ končno stanje, tj. celica, ki leži v desnem spodnjem kotu, kjer je n dolžina oziroma širina kvadratnega labirinta. Definirajmo sedaj premikanje našega agenta po labirintu.

Definicija 3.2. Naj bo A agent, ki se giblje po labirintu. Začne v celici $(0,0)$ in se premika po labirintu, vse dokler ne pride do končne celice $(n-1, n-1)$. Agent A pri premikanju skozi labirint upošteva predpisane prehodne verjetnosti. Na vsakem koraku izbere nadaljno smer gibanja, ki ni enaka smeri iz katere je prišel, razen v primeru, ko se znajde v slepi ulici. Takrat agent A nadaljuje svoje gibanje nazaj v smeri iz katere je prišel, tj. njegova edina možna smer premikanja.

Čeprav smo vnaprej določili verjetnosti, s pomočjo katerih se bo gibal agent A, to gibanje še vedno temelji na naključni izbiri. Zaradi tega bomo gibanje agenta A po labirintu ponovili večkrat, na primer 1000-krat, in vzeli povprečno število korakov, ki jih je agent naredil čez vse ponovitve. Temu načinu ustvarjanja naključnih poti s ciljem vrednotenja strukture imenujemo tudi Monte Carlo. Glede na to povprečno število obiskanih celic (ne nujno različnih), v nadaljevanju povprečje, določi težavnost labirinta. Odločili smo se, da bomo labirinte razdelili v 3 kategorije: lahek, srednji in težek.

Algoritem vrednotenja smo preizkusili na labirintih velikosti 3x3, 4x4 in 7x7. Na podlagi teh primerov smo določili meje izračunanega povprečja za razporeditev labirintov v tri različne kategorije težavnosti. Ta razporeditev velja za labirinte velikosti nxn, kjer je $n > 5$.

Tabela 1: Težavnost labirinta glede na razpon povprečja

Težavnost labirinta	Razpon povprečja
Lahek	povprečje $\leq n^2$
Srednji	$n^2 <$ povprečje $< \sqrt{n} \cdot n^2$
Težek	povprečje $\leq \sqrt{n} \cdot n^2$

Za testiranje smo izbrali Kruskalov algoritem, Primov algoritem, algoritem Lovi in ubij ter algoritem Iskanje v globino. Za vsakega izmed teh štirih algoritmov smo ustvarili 100 labirintov velikosti 10x10. Za vsak labirint je računalnik izračunal njegovo vrednost povprečja in podal stopnjo težavnosti v skladu s tabelo Tabela 1. Povprečje smo izračunali na 10000 ponovitvah. Na podlagi naših meritev smo prišli do naslednjih ugotovitev. Kot je razvidno iz tabele Tabela 2 ima Kruskalov algoritem najvišje povprečno število korakov, ki jih je agent naredil pri iskanju poti. Za njim sledi Primov algoritem, nato algoritem Lovi in ubij in kot zadnji algoritem Iskanje v globino.

Tabela 2: Povprečno število korakov glede na algoritem

Algoritem	Povprečno število korakov za labirinte velikosti 10x10
Kruskalov	354,4
Primov	309,4
Lovi in ubij	258,8
Iskanje v globino	224,9

Na opisani način smo ovrednotili kompleksnost manjših labirintov dimenzij 9x9, 8x8 in 7x7. Pri vseh dimenzijah se je izkazalo, da agent pri labirintih, ki jih ustvari Kruskalov algoritem, naredi največje povprečno število korakov pri iskanju poti v labirintu. Nato je sledil Primov algoritem, za njim algoritem Lovi in ubij ter kot zadnji algoritem Iskanje v globino.

3.2 Predstavitev aplikacije

V tem podpoglavju bomo predstavili samostojno izdelano interaktivno učno okolje (aplikacijo) za učenje algoritmov, ki ustvarjajo labirinte. Aplikacija ima dve glavni funkcionalnosti: učenje algoritmov, ki je del sklopa Poglej, in samostojno ustvarjanje labirintov z izbranim algoritmom, ki je del sklopa Ustvari. Aplikacija ponuja ponazoritev delovanja izbranih algoritmov, s katerimi lahko ustvarjamo labirinte. Po drugi strani pa uporabnikom nudi možnost ustvarjanja svojih labirintov, vendar le, če so njihovi posamezni koraki ustrezni glede na izbrani algoritem. Za vsak izvedeni korak dobi uporabnik takojšnjo povratno informacijo glede pravilnosti oziroma nepravilnosti koraka. Ob morebitni nepravilnosti koraka uporabnik dobi pojasnilo, zakaj izvedeni korak ne ustreza koraku izbranega algoritma. Natančnejši opis aplikacije je podan v [11].

V sklopu Poglej ponazorimo delovanje izbranih algoritmov s katerimi lahko ustvarimo labirinte. Odločili smo se, da v aplikacijo vključimo naslednje štiri algoritme: Kruskalov algoritem, Primov algoritem, algoritem Lovi in ubij ter algoritem Iskanje v globino. Princip delovanja aplikacije je pri vseh štirih algoritmih enak. Uporabnik ima na voljo tri gumbe s katerimi upravlja vizualizacijo delovanja algoritmov za ustvarjanje popolnih labirintov, in sicer “Poženi”, “Korak” in “Ponastavi” (v

tem vrstnem redu). S klikom na gumb "Poženi", se bo na mreži začel izvajati izbrani algoritem, dokler ne bo labirint dokončno ustvarjen. Gumba "Poženi" in "Korak" sta do nadaljnjega onemogočena, tj. dokler uporabnik ne klikne na gumb "Ponastavi". S klikom na gumb "Korak", se izvede naslednji korak izbranega algoritma. Ko uporabnik prvič klikne nanj, se izvede prvi korak algoritma in gumb "Poženi" je do nadaljnjega onemogočen, tj. dokler uporabnik ne klikne na gumb "Ponastavi". Po vsakem naslednjem kliku na gumb "Korak" se v labirintu odstrani ena izmed sten. To lahko ponavljamo, dokler ne dobimo popolnega labirinta. S klikom na gumb "Ponastavi" se ponovno naloži prikazana scena, tj. kot da bi kliknili gumb "Nazaj" in nato zopet izbrali enak algoritem. Na ta način lahko uporabnik prekine usvajanje delovanja algoritma na labirintu ali preneha s sledenjem algoritmu po korakih.

V sklopu Ustvari lahko uporabnik sam izdela labirint po korakih enega izmed algoritmov ali preveri, če razume delovanje enega izmed algoritmov. V ta del aplikacije sta vključena dva izmed prejšnjih štirih algoritmov iz sklopa Poglej. Ta dva algoritma sta: Kruskalov in Primov algoritem. Uporabnik po izbiri algoritma nato izbere tudi težavnost: začetnik ali poznavalec. Pri začetniku so celice labirinta obarvane tako, da uporabniku pomagajo pri izbiri ustreznih dveh celic, med katerima dvema bo ustvaril prehod. Na ta način je začetniku lažje ugotoviti med katerimi celicami že obstaja pot v labirintu in med katerimi ne, med katerimi celicami lahko ustvari prehod in kdaj je labirint končan. Pri poznavalcu pa so vse celice pobarvane z belo barvo. Ta način je za uporabnika zahtevnejši, saj mora sam dobro premisliti, kateri dve celici lahko poveže med seboj, tj. ustvari prehod med njima, in med katerimi celicami že obstaja pot v labirintu.

Po dokončno ustvarjenem labirintu se uporabniku izpiše tudi stopnja težavnosti njegovega ustvarjenega labirinta. Poleg tega pa se tudi omogoči gumb "Izvedi več". Ob kliku nanj, se uporabniku prikaže matematično ozadje ustvarjanja labirintov. V labirintu se izrišejo vozlišča grafa oziroma drevesa in povezave ter prikaže za učence prilagojen opis definicije grafa. Poleg tega pa se omogoči tudi gumb "Izvozi". Ob kliku nanj se uporabniku prenese slika njegovega ustvarjenega labirinta v formatu .png. Uporabniku se odpre novo okno, kjer izbere mesto v svojem računalniku, kamor bo shranil to sliko.

3.3 Preizkus aplikacije

Aplikacijo smo preizkusili s tremi priložnostno izbranimi učenkami različnih starosti, ki jih naprej imenujemo testiranke. Prva je bila učenka sedmega razreda osnovne šole, druga učenka osmega razreda osnovne šole, tretja pa je bila dijakinja prvega letnika gimnazije. Vse tri prihajajo iz osrednjeslovenske regije. Vsaka od testirank je preizkusila aplikacijo. Preizkus je potekal tako, da smo testiranki najprej predstavili aplikacijo in njene funkcionalnosti, nato pa je tudi sama preizkusila uporabo. Predstavitev aplikacije z naše strani je potekala frontalno in je trajala 10 minut. Po končani predstavitvi so testiranke same preizkušale aplikacijo. Preizkušanje je v povprečju trajalo 30 minut. Po končanem preizkusu smo z vsako od testirank izvedli polstrukturiran intervju o njeni izkušnji z aplikacijo. Tekom pogovora smo zastavili naslednja vprašanja:

1. Kaj ti je bilo pri aplikaciji (najbolj) všeč?
2. Kaj ti pri aplikaciji ni bilo všeč?
3. Ali si že kdaj prej slišala za besedo algoritem?
4. Ali bi imela takšno aplikacijo tudi doma na osebnem oziroma družinskem računalniku?
5. Ali bi se ti zdela uporaba aplikacije v šoli primerna, če bi pri pouku ali pri šolskem krožku obravnavali delovanje Kruskalovega ali Primovega algoritma?
6. Kaj bi pri aplikaciji izboljšala?

Pri prvem vprašanju so testiranke povedale, da jim je všeč, da lahko samostojno ustvarjajo labirinte. Všeč jim je bila tudi sprotna razlaga korakov posameznega algoritma v sklopu poglej in olajšava z barvnimi celicami pri začetniku. Pri drugem vprašanju so dejale, da ni nič takšnega, kar jim ne bi bilo všeč. Na tretje vprašanje sta dve testiranki odgovorili pritrdilo. Besedo algoritem sta že srečali pri pouku matematike, vendar pa se nista spomnili kaj beseda pomeni. Na četrto vprašanje so vse tri testiranke odgovorile pritrdilno. Povedale so, da bi aplikacijo z veseljem uporabljale, ena izmed testirank je še dejala, da bi jo uporabila za potrebe šolskega časopisa, da bi lahko vstavila svoj labirint pod razvedrilo, kjer bi ga rešili še ostali učenci. Tudi na peto vprašanje so vse tri testiranke odgovorile pritrdilno. Povedale so, da vidijo uporabo aplikacije v okviru šolskega krožka. Pri zadnjem vprašanju pa je ena izmed testirank kot izboljšavo navedla dodatno stopnjo težavnosti.

Vse tri testiranke so bile prijetno presenečene in navdušene nad aplikacijo in njeno uporabo ter uporabnostjo. Navigacija po aplikaciji je potekala brez vmesnih prekinitev in pomoči. Ustvarjale so predvsem srednje in težke labirinte z malo napakami. Napake so se večinoma nanašale na ponesreči dvojno kliknjeno isto celico labirinta ali na ponesreči kliknjeno sosednjo celico od zamišljene zaradi slabše koordinacije računalniške miške. Ob prvotnem vrednotenju uporabnosti aplikacije za ustvarjanje labirintov se zavedamo individualnih razlik med testirankami. Z rezultati vrednotenja smo zadovoljni.

4 ZAKLJUČEK

V prvem delu prispevka smo predstavili osnovne značilnosti labirintov in njihovo povezavo s teorijo grafov. Predstavili smo nekaj algoritmov s katerimi lahko ustvarimo popolne labirinte. Naredili smo tudi pregled vrednotenja težavnosti algoritmov, ki so jih izvedli drugi avtorji. Nato smo opisali empirični del, kjer smo predstavili svojo metodo za vrednotenje težavnosti ustvarjenega labirinta. Predstavili smo tudi ugotovitve glede tega, kateri algoritmi ustvarijo težje in kateri lažje labirinte. Nato smo predstavili izdelano aplikacijo s katero se uporabnik uči delovanja algoritmov za ustvarjanje labirintov. Na koncu pa smo predstavili rezultate preizkusa aplikacije, ki smo ga izvedli na treh priložnostno izbranih učencih.

Primer se osredotoča na področje algoritmičnega ustvarjanja labirintov, vendar si želimo, da bi naša aplikacija in pridobljena spoznanja vplivala tudi na širši razvoj računalniškega mišljenja, zlasti v dimenzijah algoritmičnega mišljenja in validacije.

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Šolska knjižnica v koraku s časom

School Library Keeping up with the Time

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POVZETEK

V prispevku smo opisali uvajanje novosti s področja knjižničarstva v okolje šolske knjižnice. Avtomatizirana sistemska sporočila kot takšna sicer niso novost, vendar so na novo vpeljana v našo šolsko knjižnico in so prinesla takojšno izboljšanje pri rednem vračanju gradiva. Tudi pri inventuri smo v preteklem šolskem letu uvedli novost in sicer uporabo aplikacije mInventura, ki omogoča zajem inventarne številke preko mobilnega telefona, kar je pripomoglo k hitrejšemu odčitavanju gradiva. Vklop Lokatorja gradiva sicer zahteva kar veliko dela s strani knjižničarja pri vnašanju podatkov a ko je enkrat vse vneseno, nam ni potrebno več nič dodajati, razen sprememb, če karkoli premikamo v postavitvi knjižnice, kar pa se zgodi zelo redko ali pa gre le za spremembe v manjšem obsegu. Nova programska oprema Cobiss Lib je sicer še v prehodnem obdobju, vendar smo se v večini šolskih knjižnic že seznanili z njo in jo tudi uporabljamo vzporedno s Cobiss3. Predstavljena platforma Cobiss Ela pa zaenkrat poraja še ogromno vprašanj glede vključevanja šolskih knjižnic in bomo morali počakati, dokler se vsi deležniki ne dogovorijo o dolgoročni strategiji glede e-knjig v šolstvu.

KLJUČNE BESEDE

Avtomatizacija, aplikacije, Cobiss Ela, Cobiss Lib, e-knjige, inventura, lokator gradiva, mInventura

ABSTRACT

We described how proffesional librarianship novelties are introduced into the environment of the school library. Automated system messages as such are not a novelty, but they have been newly introduced in our school library and have brought an immediate improvement in regular returns. In the past school year, we also introduced an innovation in the inventory, the use of the mInventura application, which enables the capture of the inventory number via a mobile phone, which helped to scan the inventory faster. Incorporating the Locator does require a lot of work on the part of the librarian when entering data, but once everything is entered, we do not need to add anything, except for changes, if we move anything in the layout of the library, which happens very rarely or it is only changes on a smaller scale. The new Cobiss Lib software is still in the transition period, but we have already familiarized ourselves with it in most school libraries and are also using it in parallel with Cobiss3. The presented Cobiss Ela platform still raises a lot of questions regarding the inclusion of school libraries, and we will have to wait until all stakeholders agree on a long-term strategy regarding e-books in education.

KEYWORDS

Automation, applications, book locator, Cobiss Ela, Cobiss Lib, e-books, inventory, mInventura

1 UVOD

Novosti s širšega področja knjižničarstva posegajo tudi v šolske knjižnice. V preteklem šolskem letu smo pri delu v šolski knjižnici na Gimnaziji Moste uvedli kar nekaj novosti. Nekatere so pripomogle k lažjemu in hitrejšemu izvajanju postopkov in morda niti niso tako več nove, smo jih pa letos prvič s pridom koristili.

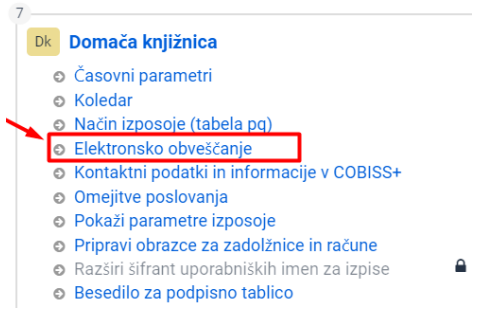
2 AVTOMATSKA SISTEMSKA SPOROČILA

Cobiss omogoča vnos e-poštnega naslova člana knjižnice, s katerim se lahko uporabniki prijavijo v Cobiss+ ali na mobilno verzijo mCobiss, kjer sami podaljšujejo in rezerviraj o gradivo. Vnos e-poštnih naslovov poteka ročno, tako da uporabnika odpremo in vtipkamo podatke. To se po navadi uporablja bolj za popravljanje ali vnos novih naslovov, sicer pa koristimo paketni vnos preko exelove tabele. V tem načinu torej lahko vnesemo veliko količino naslovov in drugih podatkov v le nekaj sekundah. Ob paketnem vnosu program sam pošlje obvestilo uporabniku z več informacijami o nadaljnji nastavitvi gesla in prijavi v Mojo knjižnico. Ravno to je razlog, da sem ugotovila da je bolj smiselno vnašati vsak oddelek posebej in sicer tik pred uro knjižnično informacijskega znanja. Na uri jim povem, da so dobili e-pošto in že preverim neveljavne ali nove naslove, če kdo morda ni dobil pošte. Nato pri uri vodimo dijake, da si nastavijo geslo in zakaj je to uporabno. Pri nas se dijaki rezervacije redko poslužujejo, tudi podaljševanje največkrat opravijo z dogovorom pri knjižničarki.

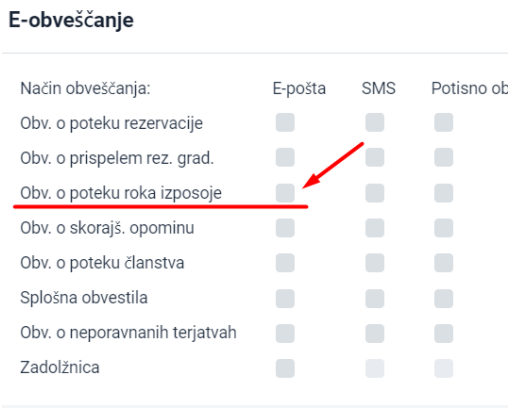
Prav tako vneseni e-poštni naslovi omogočajo dodatne opcije, kot je avtomatsko obveščanje. Lahko povemo, da je bil učinek obvestil viden takoj, saj se dijaki redno oglasijo v knjižnici z vračilom gradiva, ki bi ga sicer pozabili vrniti dokler jih nismo k temu pisno ali osebno pozvali. Podobno ugotovitev glede porasta podaljševanja gradiva so ugotovili tudi v drugih šolskih knjižnicah [1].

Avtomatsko obveščanje smo na Gimnaziji Moste vklopili za vse vpisane dijake. Za zaposlene ta opcija ni vklopljena oz. je vklopljena le pri nekaterih testno. Vklop avtomatskega

obveščanja je sicer zelo preprost. Izberemo lahko več parametrov avtomatskih sporočil, mi smo vklopili možnost avtomatskih opomnikov sporočil o skoraj pretečenem roku izposoje. To možnost najprej vklopimo znotraj segmenta »Izposoja« na »Domači knjižnici«, alineja »Elektronsko obveščanje«, kar prikazujeta sliki 1 in 2. Seveda lahko označimo tudi druga avtomatska obvestila, ki jih želimo aktivirati za pošiljanje (o poteku rezervacije, o prispelem rezerviranem gradivu, o skorajšnjem opominu, o poteku članstva, ipd.

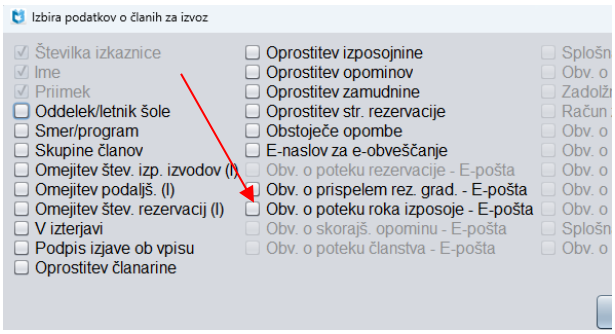


Slika 1: Elektronsko obveščanje



Slika 2: Izbor avtomatskih obvestil

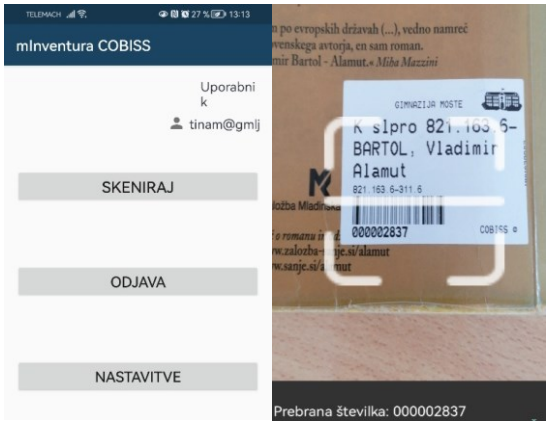
Ko smo sistemsko uredili avtomatska sporočila, moramo to možnost omogočiti tudi članom. V tem primeru lahko zopet urejamo in vnašamo e-poštni naslov posamezno, preko kartice odprtega člana. Lahko pa uporabimo paketno metodo za spreminjanje podatkov o članih [3], pri kateri je sedaj dodana možnost spreminjanja nastavitev e-obveščanja (kot prikazuje slika 3). Torej podatke o članih najprej izvozimo, pri tem izberemo podatek »Obv. o poteku roka izposoje – E-Pošta«. Nato v Exel datoteki, ki jo program ustvari, vpišete pri tem podatku pri vseh članih številko »1«, to pomeni potrjevanje prejema sporočil. Tako urejeno datoteko nato uvozimo in s tem so podatki spremenjeni in obvestila omogočena. Seveda lahko hkrati izberemo in urejamo več podatkov.



Slika 3: Izbira podatkov o članih

3 MINVENTURA

Letos nas je ponovno obiskalo leto v katerem je previdena inventura, ki se izvaja na vsakih 5 let ali manj. Podvig, ki poleg fizičnega pregleda polic zahteva tudi poznavanje zakonske podlage [5]. Pri fizičnem delu so na Izum-u pripravili aplikacijo, ki zadevo olajša. Aplikacija mInventura sedaj omogoča, da pametni telefon uporabljamo namesto skenerja, saj kamera zajame kodo inventarne številke in jo zabeleži. Aplikacija je res preprosta, enostavno si jo naložimo na telefon, prijavimo se z uporabniškim imenom in geslom, ki ga imamo odprtega pod našo knjižnico in nato lahko že pričnemo s skeniranjem (prikaza na sliki 4).



Slika 4: Aplikacija mInventura in primer odčitavanja

Aplikacija je zelo dobrodošla, saj je odčitavanje s telefonom preprosto za uporabo, ne potrebujemo dodatnih skenerjev niti prenosnikov, hkrati lahko odčitava več zaposlenih, ki jim predhodno seveda uredimo dostope preko Izum portala Izobraževanje.

Pri odčitavanju s telefoni smo opazili le eno slabost. Aplikacija namreč ne javlja izposojenega gradiva na polici (to vidimo šele naknadno po pregledu izpisov in moramo ponovno poiskati gradivo, ki smo ga že imeli v rokah) enako je pri gradivu s statusom izgubljeno ali odpisano. Z našega vidika izguba je to časa, saj zahteva, da po pregledu seznamov ponovno iščemo to gradivo na polici in bi si želeli v prihodnosti tudi to izboljšavo. Kljub temu pa je inventura na ta način olajšana in tekoče deluje. Pri nas smo inventuro izvedli v kombinaciji, torej uporaba

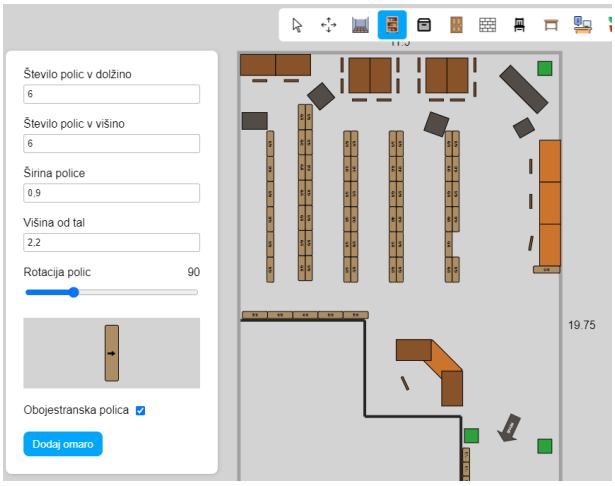
aplikcije mInventura in direktno odčitavanje s skenerjem v okolju Cobiss3.

4 LOKATOR GRADIVA

Vzpostavitve Lokatorja gradiva smo se lotili predvsem, ker nas je zanimalo kako poteka vnos v aplikacijo in končna uporaba. Prav nas je zanimalo ali bo končni izdelek izboljšal uporabniško izkušnjo dijakov, ter nenazadnje tudi pripomogel pri razlagi in predstaviti uporabe knjižnice pri urah knjižnično informacijskih znanj.

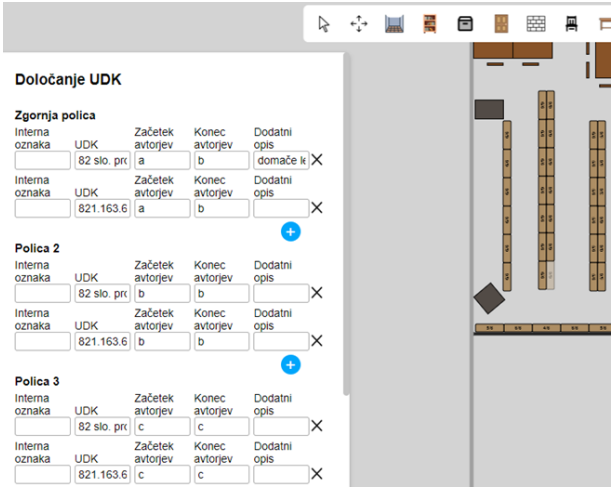
Aplikacijo sestavljata dva dela. Prvi je namenjen knjižnici oz. knjižničarju, ki pripravi tloris prostora. Drugi del je namenjen uporabniku, ki ob iskanju lahko izbere vizualni prikaz kje točno se nahaja izbrano gradivo. V Lokator gradiva lahko vnašamo več nadstropij, predvidevam, da bi lahko namesto nadstropij vnašali tudi različne lokacije, če je šolska knjižnica razporejena v različne prostore ali stavbe.

Aktivacija Lokatorja zahteva kar nekaj predpriprave in časa. Najprej si je potrebno premeriti in zrisati prostor, površino tal, vse police in druge elemente, ki jih bomo dodali ter sledenje UDK po policah. V veliko pomoč je bil tloris knjižnice, ki smo ga pridobili pri hišniku, tako da so bile potrebne le meritve velikosti polic. Velikost miz, stolov in rastlin je v aplikaciji dodeljena, ostale elemente lahko prilagajate. Vse osnovne informacije glede uporabe aplikacije vnosa podatkov pridobimo v navodilih, ki jih je pripravil IZUM [2]. Po izrisu tlorisa, polic in ostalih elementov (prikaz na sliki 5) je potrebno vnašanje podatkov na police, to so tisti podatki, ki bodo iskanje v COBISS+ pravilno usmerili v 3D prikazu.



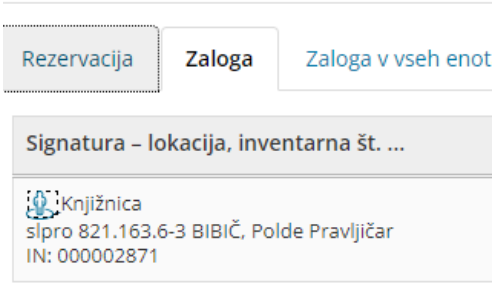
Slika 5: Vnos tlorisa in pohištva

UDK in interne oznake so tisti ključni podatki, na podlagi katerih se bo kasneje aplikacija povezala z bazo COBISS+ za prikaz iskanega gradiva. Pri nas se je pojavila težava, namreč v uporabi so nove UDK postavitve, še vedno pa so na velikem številu gradiva dodeljeni stari UDK vrstilci. Sčasoma smo s preizkušanjem aplikacije našli prehodno rešitev. V aplikacijo smo kot dodatni UDK dodali stari številčni UDK vrstilec k vsaki polici, kjer se takšno gradivo lahko nahaja. Torej na primeru leposlovja pri slovenski prozi smo na vse police vključila dodatni UDK (prikaz na sliki 6).

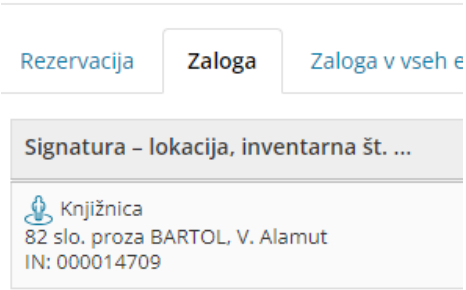


Slika 6: Dodatni vnosi starih UDK vrstilcev

Seveda smo te dodatne vnose preverili, kako delujejo v praksi. Spodaj je prikazano kako se izkaže takšna rešitev pri iskanju gradiva s strani uporabnika (sliki 7 in 8).

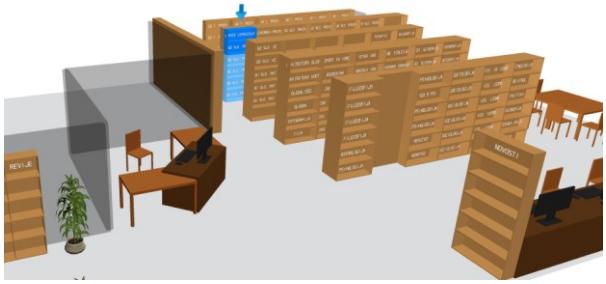


Slika 7: Omogočanje prikaza s staro UDK oznako



Slika 8: Prikaz z novo oznako UDK

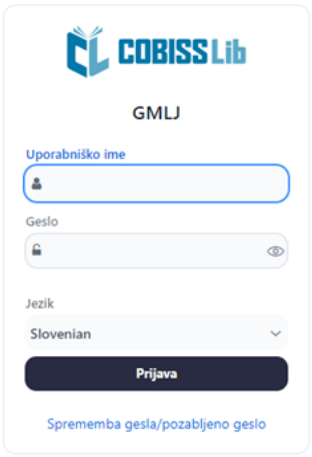
V obeh primerih gre za avtorja s črko B in spada pod slovensko leposlovje. Prvi ima številčni UDK »821.163.6-3«, drugi pa novejšo oznako, ki vsebuje tudi besedilni opis »82 slo. proza« . Če starega UDK nebi vnesli, gradivo poleg nebi prikazovalo ikono Lokatorja. S takšno rešitvijo pa je obeh primerih lokator povezan s COBISS+ in prikazuje pravo lokacijo knjige tudi v 3D izrisu (slika 9).



Slika 9: Vizualni prikaz iskanja gradiva

5 COBISS LIB

Še ena novost, ki smo jo v knjižnicah letos sprejemali različno, saj je zaenkrat še v prehodnem obdobju in to je novo okolje Cobiss Lib. Vse kar smo sedaj izvajali preko Cobiss3 programske opreme, se sedaj deli na dva segmenta, in sicer Cobiss Cat in Cobiss Lib. Prvi je namenjen katalogizatorjem za obdelavo gradiva, drugi pa zajema ostale funkcije, ki jih šolske knjižnice potrebujemo pri vsakdanjem delu [8]. Glavna novost je ta, da Cobiss Lib ne potrebuje namestitve vmesnika, ker je dostopen preko kar preko brskalnika. Torej v spustnem seznamu poiščemo našo šolo, nato pa se vpišemo z uporabniškim imenom za vstop v pravo okolje in že lahko pričnemo z delom (prikazuje slika 10).



Slika 10: Vstop v Cobiss Lib preko brskalnika

Izum je za pomoč knjižničarjev pripravil tudi navodila za delo v novi aplikaciji, predstavitvene posnetke, online izobraževanja, ter anketo o uporabi in predlaganih izboljšavah.

Pri delu s Cobiss Lib smo knjižničarju ugotovili in sporočili kar nekaj predlaganih optimizacij in prilagoditev, še vedno pa je zadeva prehodnem obdobju do konca novega leta, ko se stari program Cobiss3 preneha uporabljati. Kar nekaj komentarjev je prišlo na počasno odzivanje, najverjetneje zaradi obremenjenost mreže, prav tako so nekatere funkcije sedaj drugačne zato ker gre za brskalnik. Kljub temu se hitro lahko navadimo delu v novem okolju, je pa res, da je potrebnih več klikov za ukaze in za vnos podatkov.

Novo okolje je vizualno prenovljeno, čeprav je logika dela zelo podobna, le da tu vidimo vse možnosti že odprte. Kot pri vsaki novosti, nas tudi tu čaka obdobje izboljšav in nadgradnje na podlagi izkušenj in uporabe aplikacije v praksi.

6 COBISS ELA

Da bo slovenski prostor dočakal uresničitev platforme, ki bi združila vse založnike in ponudbo e-knjig za izposojo smo prvič slišali na Cobiss dnevih decembra 2023, ki naj bi začela delovati takoj pomladi. Junija 2024 je IZUM na online konferenci Novosti v knjižničarstvu podrobno predstavil novo platformo imenovano Cobiss Ela [7]. Novomeška knjižnica Mirana Jarca je nacionalna koordinatorka platforme in knjižnicam nudi poslovno in vsebinsko pomoč, pripravili so tudi navodila za bralce pri izposoji in namestitvi aplikacije [6]. IZUM pa je prevzel tehnično podporo.

»Platforma COBISS Ela omogoča celovit tokokrog e-knjige od založnika do bralca« [4]. Platforma namreč založnikom omogoča dodajanje e-knjig v formatu ePUB, pri čemer vsaki e-knjigi posebej določi pogoje izposoje (število točk za izposojo, kar predstavlja vrednost posamezne izposoje in veljavnost licence. Izposoja e-knjig že deluje in sicer imamo možnost branja na osebnem računalniku in na pametnih telefonih oz. mobilnih napravah, tudi bralniki naj bi bili omogočeni. Uporabiti je potrebno aplikacijo. V praksi je trenutno branje preko telefona ali druge mobilne naprave onemogočeno. Ta ukrep so izvedli zaradi varnostnih očitkov uporabe aplikacije Cantook, zato bo potrebna nadgradnja ali omogočanje nove aplikacije za odpiranje datotek e-knjig. Projekt ima še kar nekaj težav, ki se nam zdijo tako kot pri vsakem novem projektu, sploh tako obsežnem, normalni in verjamemo, da bodo ovire sčasoma presežene. Posodobitve in nadgradnje so objavljene na spletni strani namenjeni bralcem https://www.cobiss.si/bralci/ela/, kjer je IZUM dodal tudi pomoč v obliki video navodil.

Četudi Cobiss Ela ne deluje še s polno paro, se nam že poraja vprašanje kako bo z e-knjiga v šolskih knjižnicah. Vse kar smo uspeli izvedeti je, da za področje šolskih knjižnic zaenkrat potekajo dogovarjanja z ministrstvom. V juniju 2024 je šolski Bbiblos še vedno deloval, vendar je logična poteza, da bi v naslednjem letu v šolskih knjižnicah omogočili vsaj domača branja preko Cobiss Ela.

7 ZAKLJUČEK

V šolskih knjižnicah je torej kar nekaj možnih novosti, ki jih uvajamo glede na potrebe in uporabo. V praksi so se nekatere zadeve pokazale kot zelo praktične npr. avtomatska sporočila, ki pripomorejo k rednemu vračanju izposojenega gradiva. Nekatere zadeve se sprva ne zdijo zelo uporabne v šolski knjižnici, to je lokator gradiva, a je vzpostavitev vseeno smiselna, saj se zadeva lahko nadgradi in se uporabnost pokaže šele v prihodnjih letih. Je pa tu potrebna vključitev v pouk, da se dijake nauči na to možnost iskanja in prikazovanja kot pomoč pri samostojnem iskanju gradiva, kar vidimo kot največjo dodano vrednost. V knjižnicah smo kar navajeni novosti, zato menimo, da se tudi nove programske opreme kaj hitro privadijo in predlagamo izboljšave iz prakse. V prihodnosti pričakujemo predvsem novosti in spremembe na področju e-knjig.

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Odkrivanje naravoslovnih konceptov skozi igro: Kombinacija tradicionalnih in digitalnih metod v vrtcu

Discovering Science Concepts through Play: A Combination of Traditional and Digital Methods in Kindergarten

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POVZETEK

Digitalna tehnologija ima številne pozitivne učinke na vzgojno-izobraževalni proces v vrtcu, kjer postaja nepogrešljiv pripomoček pri raziskovalnem delu z otroki. Varna in premišljena raba interneta, računalnika, pametnega telefona, fotoaparata in projektorja omogoča vzgojiteljem boljšo motivacijo otrok ter spodbujanje njihovega zanimanja za odkrivanje novih vsebin.

V vrtcu prepoznavamo več prednosti uporabe digitalne tehnologije. Otroci so naravno radovedni in tehnologija lahko to radovednost še dodatno spodbudi. Zelo pomembno je zagotoviti uravnotežen pristop k digitalnim aktivnostim. S skupinskim delom na projektih, kjer otroci uporabljajo različne digitalne naprave, se učijo sodelovanja, komunikacije in reševanja problemov. Internet je bogat vir informacij, ki jih lahko vzgojitelji uporabimo za razširitev učnih vsebin. V prispevku bom opisala varno rabo digitalne tehnologije v vrtcu, povezano s tradicionalnimi načini podajanja znanja.

KLJUČNE BESEDE

Predšolski otroci, digitalna tehnologija, novi pristopi, zgodnje naravoslovje, varna raba interneta, kreativnost, motivacija otrok, digitalna pismenost

ABSTRACT

Digital technology has many positive effects on the educational process in kindergarten where it is becoming an indispensable tool in research work with children. The safe and thoughtful use of the internet, computers, smartphone, cameras and projector enables educators to better motivate children and stimulate their interest in discovering new content.

In kindergarten, we recognize several advantages of using digital technology. Children are naturally curious, and technology can further encourage that curiosity. It is very important to ensure a balanced approach to digital activities. Group work on projects where children use different digital devices teaches them cooperation, communication and problem solving. The internet is a rich source of information that educators can use to expand learning content. In this paper, I will describe the safe use of digital technology in kindergarten, connected with traditional ways of imparting knowledge.

KEYWORDS

Preschool children, digital technology, new approaches, early science, safe use of the Internet, creativity, children's motivation, digital literacy

1 UVOD

Digitalna tehnologija je postala del našega življenja. Na nek način nas spremlja in v veliki meri pomaga pri naših opravilih v prostem času in v službi. Tako je tudi v vrtcu nepogrešljiva pri izvedbi mnogih nalog. Če primerjam delo pred nekaj leti in sedaj, si ga sedaj zelo težko predstavljam brez digitalne tehnologije. Digitalni pripomočki, kot so fotoaparat, računalnik, mobilni telefon in projektor, so nepogrešljivi pripomočki, ki nam vzgojiteljem pomagajo pri ustvarjanju spodbudnega učnega okolja v vrtcu. V Kurikulu, ki je naš nacionalni dokument, imamo zapisane cilje - le te uresničujemo na različne načine. Iščemo zanimive in spodbudne teme, v načrtovanje vključimo ideje otrok. Odprtost Kurikula zahteva avtonomnega strokovnega delavca, ki zna ustvarjati spodbudno učno vzgojno okolje, v katero spada tudi smiselna uporaba digitalne tehnologije.[1]

2 PREDŠOLSKI OTROCI V DIGITALNI DOBI

Otroci v digitalni dobi imajo drugačne potrebe, kot so jih imeli pred leti, ko se je tehnologija začela razvijati. Naša naloga je, da otroke vzgajamo v duhu digitalnega napredka in jim pomagamo izbrati dobro od slabega. Vsak otrok mora imeti stik s tehnologijo, pomembno je le, v kolikšni meri mu bomo to dopustili. Postaviti moramo meje. Mediji imajo pomembno vlogo v življenju otroka, vendar ne morejo razviti zaupanja, navezanosti, veselja in odkrivanja pravljičnih svetov, saj se vse to lahko pojavi le ob komunikaciji med dvema osebama. [2] Otroke moramo usmerjati v uporabo digitalne tehnologije v učne namene, ne le zgolj zabavne. Digitalna tehnologija nam nudi širok spekter pripomočkov, ki jih moramo uporabiti in izkoristiti v namene izobraževanja otrok. Nemalokrat se pri otrocih poraja kakšno vprašanje, na katerega nimamo primernega odgovora. V takšnem primeru ni nič narobe, če otrokom odkrito povemo, da

odgovora ne poznamo. Lahko jih spodbudimo k razmišljanju, kaj naj v takšnem primeru naredimo. V večini primerov otroci predlagajo, da pobrskamo po internetu. Takšna vprašanja lahko privedejo do izvedbe raziskovalnih nalog, v katerih otroci z veseljem sodelujejo, ker so bili s svojim vprašanjem pobudniki raziskovalne teme. Delam v skupini otrok, starih od 2-6 let. Skupina te starosti je z vzgojnega vidika zelo zahtevna, tako pri načrtovanju vzgojnega dela, kot pri izvedbi dejavnosti. Smo zelo povezani in delujemo kot družina, starejši pomagajo mlajšim, mlajši se učijo od starejših in hitreje pridobivajo na samostojnosti. Kljub razlikam v starosti smo se lotili kar nekaj raziskovalnih nalog, v katere smo vključili tudi uporabo digitalne tehnologije. Pri načrtovanju sem sledila ciljem iz Kurikula in upoštevala vzgojna načela.

3 AKTIVNOSTI OTROK

Opisala bom primer raziskovalne naloge, kjer so otroci preko aktivnega sodelovanja spoznavali naravne zakonitosti in se seznanili z uporabo digitalnih pripomočkov.

3.1 IZDELOVANJE OPTIČNIH IGRAČ-SLIKOFRCEV

V vrtcu smo imeli predstavitev zavoda Vizo, ki se ukvarja s filmsko vzgojo v vrtcih. Skupaj z otroki so izdelali optične igrače-slikofrce in predstavili, kako posnamemo enostaven film.

Starejšim otrokom je bila vsebina zanimiva, zato so si želeli izdelati več slikofrcev, s pomočjo katerih so predmeti na sličicah oživeli (slika 1). Naslednji dan je padal dež. Ena izmed deklic v moji skupini je tiho opazovala dežne kapljice in me vprašala, zakaj pada dež. To vprašanje je bilo naše izhodišče za začetek raziskovalne naloge. Nekaj otrok, ki so slišali dekličino vprašanje, je začelo podajati odgovore. Vprašala sem jih, če vedo, kako in zakaj pada dež na zemljo in kaj se s to vodo zgodi. Odgovori otrok so bili zelo zanimivi, vseeno pa smo si skupaj ogledali zelo nazoren posnetek o skrbi za čisto vodo in kroženje vode v naravi, ki smo ga poiskali na internetu [2].

Slika 1: Igra s slikofrci

3.2 IZDELAVA PLAKATA

O vsem, kar so videli na posnetku, smo se pogovorili in izdelali plakat z značilnostmi vode, ki so jih že poznali (slika 2). Otroci potrebujejo zelo konkretno razlago, zato sem se odločila, da vsa agregatna stanja vode spoznajo s pomočjo preprostih naravoslovnih eksperimentov.

Slika 2: Plakat-značilnosti vode

3.3 POSKUS IZHLAPEVANJA VODE

Vse, kar smo zapisali na plakat, so tudi preizkusili. Izvedli so poskus izhlapevanja vode, tako da so merili lužo in jo opazovali, kako se suši. Isti poskus so naredili tudi z vodo, ki so jo postavili na teraso. V dva enaka kozarca so natočili vodo in označili nivo vode. Enega so zaprli s plastično folijo, drugega so pustili odprtega (slika 3). Poskus je trajal nekaj dni. Na plastični foliji so se nabrale kapljice, na odprtem kozarcu pa je bil nivo vode nižji. Vse to so otroci že predvideli, ker so nekaj dni prej opazovali lužo in znali razložiti, da je s pomočjo sonca voda izhlapela (slika 4).

Slika 3: Izhlapevanje vode v kozarcu

Slika 4: Merjenje luž

3.4 POSKUS ZMRZOVANJA VODE

Za četrto, trdno agregatno stanje, sem otroke vprašala, kaj se zgodi z vodo, če jo damo v zmrzovalnik. Vsi starejši otroci so odgovorili, da nastane led. Seveda so tudi to preizkusili. Vodo so natočili v vrečke za izdelovanje ledenih kock in v dva lončka, enega so pustili odprtega, drugega so zaprli. Ugotovili so, da voda zmrzne enako v zaprtem, kot odprtem lončku (slika 5). Z ledenimi kockami so nato risali po toplih tleh in opazovali taljenje ledu (slika 6).

Slika 5: Poskus zmrzovanja vode.

Slika 6: Risanje z ledom, opazovanje taljenja ledu.

3.5 POSKUS IZPAREVANJA VODE

Z njimi sem izvedla tudi tako imenovan »umetni dež« poskus izparevanja vode. V večjo posodo s steklenim pokrovom smo nalili vodo in jo zavreli. Otroci so lahko opazili paro, ki se je nabirala na steni pokrovke (slika 7). Naslednji dan, ko se je vse ohladilo, so kapljice, ki so se nabrale na pokrovu, kapljale dol kot dež.

Slika 7: Izparevanje vode-umetni dež.

S pomočjo eksperimentov in filma o kapljici so otroci razumeli, da voda v naravi kroži. Odločili so se, da skupaj napišemo zgodbo o kapljici vode. Zgodba je nastajala nekaj dni v jutranjem bralnem kotičku. Najprej so izbrali ime glavne junakinje kapljice-Plavka,ki je živela v močvirju. Nastajale so zanimive ideje, v ospredju je bilo vseskozi kroženje vode. V pogovoru sem otroke vodila z vprašanji odprtega tipa. Vse njihove odgovore sem zapisala. Kapljica Plavka je potovala po vseh mogočih krajih in nastala je zgodba, na katero so bili zelo ponosni. Naslov so ji dali Plavkino potovanje.

3.6 Zgodba: PLAVKINO POTOVANJE (AVTORJI: otroci skupine Metulji in vzgojiteljica Renata Mlinar)

Kapljica Plavka je živela v močvirju. Tam je živela tudi žabica Regica. Rada je regala in skakala iz lokvanja na lokvanj in tam srečala prijateljico Plavko. »Skoraj si me pohodila!« »Oprosti. Nisem te videla.« Žabica je bila osamljena in se je zelo rada igrala s Plavko. Nekega dne pa je močno sijalo sonce in posušilo kapljico. Z meglico je odšla do oblakov, kjer je spoznala veliko prijateljic kapljic. Spoznala je tudi dva glasna moža – Bliska in Groma. Začelo jo je zelo hladiti, ropotalo in bobnelo je. Začelo je deževati. Plavka je padla na rito v ledeno deželo, kjer je srečala pingvine. Bila je zelo vesela. Spomnila se je na pesmico »Si že videl kdaj, pingvine piti čaj« in jih to pesem tudi naučila. Pingvini so bili zelo veseli in so Plavko spravili v iglu. Tam se je spremenila v led. V deželo pingvinov so prišli tudi ribiči, ki so potrebovali led za ribe. Prišli so do pingvinov in jih vprašali: » Nam odstopite malo ledu?« »Seveda.« Dali so jim kos ledu v katerem je bila Plavka. Odnesli so ga na ribiško ladjo. Led so zdrobili na koščke in ga posuli po ribah. Ladja je priplula v Afriko, kjer je zeloooo vroče. Ribe so odpeljali na tržnico. Sonce je močno sijalo in Plavka se je zopet stopila. Odpotovala je nazaj v oblake k prijateljicam kapljicam. Skupaj so se veselile, da bodo kmalu zopet odšle na potovanje proti zemlji.

3.7 PRIPRAVA MATERIALA ZA FILM

Preko vseh poskusov, ki so jih izvedli in s pomočjo zgodbe o kapljici so otroci pridobili veliko znanja. To znanje so povezali s predstavljeno animacijo zavoda Vizo. Odločili smo se, da zgodbo oživimo. Spomnila sem jih na gibljive slike-slikofrce in animacijo s sličicami. Razdelili smo si delo. Mlajši otroci so s pomočjo odraslega pripravili podlago -mlako.

Slika 8: Ustvarjanje-osnova za pripravo animacije

Uporabili so akvarelne barve. S tehniko odtiskovanja s penasto gobico so ustvarili mlako, senčili so jo s temnejšimi odtenki modre barve (slika 8). Dodali so še nekaj mivke in s tem ustvarili plastičnost. Pri tem so zelo uživali, bili so vztrajni in umirjeni. Starejši otroci so s tehniko risanja s črnim flomastrom in barvanja s flomastri narisali vse like in predmete iz zgodbe (slika 9). Jaz sem jih izrezala. Potrebovali smo več kosov enake figure, zato so bili otroci zelo zaposleni in ustvarjanje je trajalo več dni.

Slika 9: Risanje likov za film

Ko je bil ves material za film pripravljen, so otroci pričeli s polaganjem sličic po vsebini zgodbe in fotografirali vsak prizor (slika 10). Pri tem sem jim pomagala, kadar je bilo potrebno. Pri rokovanju s fotoaparatom so bili zelo spretni.

Slika 10: Polaganje sličic, fotografiranje

Možnost fotografiranja sem omogočila vsem starejšim otrokom. Pokazala sem jim, kako fotografijo oblikujemo, jo povečamo, zmanjšamo. Ob tem so pridobivali izkušnje z upravljanjem miške (slika 11).

Slika 11: Urejanje fotografij z računalniško miško

Kar nekaj otrok je imelo težave pri manipulaciji z miško. Ob večkratni uporabi se je stanje izboljšalo. Nastale so odlične fotografije, ki smo jih vstavili v program Stop motion in zgodba o kapljici Plavki je oživela.

4 ZAKLJUČEK

Dejavnosti z uporabo digitalne tehnologije so predšolskim otrokom zelo vabljive, zato jih je pomembno usmerjati k smiselni a omejeni uporabi. Popolna prepoved ni primerna, saj lahko tehnologijo koristno vključimo v izobraževalne procese. Digitalni pripomočki, kot so računalniki in fotoaparati, pritegnejo otroke z visokim nivojem koncentracije in pozornosti, saj vključujejo več čutil hkrati. Z uporabo tehnologije lahko izobraževalne teme nadgradimo in naredimo bolj privlačne. Skozi temo naravoslovja so otroci razvijali medsebojno komunikacijo in komunikacijo z odraslimi ter s tem izboljšali skupinsko povezanost. Naučili so se poslušati in spoštovati vrstnike, kar je ključnega pomena za njihov socialni razvoj.

Pri ustvarjalnih dejavnostih so krepili svoj besedni zaklad in domišljijo. Ena izmed uspešnih aktivnosti je bila izdelava poučne zgodbe, kjer so otroci uporabili različne likovne tehnike za upodobitev živali in predmetov, ki so jih nato vključili v nastanek filma. Pri tem so sodelovali vsi otroci, od najmlajših do najstarejših. Pridobili so občutek pripadnosti skupini in uspeh pri doseganju skupnega cilja.

Zelo učinkovit pristop pri pridobivanju novega znanja in veščin so bili naravoslovni eksperimenti, ki so jih izvajali. Pridobili so sposobnost samostojne razlage enostavnega kroženja vode v naravi. Naučili so se rokovanja z računalniško miško in osnov urejanja fotografij. Ob teh aktivnostih so bili visoko motivirani ter miselno in fizično aktivni. Razvijali so koordinacijo oko-roka-ekran in akomodacijo oči. Spoznali so osnove snemanja filma, dejavnost, ki jo bodo lahko še naprej razvijali. Ponosni so bili na svoje izdelke, okrepili svojo samozavest in občutek, da jim je uspelo. Naučili so se vrednotiti svoje delo in trud, kar pomembno vpliva na njihov osebnostni razvoj.

Vse te aktivnosti dokazujejo, da lahko digitalna tehnologija, če je pravilno uporabljena, pomembno prispeva k izobraževanju in razvoju predšolskih otrok in jih hkrati pripravlja na digitalno pismenost, ki je vse bolj pomembna v sodobnem svetu.

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Stolp v Pisi z vidika likovne umetnosti, matematike in informatike

The Tower of Pisa from the Perspective of Visual Arts, Mathematics, and Ccomputer Science

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POVZETEK

Že vrsto let na Srednji šoli Veno Pilon Ajdovščina v 1. letnikih gimnazijskega programa izvajamo ekskurzijo v Piso in Firence. Arhitekturno in zgodovinsko zelo pomembni mesti smo poleg likovne umetnosti dijakom predstavili še z matematičnega vidika ter pri tem vključili pridobljena znanja iz informatike. Stolp v Pisi so gradili med 12. in 14. stoletjem, vendar se je zaradi mehkega terena skozi celotno fazo gradnje nagibal. Kasneje so ga ustrezno utrdili in s tem preprečili, da bi se porušil. Dijaki so na terenu spoznali zgodovinsko in likovno ozadje stolpa ter se preizkusili v fotografiji. Pri pouku matematike pa smo narisali graf nagnjenosti stolpa v odvisnosti od leta ter zapisali ustrezno prilagoditveno funkcijo. Zapisali smo najustreznejši matematični model in tako npr. odčitali za koliko stopinj je stolp nagnjen ali kdaj bi se brez ustrezne sanacije podrl. Pri izvedbi smo se posluževali ustrezne tehnologije, ki nam je delo olajšala. Kasneje so dijaki pri likovni umetnosti izdelovali modele poševnega stolpa v Pisi ter ustvarjali animacije izgradnje stolpa.

KLJUČNE BESEDE

Digitalna pismenost, informacijsko-komunikacijska tehnologija, informatika, likovna umetnost, matematika, medpredmetna povezava, matematično modeliranje

ABSTRACT

For many years, at Veno Pilon Hight School in Ajdovščina, we have been organizing an excursion to Pisa and Florence for first-year students of the gymnasium program. In addition to introducing these architecturally and historically significant cities from the perspective of visual arts, we also presented them to the students from a mathematical viewpoint, incorporating their knowledge of computer science. The Tower of Pisa was constructed between the 12th and 14th centuries, but due to soft ground, it leaned throughout the entire construction phase. Later, it was appropriately reinforced to prevent it from collapsing. On-site, the students learned about the historical and artistic background of the tower and practiced photography. In math class, we drew a graph showing the tower's inclination over time and derived the corresponding regression function. We identified the most suitable mathematical model to, for instance, determine the degree of the tower's tilt or predict when it would collapse without proper restoration. We utilized appropriate technology to facilitate the work. Later, in visual arts, the students created models of the Leaning Tower of Pisa and made animations of the tower's construction.

KEYWORDS

Digital literacy, information and communication technology, informatics, fine art, mathematics, interdisciplinary course, mathematical modeling

1 UVOD

Medpredmetno in timsko poučevanje učiteljem predstavlja velik izziv. Poleg iskanja idej za predstavitev snovi na drugačen, avtentičen način, je tovrsten pristop vsakič inovativen. Povezati se s predmeti, ki se zdijo sprva nezdružljivi in kjer se zdi, da je nemogoče poiskati skupni imenovalec zato zahteva podrobnejšo organizacijsko in dobro snovno pripravo.

V 1. letniku gimnazijskega programa dijaki običajno obiščejo Firence in Piso z namenom spoznati arhitekturno in kulturno dediščino. Pri pouku likovne umetnosti se dijaki seznanijo z zgodovinskim ozadjem ter umetniškim pomenom toskanskih mest. S profesorico likovne umetnosti Damjano Plešnar in profesorico informatike Urško Kompara Žvokelj smo želele, da so še posebej pozorni na poševni stolp v Pisi. Dijaki so imeli nalogo, da fotografirajo stolp iz različnih zornih kotov in pri tem upoštevajo osnovna načela in pravila fotografijo. Fotografije smo potem uporabili za matematično modeliranje, saj smo iskali ustrezen model za prilagoditveno funkcijo, ki opisuje nagnjenost stolpa v odvisnosti od leta. Dijaki so uporabili programe za dinamično geometrijo in za risanje grafov, in sicer prosto dostopna programa GeoGebra in Graph. Kasneje so pri likovni umetnosti ter informatiki ustvarjali animacije gradnje stolpa v Pisi s pomočjo aplikacije StopMotion Studio.

Dijaki so na ta način pridobili nova znanja, tudi v kontekstu vseživljenjskega učenja. Tak način dela ima tudi močan motivacijski učinek, saj dijakom predstavimo neko snov multiperspektivno.

Drugo in tretje poglavje sta povzeti po [7].

2 MEDPREDMETNO POUČEVANJE

Med načeli in cilji posodabljanja učnih načrtov (Smernice, 2007) sta tudi povezovanje predmetov in disciplin ter holističnih pristop učenja in poučevanja. Martin-Kneip, Fiege in Soodak (1955) opredeljujejo medpredmetno povezovanje kot primer holističnega učenja in poučevanja, ki kaže realen interaktiven svet, njegovo kompleksnost, odpravlja meje med posameznimi disciplinami in podpira načelo, da je vse znanje povezano. Medpredmetno povezovanje ne pomeni le razvijanja konceptualnega povezovanja (povezovanje sorodnih pojmov pri različnih predmetih), ampak razvija pri učencih tudi generične veščine, ki so neodvisne od vsebine in so uporabne v različnih okoliščinah (npr. kritično mišljenje, obdelava podatkov, uporaba IKT…).

Dejavnosti, povezane z medpredmetnim povezovanjem, vodijo k doseganju kompleksnih znanj in h kompleksnim pričakovanim rezultatom. Medpredmetne povezave uresničujemo in izvajamo na različnih ravneh in z različnimi cilji:

a) Na ravni vsebin: obravnava oz. reševanje interdisciplinarnih problemov. Pri teh dejavnostih uporabljamo specifična znanja posameznih disciplin in tudi generične veščine in spretnosti, ki predstavljajo aplikacijo specifičnega znanja na avtentične probleme.

b) Na ravni procesnih znanj: učenje in uporaba procesnih znanj (npr. iskanje virov, oblikovanje poročila ali miselnega vzorca, govorni nastop, delo v skupini,…).

c) Na konceptualni ravni: obravnava pojmov iz različnih predmetnih perspektiv z namenom poglabljanja in razumevanja (npr. naravna rast pri biologiji v povezavi z eksponentno funkcijo pri matematiki, eksponentno pojemanje v povezavi z upadanjem vrednosti dobrin na trgu idr.). Primeri naj bodo kot pomembni zgledi, ki so namenjeni razumevanje matematike in osmišljanju matematičnih vsebin.

Pri tovrstnih dejavnostih dijaki pridobivajo izkušnje in se učijo matematike ter tudi generičnih znanj, ki naj bi se v končni fazi kazala kot kompleksni pričakovani rezultati, kot npr., da dijaki:

- prepoznajo vlogo in pomen matematike in drugih disciplin v realnih situacijah in se učijo matematiziranja;
- uporabljajo matematiko v matematičnih kontekstih in v realnih situacijah,
- modelirajo, primerjajo modele ter rezultate različnih modelov in interpretirajo njihove rešitve z vidika matematike in realnih situacij idr.

Didaktični vidiki medpredmetnega povezovanja iz perspektive matematike:

- obravnavati matematične pojme iz različnih predmetnih perspektiv;
- prepoznati matematični kontekst v realnih situacijah in modelirati;
- reševati interdisciplinarne probleme in matematizirati;
- razvijati uporabo IKT kot možnosti za razvoj matematičnega znanja ter kot podporo pri učenju in poučevanju;
- razvijati generične veščine in spretnosti.

Z medpredmetnim sodelovanjem omogočimo, da zadane cilje dosežemo lažje, saj jih posamezen profesor v okviru svojega predmeta ne more doseči tako dobro in poglobljeno, kot kadar sodeluje s profesorjem drugega predmetnega področja. Tovrsten način dela poveča motivacijo, izboljša komunikacijo ter omogoča rast na profesionalnem področju, saj s tem sodelujoči razširi in poglobi lastno znanje.

3 MATEMATIČNO MODELIRANJE

Modeliranje pomeni konstruirati strukturo ali teorijo, ki vključuje lastnosti objekta, sistema ali procesa. Model reprezentira fizično ali abstraktno situacijo (Abrams, 2001). Matematično modeliranje pomeni prevesti situacijo iz resničnega sveta v matematični jezik (model).

V raziskavi PISA 2006 (Repež, A., Straus, M., 2008) je modeliranje opredeljeno kot: » Prenos realnosti v (matematični) svet, interpretacija modelov v smislu skladnosti z realnostjo, delo z modelom, vrednotenje, analiziranje in kritika modela, posredovanje podatkov o modelu ter spremljanje in nadzorovanje procesov modeliranja.«

Matematični modeli poskušajo dati posnetek pomembnih značilnosti dejanskega stanja situacije, objekta ali procesa v matematičnem jeziku. Pri sestavljanju matematičnega modela upoštevamo fizikalne ali katere druge zakone, npr. v družboslovju.

Matematično modeliranje je primer celostnega učenja pri pouku matematike. Predstavlja razvoj problemskih znanj ter reševanje problemskih situacij na eni stani, ter bogati vsebinska znanja na drugi strani. V tematskih sklopih kot je pojem funkcije ali področje statistike ter obdelave podatkov je nepogrešljiv gradnik, kjer teoretična znanja podkrepimo z uporabo različne informacijsko-komunikacijske tehnologije. Hkrati lahko vključujemo tudi kontekste drugih področij (npr. naravoslovnih in družbenih).

Glavne faze modeliranja:

1. seznanjanja s problemom (uvid v problem),
2. oblikovanje predpostavk in matematična formulacija (prevajanje realističnih situacij v matematični kontekst/problem, analiziranje in razumevanje situacije, postavitev predpostavk, določanje povezav med spremenljivkami idr.),
3. postavitev modela (zapis funkcije, formule, postavitev geometrijskega modela idr.),
4. ugotavljanje veljavnosti modela (z vidika matematike in realistične situacije),
5. uporaba in interpretacija modela (interpretacija rešitev z vidika matematike in realistične situacije, primerjava med modeli).

4 IZVEDBA DEJAVNOST

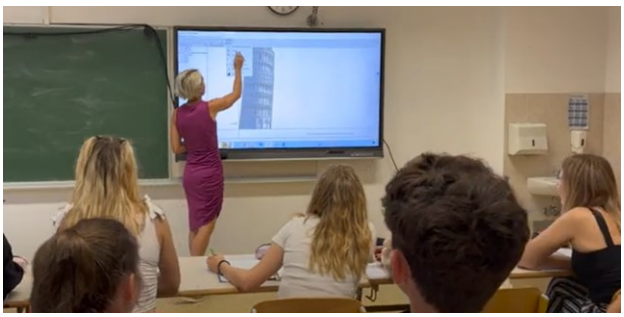
Naš projekt medpredmetnega povezovanja se je pričel, ko smo z dijaki 1. letnika gimnazijskega programa obiskali svetovno znan poševni stolp v Pisi (slika 1). Stolp je bil zgrajen med 12. in 14. stoletjem in je prvotno služil kot zvonik za sosednjo katedralo. Zaradi mehkega terena se je nagibal skozi celotno fazo gradnje, zaradi skrbi, da bi se porušil, so strokovnjaki začeli meriti njegovo nagnjenost.

Slika 1: Obisk Pise.

Med ogledi znamenitosti so se dijaki preizkusili v fotografiji s pametnim telefonom. V pomoč so jim bili nasveti profesoricUrške Kompara Žvokelj o kompoziciji, svetlobi in obdelavi fotografij, ki so jih osvojili pri pouku informatike. Ustvarjanje in urejanje digitalnih vsebin ter umetniško izražanje z uporabo digitalnih sredstev so bile tiste digitalne kompetence, ki so jih dijaki pridobili v tem delu dejavnosti. Cilji, ki so bili pri tem vključeni so bili, da dijaki:

- spoznajo osnovna načela in pravila fotografije (pravilo tretjin, ostrenje in optimizacija osvetlitve …),
- samostojno pregledajo nastavitve svojega pametnega telefona (znajo vključiti mrežo, način HDR …),
- samostojno prenesejo aplikacije za obdelavo fotografij s spletne trgovine aplikacij,
- posnamejo fotografije na izbrano temo in jih posredujejo učitelju prek spletnega okolja MS Teams.

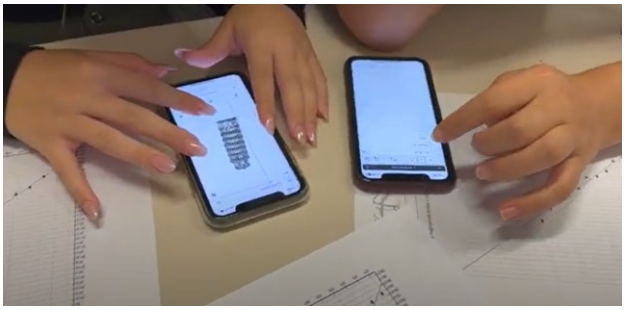
Dejavnost smo nadaljevali pri pouku matematike, ko smo obujali spomine na potepanje po znamenitih toskanskih mestih. Zgodovinska dejstva in zanimiva arhitekturna spoznanja o poševnem stolpu v Pisi smo želeli nadgraditi z matematičnimi modeli. Kljub temu, da je stolp trenutno utrjen, nas je zanimalo za koliko je nagnjen in kako se je nagibal skozi leta. Pričeli smo s frontalnim prikazom nagnjenosti stolpa na interaktivni tabli s pomočjo odprtokodnega programa GeoGebra (slika 2). S pomočjo orodij in fotografije stolpa smo določili za koliko stopinj je stolp nagnjen. Dijaki so primer reševali vsak na svojem telefonu s pomočjo istoimenske aplikacije.



Slika 2: Razlaga s pomočjo interaktivne table.

V nadaljevanju učne ure so dijaki samostojno reševali učni list na temo modeliranja z linearno funkcijo. Podane podatke nagnjenosti stolpa v danem letu, so vnašali v tabelo in kasneje poiskali ustrezni model. Po končanem samostojnem raziskovanju so bili podatki prikazani še na interaktivni tabli, kjer smo skupaj z dijaki poiskali ustrezno prilagoditveno funkcijo še s pomočjo programa Graph. Dijaki dobljeni predpis primerjajo s tistim, ki so ga izpeljali sami s svojimi izračuni. Pri zadnjem delu izvedbe dijaki uporabijo svoje pametne telefone ali tablične računalnike ter program GeoGebra (slika 3). Ta del tako deluje na dijake motivacijsko, saj svoje predpise linearne funkcije primerjajo s tisto, ki jo izpiše program. Nalogo lahko rešujejo dijaki samostojno ali pa v parih oziroma skupinsko in na ta način krepimo socialne ter tudi digitalne kompetenca, in sicer prepoznavanje potreb in problemov, reševanje konceptualnih problemov in problemskih situacij v digitalnih okoljih. V tem delu so bile uporabljene digitalne kompetence, in sicer reševanje konceptualnih problemov in problemskih situacij v digitalnih okoljih ter vključeni naslednji cilji, kjer dijaki:

- modelirajo primere iz vsakdanjega življenja z linearno funkcijo,
- presojajo o veljavnosti modela,
- kritično interpretirajo rezultate,
- razvijajo kritični odnos do informacij oziroma podatkov.



Slika 3: Uporaba pametnih telefonov.

Dijaki so pri likovni umetnosti s profesorico Damjano Plešnar izdelovali modele poševnega stolpa v Pisi, kar zahteva velik nabor sposobnosti in spretnosti, med drugim tudi prostorsko vizualizacijo, ki je bistvenega pomena za matematično pismenost. Pri tej dejavnosti smo uporabili predstavitev pojmov z modeli, ki je eden od dejavnosti izkustvenega učenja.

Če je fotografija umetnost, ki ujame trenutek in ga naredi večnega, pa je animacija tehnika, ki ustvari iluzijo gibanja in oživi predmete. Naše sodelovanje se je tako nadaljevalo z izdelavo animacije poševnega stolpa v Pisi z različnimi likovnimi pristopi na slikovnem polju ali v prostoru. Konstrukcija stolpa je nastajala z rezanjem papirja ter čipke, oblikovanjem gline in risanjem. Dijaki in dijakinje so s pomočjo pametnih telefonov in aplikacije StopMotion Studio izdelali krajše videoposnetke.

Dijaki pri tem usvajajo naslednje cilje:

- samostojno prenesejo aplikacijo s spletne trgovine aplikacij,
- spoznajo osnovne ukaze pri delu z aplikacijo Stop Motion Studio,
- izdelajo animacijo v prilagojenih pogojih dela,

- z animacijo učinkovito prikažejo primer,
- uspešno izvozijo ustvarjeno animacijo na pametni telefon.

Slika 4: Aplikacija StopMotion Studio.

5 ZAKLJUČEK

Izkazalo se je, da se lahko skozi tri leta gimnazijskega izobraževanja večkrat vračamo k istemu izhodišču. Tokrat smo se podali v sosednjo Italijo in preko zgodovine, umetnostne zgodovine, likovne umetnosti, matematike in nenazadnje uporabe informacijsko-komunikacijske tehnologije na prijeten način povezali na videz zelo različna predmetna področja. Vse prevečkrat pa se srečamo z nepremostljivo oviro v našem prenatrpanem učnem načrtu, ki od posameznika zahteva nenehno uresničevanje splošnih, procesnih in vsebinskih učnih ciljev. Največja ovira se zdi pomanjkanje časa in energije za timsko poučevanje in medpredmetna povezovanja. Pa vendar je končni izdelek potem za posameznika neprecenljiv in je lahko učitelju v zadovoljstvo in ponos. Pri tovrstnih sodelovanjih je odziv dijakov pozitiven in je zato motivacija za delo večja, tudi zaradi uporabe tehnologije, ki pri dijakih vzbudi zanimanje. Učitelji smo tisti, ki s skrbno načrtovanimi dejavnostmi spodbujamo razvoj digitalnih kompetenc, saj so ključne za razvoj sodobne družbe.

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Ali bo umetna inteligenca spremenila raziskovanje v osnovni šoli

Will Artificial Intelligence Change Research in Primary School?

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POVZETEK

V prispevku želimo prikazati, kako pomembno je raziskovanje. Zelo pomembno je, da se učenci z raziskovanjem srečajo že v osnovni šoli. Učenci spoznavajo osnovne korake raziskovanje, med katerimi je tudi uporaba in iskanje ustrezne literature. Med iskanjem in brskanje po spletu zagotovo naletijo tudi na umetno inteligenco. Pa se je sploh zavedajo? Pojavi se vprašanje, ali lahko in kako lahko umetna inteligenca vpliva na raziskovanje.

Pri raziskovanju je pomen mentorja zelo velik, saj lahko veliko pripomore k pravilnemu usmerjanju in uporabi ustreznih virov. Ugotovili smo, da zaenkrat v osnovni šoli umetna inteligenca še ne posega v raziskovanje, zavedamo pa se, da bomo morali zagristi tudi v to jabolko in učencem predstaviti prednosti in slabosti uporabe umetne inteligence.

KLJUČNE BESEDE

Raziskovanje, umetna inteligenca, osnovna šola

ABSTRACT

In this article, we want to show how important research is. It is very important that students are exposed to research already in primary school. Students learn the basic steps of research, including the use and search for relevant literature. While searching and browsing the web, they are bound to come across artificial intelligence. Are they even aware of it? The question arises as to whether and how artificial intelligence can influence research.

In research, the importance of a mentor is high, as she/he can greatly contribute to the correct direction and use of appropriate resources. We established that artificial intelligence has not interfered with research in primary schools yet, but we are aware that we will have to bite into this apple and present students the advantages and disadvantages of using artificial intelligence.

KEYWORDS

Research, artificial intelligence, primary school

1 UVOD

Pred več kot sto leti se pojavijo prve ideje, kako bi moralo biti poučevanje povezano z raziskovanjem in ne le s prenašanjem znanja iz učitelja na učenca. Prav raziskovalec Dewey [1] je trdil, da bi moralo poučevanje temeljiti na aktivnostih učencev in načinih, kako lahko učenci z raziskovanjem pridobijo znanje.

Kot navaja Merriam Webster [3] je raziskovanje večplastnega pomena. Med raziskovanje uporabljamo različne raziskovalne metode kot so zbiranje informacij o nekem predmetu ali pojavu, pazljivo in prizadevno iskanje, premišljeno poizvedovanje ali proučevanje, preiskovanje ali eksperimentiranje za odkrivanje ali tolmačenje dejstev, preverjanje sprejetih teorij ali zakonov v luči novih podatkov, praktična uporaba takih novih ali preverjenih teorij in zakonov. Že prva metoda je velikokrat vključena pri pouku, pa se niti učitelji niti učenci tega sploh ne zavedamo. Če želimo nekaj opisati, moramo znati zbati prave informacije o predmetu ali pojavu, ki ga želimo opisati. Velikokrat pa raziskovanje povezujemo z eksperimentiranjem [2], odkrivanjem in preverjanjem teorij, vendar se osnove skrivanji že v samem iskanju informacij. V osnovni šoli le redki pridejo na nivo samostojnega eksperimentiranja za odkrivanje dejstev. Vendar prav pri pisanju raziskovalnih nalog, lahko učence privedemo tudi do tega.

Pomembni procesi raziskovanja so pravzaprav glej, misli in deluj [2]. Glej kot zbiraj informacije, jih zapiši in prebiraj. Misli pomeni analiziraj dobljene podatke, prepoznaj bistvene podatke, ki so za raziskavo pomembni in jih uporabi – deluj – za oblikovanje rešitev. Pa lahko tukaj pomaga tudi umetna inteligenca? Menimo, da do neke mere ja, vendar je potrebno pazljivo in veliko preverjanja podatkov pridobljenih s pomočjo različnih brskalnikov umetne inteligence.

2 PREGLED STANJA

V učnih načrtih za osnovno šolo je se učenci raziskovanja le dotaknejo oziroma postavijo neke temelje in spoznajo osnovne postopke. Na šoli se nam zdi spodbujanje k pisanju raziskovalnih nalog in raziskovanju nasploh velikega pomena. Učenci začno razvijati različne kompetence, ki jih nato lahko uporabijo tudi v vsakdanjem življenju. Na šoli zato učenci začno z prvimi koraki raziskovanja že v četrtem razredu, kjer opisujejo najljubšo žival, nadgrajujejo raziskovanja v petem razredu z opisom mesta in tako naprej do opisovanja znanih osebnosti pri pouku tujega jezika. Pa vendar je raziskovanje več, kot le povzemanje iz spleta in knjig.

V tretjem vzgojno-izobraževanem obdobju veliko naših učencev stopa v svet raziskovanja, kjer spoznavajo čare besede zakaj. Sodelujemo na natečaju Mladi za napredek Maribora, ki je regijsko tekmovanje in odskočna deska za napredovanje na

državni nivo Mladi raziskovalci Slovenije, na katerega se redno vsako leto uvrščamo.

Hitro se pojavi vprašanje, ali bo na radovednost učencev vplival razvoj umetne inteligence in raziskovanje učencev več ne bo tak pritegnilo kot do sedaj. Menimo, da ne. Upamo, da bo umetna inteligenca pripomogla k večjemu raziskovalnemu napredku že v mladosti. Učenci se ne bodo učili samo raziskovalnih metod dela, ampak tudi ustrezne uporabe umetne inteligence. Menimo, da mora biti umetna inteligenca samo pomoč pri raziskovanju in odkrivanju novega, neznanega, ne pa da jo uporabimo za pisanje celih nalog.

3 RAZISKAVA

V raziskavah, ki so jih izvedle fakultete [4] lahko zasledimo, da veliko študentov uporablja ChatGPT. Po zadnjih podatkih več kot polovica študentov. Od vseh teh študentov jih več kot 90% uporablja umetno inteligenco za iskanje informacij, ki bi jih lahko dobili iz drugih strokovnih virov. Vendar gre z umetno inteligenco lažje in hitreje. Študentje poročajo: Bolj kot študenti uporabljajo ChatGPT za preiskovanje tega, kaj umetna inteligenca zmore, bolj verjetno poročajo o negativnih učinkih rabe ChatGPT na njihov študijski uspeh. Prav zaradi tega nas je zanimalo, koliko naših raziskovalcev v osnovni šoli uporablja kakršnokoli umetno inteligenco pri pisanju raziskovalnih nalog. V anketi, ki smo jo izvedli med učenci, ki so v zadnjih dveh letih pisali raziskovalne naloge, smo dobili zanimive odgovore. Učenci so poznali umetno inteligenco, ki deluje preko družabnih omrežij, kot so SnapChat, Instagram in podobno. Z umetno inteligenco komunicirajo, a le te ne uporabljajo za šolsko delo. Primer Copilot in ChatGPT so spoznali pri pouku, a jih po njihovih besedah ni pritegnil tako, da bi jo redno začeli uporabljati.

Na šoli smo v zadnjih dveh letih izdelali 26 raziskovalnih nalog, ki smo jih prijavili na prej omenjen natečaj, in tako smo lahko anketirali le 29 učencev. Od vseh anketiranih učencev niti eden ni uporabljal ChatGPT, Copilot ali podobnih orodij umetne inteligence pri pisanju raziskovalne naloge. Seveda je vzorec zelo majhen. Anketiranje pred prihodom ChatGPT se nam ni zdelo smiselno, saj se umetna inteligenca takrat še ni pojavljala v javnosti. Tisti učenci umetne inteligence zagotovo niso uporabili.

Na šoli se zavedamo, da je raziskovanje izjemnega pomena za razvoj otroka. Pri pisanju raziskovalnih nalog učenci spoznavajo različne načine učenja, s katerim lahko nadgradijo klasičen pouk v učilnici. Pridobijo kompetence, ki so pomembne za njihov nadaljnji razvoj in življenje.

Skozi anketo smo spoznali, da učenci še niso vešči uporabe umetne inteligence in v zadnjih dveh letih s pomočjo le te niso pisali raziskovalnih nalog. Verjamemo pa, da se bodo rezultati spremenili.

Ker so nas rezultati anketiranih učencev presenetili, smo anketirali tudi mentorje raziskovalnih nalog. Teh je manj kot učencev, zato smo mentorjem postavili vprašanja v obliki intervjuja. Rezultati intervjujev mentorjev raziskovalnih nalog na šoli so enaki kot rezultati pri učencih. Mentorji si pri pregledu nalog in pomoči učencem niso pomagali z umetno inteligenco, čeprav jo poznajo, saj je bila predstavljena na različnih konferencah in strokovnih srečanjih. Mentorji raziskovalcem se zavedajo, da bo potrebno ugrizniti tudi v to jabolko in spoznati ter raziskati, kako lahko umetna inteligenca pomaga pri raziskovanju. Učence je potrebno naučiti smiselne uporabe umetne inteligence, jih spodbuditi in jim pokazati, kako nam umetna inteligenca lahko delo olajša, ne pa tudi opravi namesto nas. Seveda moramo uporabo umetne inteligence najprej spoznati mentorji raziskovalcem, saj le tako bomo lahko učencem pomagali in jih usmerili na pravo pot.

4 ZAKLJUČEK

Zavedamo se, da umetna inteligenca bo vplivala na raziskovanje tudi že v osnovni šoli. Na mentorjih oziroma učiteljih pa je, kako bomo učencem prikazali smiselno in varno uporabo umetne inteligence. Zaenkrat vsaj na naši šoli se učenci tega orodja še ne poslužujejo. Verjamemo, da se ga bomo v prihodnje, saj nas bo v to prisililo okolje. Zavedati se moramo vseh pasti in prednosti, ki nam jih umetna inteligenca prinaša. Ne zapirajmo vrat, ugriznimo v izzive, ki jih prinaša prihodnost, in stopimo izven okvirjev ugodnega. Verjamemo, da nam bo uspelo in da bo umetna inteligenca pripomogla k še boljšim in kakovostnejšim raziskovalnim nalogam.

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Poučevanje algoritmov in programiranja z Arduino platformo: Praktični primer iz srednješolskega okolja

Teaching Algorithms and Programming with the Arduino Platform: A Practical Example from a High School Environment

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POVZETEK

V prispevku predstavljamo projektno usmerjen pristop k poučevanju algoritmov in programiranja z uporabo platforme Arduino, ki smo ga izvajali na Elektro in računalniški šoli, Šolskega centra Velenje, v okviru projekta KATARINA. Skozi praktično delo na pametnem merilniku temperature in vlažnosti so dijaki pridobili trdno osnovo v programiranju in razumevanju ključnih konceptov, kot so zanke, pogoji in funkcije, ter razvili dragocene praktične veščine. Kljub izzivom, kot so razlike v predznanju dijakov in kompleksnost povezovanja elektronskih komponent, so dijaki uspešno premagovali ovire in dosegali cilje. Arduino se je izkazal kot učinkovito orodje za poučevanje in spodbujanje inovativnosti, kar je bistveno pripomoglo k motivaciji dijakov in njihovi pripravljenosti za nadaljnje izobraževanje.

KLJUČNE BESEDE

Arduino, algoritmi, programiranje, srednješolsko izobraževanje, praktično učenje

ABSTRACT

The paper presents a project-oriented approach to teaching algorithms and programming using the Arduino platform, implemented at the Electro and Computer School, School Center Velenje, as part of the KATARINA project. Through practical work on a smart temperature and humidity sensor, students gained a solid foundation in programming and understanding key concepts such as loops, conditions, and functions, while developing valuable practical skills. Despite challenges such as varying levels of student prior knowledge and the complexity of connecting electronic components, students successfully overcame obstacles and achieved their goals. Arduino proved to be an effective tool for teaching and fostering innovation, significantly contributing to student motivation and their readiness for further education.

KEYWORDS

Arduino, algorithms, programming, secondary education, hands-on learning

1 Uvod

V današnjem svetu, kjer tehnologija igra ključno vlogo, je poučevanje algoritmov in programiranja že v zgodnjih fazah izobraževanja ključnega pomena. Srednješolski dijaki, zlasti tisti v tehničnih programih, potrebujejo trdno osnovo na področju računalniškega razmišljanja in programiranja, da lahko učinkovito delujejo v sodobnem tehnološkem okolju. Arduino, priljubljena odprtokodna platforma za elektroniko in programiranje, predstavlja odlično orodje za povezovanje teoretičnega znanja z resničnim svetom.

Elektro in računalniška šola, Šolskega centra Velenje je vključena v project KATARINA, ki ga vodi Fakulteta za računalništvo in informatiko Univerze v Ljubljani. Na šoli smo v šolskem letu 2023/24 vključili dijake prvih letnikov programa elektrotehnik in programa tehnik mehatronike. Za poučevanje področja Algoritmi in programiranje smo izbrali platformo Arduino. V nadaljevanju bomo predstavili naš pedagoški pristop, cilje izobraževanja, opisali praktični projekt, ter delili izkušnje in izzive, s katerimi smo se srečali.

1.1 Projekt KATARINA

Projekt KATARINA, ki ga vodi Fakulteta za računalništvo in informatiko Univerze v Ljubljani, v sodelovanju z desetimi partnerskimi srednjimi šolami in gimnazijami, sistematično ustvarja podporna okolja za vključevanje temeljnih vsebin računalništva in informatike v srednješolsko izobraževanje. Projekt poudarja izmenjavo izkušenj in dobrih praks, kar bo prispevalo k nadaljnjemu razvoju in vključevanju RIN vsebin v slovenske srednje šole.

2 Pedagoški pristop in cilji

Pri poučevanju algoritmov in programiranja smo uporabili projektno usmerjeno metodo, kjer so dijaki skozi ves proces pridobivanja znanja delali na enem glavnem projektu – Pametnem merilniku temperature in vlažnosti. Ta pristop je omogočil, da so dijaki postopoma, korak za korakom, vključevali novo znanje v svoj projekt, hkrati pa so se naučili tudi reševanja konkretnih problemov iz resničnega sveta.

2.1 Učni cilji

Glavni učni cilji so bili:

- Razumevanje osnovnih konceptov algoritmov, kot so zaporedje ukazov, pogojni stavki in zanke.
- Pridobitev veščin za delo s spremenljivkami, vhodnimi in izhodnimi podatki ter uporabo funkcij.
- Uporaba Arduina za implementacijo teh konceptov v praktičnih projektih.

2.2 Metodologija poučevanja

Dijake smo skozi 24 učnih ur vodili od osnov razumevanja algoritmov do razvoja kompleksnega programa, ki uporablja različne konceptualne elemente. Poučevanje je bilo strukturirano tako, da je vsaka ura temeljila na že pridobljenem znanju, kar je omogočalo progresivno gradnjo veščin in samozavesti pri reševanju programskih problemov.

Učne enote smo razdelili tako, da so pokriti vsi cilji.

Tabela 1: Pokritost vsebin z učnimi cilji

Koncept / vsebina	Učni cilji
01 Pojem algoritma	- Dijak razloži pojem algoritma. - Dijak pokaže primer problema, kjer obstaja več algoritmov za reševanje. - Dijak prikaže različne oblike zapisov algoritma.
03 Zaporedje ukazov	Dijak uporabi spremenljivko za predstavitev spreminjajočega se podatka. - Določi ustrezni tip spremenljivke oz. tip vsebine (npr. celo število, decimalno število, niz). - Rokuje s spremenljivko (priredi in spremeni vrednost, prebere vrednost, uporabi jo v ustreznih operacijah). - Spreminja podatke enega tipa v drugega (npr. niz -> število, število -> niz, decimalno število -> celo število). - Dijak s primerom pokaže pomembnost vrstnega reda ukazov. - Dijak sledi izvajanju algoritma in napove njegov izid.
05 Vhod kot zaporedje podatkov	- Dijak sestavlja preproste programe, s katerimi prebere podatke, jih uporabi za novo informacijo in informacijo izpiše.

Za celoten proces poučevanja smo izbrali projektno nalogo, ki je predstavljala osrednji element izobraževalnega procesa. Dijaki so projekt začeli razvijati že v uvodnih učnih urah, pri čemer so postopoma uvajali in uporabili vsako novo pridobljeno znanje ter veščine. Vsaka učna enota je bila zasnovana tako, da je gradila na predhodno obravnavanih vsebinah, kar je omogočalo kontinuiran napredek in poglabljanje razumevanja. S tem pristopom so dijaki lahko postopoma dograjevali svoj projekt, kar jim je omogočilo praktično uporabo teoretičnih konceptov, razvijanje kompleksnih programskih rešitev ter krepitev njihove samozavesti pri reševanju programskih problemov. Projektno zasnovano poučevanje je dijakom omogočilo celovit vpogled v proces razvoja programske opreme, od začetne ideje do končnega izdelka, ter hkrati poudarilo pomembnost povezovanja teoretičnega znanja z njegovo praktično uporabo.

3 Pametni merilnik temperature in vlažnosti

Pametni merilnik temperature in vlažnosti predstavlja osrednjo projektno nalogo, v kateri so dijaki uporabili različne koncepte programiranja, pridobljene tekom izobraževanja. Projekt temelji na uporabi Arduina, ki omogoča zajemanje okoljskih podatkov prek senzorjev za temperaturo in vlažnost. Zbrani podatki so bili nato obdelani in prikazani na LCD zaslonu, kar je dijakom omogočilo praktično uporabo znanja s področja algoritmov, dela s podatki ter implementacije vhodno-izhodnih operacij. Projekt je bil zasnovan tako, da povezuje vse ključne elemente programskega razvoja, kar dijakom omogoča celovit vpogled v proces ustvarjanja funkcionalnega sistema.

3.1 Projektna naloga

Osrednji projekt je bil zasnovan kot razvoj pametnega merilnika temperature in vlažnosti, ki temelji na platformi Arduino. S pomočjo senzorjev so dijaki zbirali podatke o temperaturi in vlažnosti, jih obdelali ter prikazali na LCD zaslonu. Projekt je vključeval vse ključne koncepte programiranja, ki smo jih predhodno obravnavali v okviru teoretičnih vsebin.

Dijaki so začeli z enostavnim merjenjem temperature in vlažnosti ter takojšnjim prikazom vrednosti na LCD zaslonu. Nato so uporabili funkcije, tako da so prejšnji program razdelili na funkciji preberiPodatke() in prikaziNaLCD(). V nadaljevanju so v program vključili pogojni stavek, s katerim so dodali opozorilo, ki se prikaže na LCD zaslonu, če temperatura preseže določeno mejo. Števne zanke so uporabili za merjenje temperature in vlažnosti vsakih 10 sekund, pri čemer so izvedli 10 meritev, rezultate pa prikazali in shranili v tabelo. Zanke s pogojem so uporabili za neprekinjeno spremljanje in prikaz podatkov, dokler ni bil pritisnjen gumb za zaustavitev.

Tabela 2: Primer za števne zanke

Tema	Števne zanke
Naloga	Dijaki bodo uporabili števne zanke za periodično merjenje temperature in vlažnosti.
Aktivnosti	Razlaga uporabe števnih zank, pisanje kode, ki periodično meri in shranjuje podatke.
Primer naloge	Uporabite for zanko za merjenje temperature in vlažnosti vsakih 10 sekund za 10 meritev. Izračunajte povprečno vrednost. Rezultate prikažite in shranite rezultate v tabelo
Pričakovani rezultati	Dijaki obvladajo uporabo števnih zank za izvajanje ponavljajočih se nalog.

3.2 Faze projekta

Načrtovanje

V začetnih fazah projekta so dijaki spoznali osnovne pojme algoritmov in jih uporabili pri načrtovanju osnovnega algoritma za merjenje temperature in vlažnosti. To je vključevalo določitev zaporedja ukazov in razumevanje, kako lahko vhodni podatki (podatki iz senzorja) vplivajo na izhodne rezultate.

Razvoj kode

V naslednjih urah so dijaki začeli razvijati svojo kodo. Naučili so se, kako uporabiti spremenljivke za shranjevanje podatkov, kako delujejo različne vrste zank in pogojnih stavkov ter kako razdeliti kodo na funkcije, ki olajšajo ponovno uporabo in razumevanje programa. Vsaka faza razvoja kode je bila zasnovana tako, da je bila kompleksnost postopoma povečana.

Integracija in testiranje

Ko so dijaki obvladali posamezne dele kode, so jih združili v celovit program. Nato so program testirali, da bi zagotovili njegovo pravilno delovanje in da so izpolnjeni vsi zahtevani cilji. Testiranje je bilo ključnega pomena za razvoj veščin iskanja napak in izboljševanja programske opreme.

Rezultati projekta

Dijaki so skozi delo na projektu razvili trdno razumevanje osnovnih konceptov programiranja. Poleg tega so razvili praktične veščine, kot so delo s senzorji, prikaz podatkov na zaslonu in uporaba različnih programskih struktur. Projekt je bil uspešen v tem, da je dijakom omogočil neposredno uporabo naučenih teoretičnih znanj v praktičnem kontekstu.

4 Izkušnje in izzivi

4.1 Izkušnje dijakov

Dijaki so pokazali veliko zanimanje za projekt in izrazili zadovoljstvo z načinom učenja. Kombinacija teoretičnega znanja in praktičnega dela je pripomogla k boljšemu razumevanju snovi in večji motivaciji za učenje. Praktično delo je omogočilo dijakom, da so si pridobili dragocene veščine pri sestavljanju elektronskih vezij, rokovanju s senzorji in povezovanju komponent, kar je bistveno nadgradilo njihovo teoretično znanje.

Poleg tega so dijaki razvili veščine reševanja problemov, saj so morali samostojno odpravljati napake v vezavah in programskih kodah. Delo na projektu je spodbujalo kritično razmišljanje in ustvarjalnost, hkrati pa jim je omogočilo, da so se naučili sistematičnega pristopa k razvoju kompleksnih sistemov. Praktično vezanje in integracija različnih modulov sta dijakom omogočila tudi izboljšanje spretnosti načrtovanja in organizacije dela, kar je ključnega pomena za njihovo nadaljnje izobraževanje in poklicno pot.

4.2 Izzivi

Med poučevanjem smo se srečali z nekaterimi izzivi, kot so razumevanje zaporedja ukazov in uporaba zank. Vendar pa so te težave skozi praktično delo in dodatno razlago uspešno premagali. Eden izmed ključnih izzivov je bil tudi proces vezave komponent in preverjanje delovanja sistemov, saj je uspešen rezultat odvisen od mnogih dejavnikov. Dijaki so morali posvetiti veliko pozornosti pravilnemu povezovanju elektronskih komponent, zagotavljanju ustreznih napetosti in pravilnemu delovanju senzorjev, preden so dobili želene rezultate v svojih programih.

Pogosto se je zgodilo, da tudi pravilno napisana programska koda ni delovala, dokler ni bila vezava popolnoma pravilna, kar je zahtevalo dodatno potrpežljivost in vztrajnost pri odpravljanju napak. Učitelji smo morali prilagoditi tempo učenja glede na sposobnosti posameznih dijakov, kar je omogočilo boljše individualno napredovanje. Raznolikost v predznanju dijakov je predstavljala še en izziv; v razredu smo imeli dijake, ki so se doma že ukvarjali s področjem elektronike ali mehatronike in so imeli določene izkušnje, ter tiste, ki so jih to področje zelo zanimalo, a še niso imeli praktičnih izkušenj. To je zahtevalo prilagajanje učnega procesa in dodatno individualno podporo, da so vsi dijaki lahko dosegli pričakovane cilje.

Razlike v znanju in izkušnjah so se še posebej pokazale pri izdelavi projektne naloge, kjer so nekateri dijaki začeli z osnovnimi nalogami, kot je preprosto merjenje temperature in prikaz rezultatov na zaslonu, medtem ko so drugi napredovali do bolj kompleksnih rešitev. Nekateri dijaki so tako iz osnovnih nalog prešli na razvoj naprednejših funkcij, kot je avtomatizacija meritev in vodenje evidenc. Ta raznolikost v dosežkih je bila izziv, a tudi priložnost, da so dijaki s pomočjo individualiziranega pristopa razvijali svoje veščine na lastnem nivoju.

4.3 Prednosti uporabe Arduina

Arduino se je izkazal za izjemno učinkovito orodje za poučevanje programiranja. Dijakom je omogočil, da so abstraktne koncepte, kot so zanke, pogoji in funkcije, takoj videli v delovanju, kar je prispevalo k globljemu razumevanju. Pomembnost praktičnega dela pri učenju elektronike in mehatronike je velika, saj dijaki skozi praktične projekte pridobivajo ne samo teoretično znanje, ampak tudi konkretne veščine, ki jih lahko neposredno uporabijo v realnih situacijah.

Praktično delo z Arduinom omogoča dijakom, da povežejo teoretične koncepte s fizičnimi rezultati, kar izboljšuje njihovo razumevanje in utrjevanje znanja. Poleg tega pa ta praktični pristop ponuja pomembno izkušnjo v današnjem izobraževalnem okolju, kjer se dijaki pogosto srečujejo predvsem z virtualnimi vsebinami. Praktične izkušnje, ki jih ponuja delo z Arduinom, so ključne za razvoj veščin reševanja problemov, kritičnega mišljenja in inovativnosti.

Za dijake, ki se usmerjajo v področja elektronike in mehatronike, je tovrstno praktično delo nepogrešljivo, saj jim omogoča, da pridobijo izkušnje s povezovanjem komponent, razumevanjem delovanja električnih tokokrogov in ustvarjanjem delujočih sistemov. Vendar pa so te praktične izkušnje dragocene tudi za dijake na drugih področjih, saj jim omogočajo stik z realnostjo in razumevanje, kako lahko njihova teoretična znanja vplivajo na svet okoli njih.

Poleg tega je Arduino zelo prilagodljiv in dostopen, kar omogoča dijakom vseh stopenj znanja, da z njim uspešno delujejo. Njegova odprtokodna narava in široka skupnost uporabnikov ponujata bogato podporo in vire, kar dodatno olajša učenje in omogoča dijakom, da raziskujejo in razvijajo svoje projekte nad okviri učnih načrtov. Tako je Arduino ne le orodje za učenje, temveč tudi platforma za inovacije in ustvarjalnost.

5 Zaključek

Izkušnje s poučevanjem algoritmov in programiranja z uporabo Arduina so pokazale, da je ta pristop izjemno učinkovit pri povezovanju teoretičnega znanja z njegovo praktično uporabo. Dijaki so skozi projektno usmerjeno delo na pametnem merilniku temperature in vlažnosti pridobili ne le osnovne koncepte programiranja, ampak tudi dragocene praktične veščine, ki so ključne za njihovo nadaljnje izobraževanje in poklicno pot. Praktično delo z Arduinom je dijakom omogočilo, da so teoretične koncepte, kot so zanke, pogoji in funkcije, videli v delovanju in jih uporabili za reševanje konkretnih problemov.

Pomembnost praktičnega dela v izobraževanju, še posebej na področju elektronike in mehatronike, je neprecenljiva. Dijaki so skozi proces dela na projektu razvili veščine, kot so reševanje problemov, kritično razmišljanje, načrtovanje in organizacija dela. Poleg tega je praktično delo pomembno tudi v širšem kontekstu, saj dijakom omogoča, da premostijo vrzel med virtualnimi in resničnimi izkušnjami, kar je v današnjem izobraževalnem sistemu pogosto zanemarjeno.

Arduino je s svojo prilagodljivostjo, dostopnostjo in široko skupnostjo uporabnikov idealno orodje za spodbujanje inovativnosti in ustvarjalnosti pri dijakih. Ne glede na njihovo predznanje, so dijaki lahko uspešno delovali z Arduinom, kar je dodatno pripomoglo k njihovemu samozaupanju in motivaciji za nadaljnje raziskovanje in učenje.

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Uporaba umetne inteligence v osnovni šoli

The Use of Artificial Intelligence in Elementary School

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POVZETEK

V prispevku so predstavljeni primeri uporabe umetne inteligence v okviru pouka na dveh osnovnih šolah. Po pregledu strokovne literature in priporočil na področju razvijanja digitalnih strategij, s katerimi se načrtno razvija digitalne kompetence učiteljev in učencev, ugotavljamo, da strategije sicer ponujajo modele in razvojne prioritete, a ne naslavljajo posebej uporabo umetne inteligence. Na eni strani Evropski parlament naslavlja umetno inteligenco kot prednostno nalogo Evropske unije, na drugi strani šole načrtujejo strategije razvoja digitalnih kompetenc znotraj lastnih omejitev. Glede na to, da umetna inteligenca postaja del vsakdana sodobnega človeka, bi se učenci morali seznaniti z umetno inteligenco že v osnovni šoli. Prav s tem namenom predstavljamo nabor različnih tematskih sklopov, kjer so se v osnovni šoli izvajale dejavnosti z uporabo umetne inteligence.

KLJUČNE BESEDE

Umetna inteligenca, osnovna šola, ChatGPT, digitalne kompetence

ABSTRACT

The article presents examples of the use of artificial intelligence in the context of lessons at two elementary schools. After reviewing the professional literature and recommendations in the field of developing digital strategies, which are used to systematically develop the digital competence of teachers and students, we note that the strategies offer models and development priorities, but do not specifically address the use of artificial intelligence. On the one hand, the European Parliament addresses artificial intelligence as a priority task of the European Union, on the other hand, schools plan strategies for the development of digital competences within their own limitations. Given that artificial intelligence is becoming a part of modern man's everyday life, students should be introduced to artificial intelligence already in primary school. It is for this purpose that we present a set of different thematic sections where activities using artificial intelligence were carried out in elementary school.

KEYWORDS

Artificial Intelligence, Elementary School, ChatGPT, digital competences

1 DIGITALNA STRATEGIJA IN UMETNA INTELIGENCA

V okviru prenovljenih evropskih smernic, ki poudarjajo pomen vseživljenjskega učenja, se je oblikovalo osem ključnih kompetenc [1]:

- večjezičnost,
- pismenosti,
- kulturna ozaveščenost in izražanje,
- podjetnostne kompetence,
- državljanske kompetence,
- osebnostna, družbena in učna kompetenca,
- digitalne kompetence,
- naravoslovje, tehnologija, inženirstvo, matematika.

Če kompetence pomenijo skupek znanja, spretnosti in stališč, potem sama uporaba IKT opreme še zdaleč ni dovolj za razvijanje digitalne kompetence. DigComp ali okvir digitalnih kompetenc za državljane podaja enotno izrazoslovje in ponuja referenčni model, ki se ga lahko vpelje tudi na področje vzgoje in izobraževanja. Konceptualni model okvira DigComp [1] razdeli razvoj digitalne pismenosti v pet kategorij:

- informacijska in podatkovna pismenost,
- komuniciranje in sodelovanje,
- ustvarjanje digitalnih vsebin,
- varnost,
- reševanje problemov.

Šole pristopajo k razvoju digitalne kompetence na različne načine, saj so pogoji za izvedbo raznoliki. Po priporočilih stroke šole oblikujejo svojo digitalno strategijo, ki je odvisna od razvojnih prioritet [2]: od digitalne didaktike, opremljenosti šole z digitalno tehnologijo, stopnje digitalne kompetentnosti učiteljev in učencev. Vendar to ni dovolj. Izzivi sodobnega časa so pokazali, da je umetna inteligenca ena od tehnologij, ki bi morala postati del strategije, saj nas nagovarja v vsakdanjem življenju. Evropski parlament [3] umetno inteligenco definira kot zmožnost stroja, da izkazuje človeške lastnosti, kot so mišljenje, učenje, načrtovanje in kreativnost, pri čemer omogoča tehničnim sistemom, da zaznavajo okolje, obdelajo, kar zaznajo, in rešijo problem. Še več, Evropski parlament [3] umetno inteligenco postavlja kot prednostno nalogo Evropske unije. Nekatere tehnologije umetne inteligence so prisotne že več desetletij, npr. spletno oglaševanje in nakupovanje, iskanje na spletu, prevajalniki, novejše tehnologije umetne inteligence pa že spreminjajo naša vsakdanja življenja.

Brezplačno nevronsko omrežje OpenAI na svoji spletni strani [4] pojasnjuje, da je ChatGPT klepetalni robot z umetno inteligenco, ki lahko:

- odgovori na preprosta in zapletena vprašanja,
- ustvari različna besedila in reši naloge,
- sestavi natančne poizvedbe,
- preoblikuje in predeluje različne medije (knjige, filme),
- opravlja rutinske naloge oz. piše poročila,
- pomaga pri programiranju.

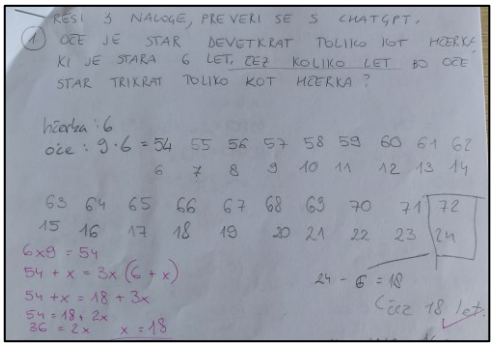
Poleg ChatGPT se na spletu najdejo številne aplikacije, ki vsebujejo tehnologijo umetne inteligence: Text, Otter, Cleo, Lensa, Alexa, Gemini, Replika, Calm, FaceApp, Siri, Google Assistant, Duolingo, Socratic, Cleo, Google Map, Leonardo, Dall-E, Craiyon. Nekatere aplikacije so bolj splošne narave in imajo širok spekter uporabe, medtem ko so se druge osredotočile na prepoznavanje obrazov, učenje tujih jezikov, branje zemljevidov, ustvarjanje grafičnih podob, ohranjanje zdravja, izobraževanje, iskanje informacij, vodenje financ in podobno. Umetna inteligenca postaja sopotnik sodobnega človeka. Ne gre zgolj za razvijanje digitalnih kompetenc, ampak tudi za prepoznavanje in razumevanje prednosti in pomanjkljivosti umetne inteligence. Kljub temu, da imajo osnovne šole že izdelane načrte za razvijanje digitalnih kompetenc, ostaja umetna inteligenca izziv za učitelje. Poleg pomanjkanja ustrezne digitalne opreme, izpada kadra, pomanjkljivega znanja na digitalnem področju, številčnih oddelkov in drugih organizacijskih omejitev strokovni delavci iščejo načine, kako umetno inteligenco integrirati v redni pouk.

V nadaljevanju so predstavljeni primeri dejavnosti z uporabo umetne inteligence na dveh osnovnih šolah pri pouku matematike, izbirnega predmeta šah, angleščine in knjižnično-informacijskih znanj.

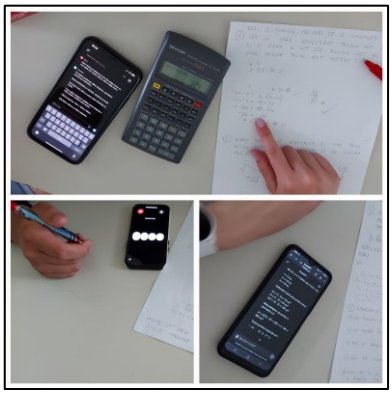
2 UMETNA INTELIGENCA V OSNOVNI ŠOLI

2.1 UPORABA UMETNE INTELIGENCE ZA UTRJEVANJE SNOVI PRI MATEMATIKI V 9. RAZREDU

Za utrjevanje celoletne snovi pri matematiki smo se odločili uporabiti umetno inteligenco. Učenci 9. razreda so k pouku prinesli pametne telefone. Predhodno smo preverili, ali imajo možnost uporabe mobilnih podatkov in dostop do aplikacije ChatGPT ter se dogovorili, da bodo telefoni napolnjeni. Učiteljica je pripravila učni list, na katerem so bile tri matematične naloge in evalvacijski vprašalnik. Navodilo je bilo, da v parih rešijo vse tri naloge, nato pa posamezno nalogo preverijo s pomočjo ChatGPT-ja. Naloge so učenci reševali na učni list, nato so zamenjali barvo pisala in preverili rešitev. Če je bila rešitev pravilna, so preverili tudi postopek reševanja. Če je bila napačna, so s pomočjo ChatGPT-ja poskusili rešiti nalogo (Slika 1). Če jim to ni uspelo, je pomagala učiteljica. Na začetku so učenci nalogo prepisali v ChatGPT, nato pa je en par našel funkcijo snemanja, tako da so nato naloge le prebrali ali pa poslikali. Ob koncu ure smo izvedli evalvacijo (Slika2).



Slika 1: Rešena naloga iz učnega lista



Slika 2: Uporaba pametnega telefona

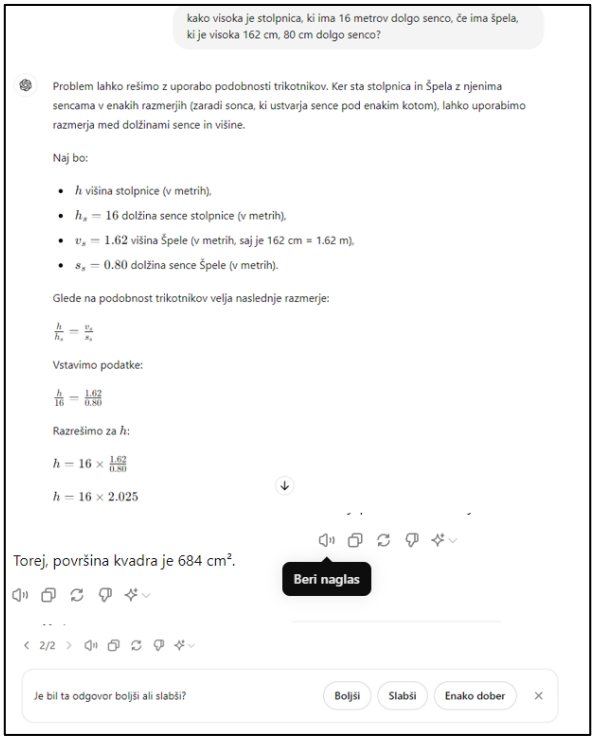
Učenci so povedali, da so pri matematiki do sedaj uporabljali PhotoMath, ne pa ChatGPT. Pri učenju matematike si pomagajo tudi s spletno platformo https://astra.si/ai/, ki nudi napredna orodja umetne inteligence za podporo učenju matematike. Uporabnikom omogoča, da rešujejo matematične naloge, analizirajo in vizualizirajo probleme ter prejmejo pomoč pri razumevanju matematičnih konceptov. S funkcionalnostmi, kot so avtomatsko preverjanje odgovorov in razlaga postopkov, platforma olajša učenje in izboljša učne izkušnje. ChatGPT uporabljajo predvsem pri predmetih angleščina, biologija, fizika, geografija, kemija, slovenščina in zgodovina.

Za prednosti uporabe ChatGPT so navedli hitrejše iskanje podatkov, pomoč z razlago, enostavne in kratke odgovore, prihranek časa ter brezplačno uporabo.

Kot slabosti so izpostavili možnost pridobivanja napačnih podatkov, nejasne postopke reševanja posameznih matematičnih nalog, ki jih učenci še niso obravnavali in jih ne razumejo, dolge odgovore in nepotrebne podatke, občasno nerazumevanje vprašanja ter počasno delovanje ali zatikanje.

Učencem so bili zelo všeč gumbi v ChatGPT, kot so preberi, kopiraj, ustvari znova, slab odgovor in sprememba modela. Z gumbom "preberi" so lahko dobili glasovno predstavitev besedila, kar jim je olajšalo razumevanje nalog. Gumb "kopiraj" jim je omogočil hitro in enostavno prenašanje besedila v druge aplikacije ali dokumente. Z možnostjo "ustvari znova" so lahko dobili novo različico odgovora, kar je bilo koristno, kadar prva razlaga ni bila dovolj jasna. Gumb "slab odgovor" so uporabljali za označevanje neustreznih odgovorov, kar je pomagalo izboljšati delovanje sistema. Funkcija "sprememba modela" jim je omogočala preklapljanje med različnimi modeli umetne

inteligence, da bi našli tistega, ki je najbolj ustrezal njihovim potrebam (Slika 3).

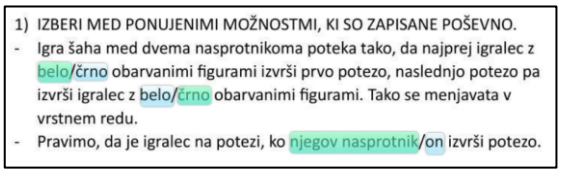


Slika 3: Uporaba umetne inteligence pri matematiki

Posebej so poudarili, da je ChatGPT pripomoček, ki pomaga pri delu, ne sme pa delati nalog namesto njih. Učna ura jim je bila zelo všeč, saj smo se veliko pogovarjali o prednostih in slabostih uporabe umetne inteligence.

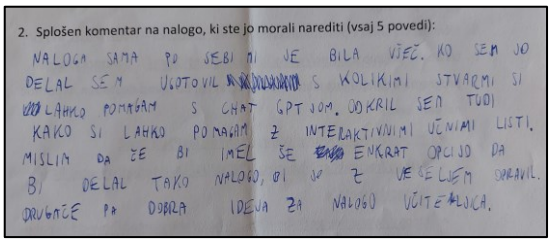
2.2 UPORABA UMETNE INTELIGENCE PRI IZDELAVI INTERAKTIVNIH UČNIH LISTOV PRI IZBIRNEM PREDMETU ŠAH

Pri izbirnem predmetu šah so učenci prejeli nalogo, da izdelajo interaktivni učni list s pomočjo spletne strani LiveWorksheets (https://www.liveworksheets.com/). LiveWorksheets je spletna platforma, ki omogoča učiteljem in učencem ustvarjanje interaktivnih učnih listov. S tem orodjem lahko učitelji pretvorijo tradicionalne papirnate naloge v digitalno obliko, kjer učenci lahko neposredno rešujejo naloge na spletu. Platforma podpira različne tipe nalog, vključno z izbiro med več možnimi odgovori, dopolnjevanjem besedila in povleci in spusti nalogami, kar pripomore k bolj dinamičnemu in angažiranemu učenju. Vsak učenec je prejel eno temo, ki se je nanašala na pravilnike Šahovske zveze Slovenije. Najprej so morali temeljito prebrati svojo temo. Nato so s pomočjo umetne inteligence, najpogosteje ChatGPT, pripravili osem vprašanj različnih tipov, pri čemer je moral vsak sklop vsebovati vsaj štiri možne odgovore, od katerih je bil vsaj en pravilen. Pri tem so morali preveriti smiselnost vprašanj in odgovorov v pravilnikih. Sprva so učni list pripravili v urejevalniku besedil, se prijavili na spletno stran LiveWorksheets in izdelali interaktivni učni list (Slika 4). Ko so bili interaktivni učni listi pripravljeni, so jih učenci pri pouku reševali na svojih pametnih telefonih. Vsak učenec je reševal učne liste svojih sošolcev, kar je omogočilo medsebojno izmenjavo znanja in idej. Po reševanju so drug drugemu podajali povratne informacije, kar je vključevalo ocenjevanje kakovosti vprašanj, ustreznosti odgovorov ter splošne uporabniške izkušnje. Ta proces je spodbudil kritično razmišljanje in izboljšal sodelovanje med učenci, saj so se naučili prepoznati in popraviti morebitne napake ter pohvaliti dobro zasnovane naloge.



Slika 4: Del interaktivnega učnega lista

Med izdelovanjem interaktivnih učnih listov smo veliko poudarka namenili pogovorom o prednostih in slabostih uporabe umetne inteligence, ki so jih učenci odkrivali med uporabo. Na koncu smo izvedli tudi evalvacijsko uro, kjer so učenci podali splošne komentarje na nalogo (Slika 5). Večina učencev je izpostavila, da naloga ni bila enostavna, saj so se morali naučiti uporabljati ChatGPT in spletno stran LiveWorksheets. Sprva je bila naloga za mnoge zahtevna, vendar so si pomagali z videovodiči za izdelavo interaktivnih učnih listov, ki jih je posredovala učiteljica. Učenci so povedali, da jim je naloga vzela veliko časa, a so se pri tem naučili mnogo novega in uporabnega.



Slika 5: Splošen komentar na nalogo

Ugotovili so, da ChatGPT ni vseveden in da lahko naredi napake. Naloga je bila težka, vendar tudi zabavna. Ko so se naučili, kako izdelati interaktivni učni list, so bili ponosni na svoje izdelke. Učenci so imeli težave z vpisom v ChatGPT in prijavo na spletno stran LiveWorksheets, vendar so te težave uspešno rešili s pomočjo sošolcev in učiteljice. Predlagali so, da bi še kdaj izvajali podobne naloge, kjer bi delali z različnimi programi umetne inteligence in primerjali rezultate.

Poseben poudarek so namenili učenju pravilnega formuliranja ukazov za ChatGPT, saj so pogosto prejeli napačna vprašanja in odgovore zaradi nepravilno oblikovanih ukazov. Učenci so ugotovili, da je natančnost in jasnost ukazov ključnega pomena za pridobivanje ustreznih informacij od umetne inteligence. Napačno oblikovani ukazi so pogosto vodili do nesmiselnih ali neustreznih odgovorov, kar je povzročilo frustracije in podaljšalo čas, potreben za dokončanje naloge. Skozi proces so se naučili, kako strukturirati svoje poizvedbe na način, ki je bil bolj razumljiv za ChatGPT. To vključuje uporabo

natančnih ključnih besed, jasnih vprašanj in, kjer je potrebno, dodatnih pojasnil za kontekst.

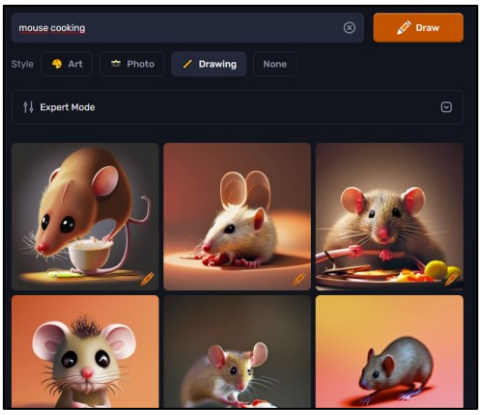
Poleg tega so spoznali, da je koristno preveriti odgovore, ki jih pridobijo, in jih primerjati z informacijami iz zanesljivih virov, kot so pravilniki Šahovske zveze Slovenije. Ta proces je učence naučil kritičnega mišljenja in preverjanja informacij, kar je pomembna veščina v današnjem digitalnem svetu, kjer so informacije lahko netočne ali zavajajoče. Učenci so skozi to izkušnjo pridobili dragocene veščine, ki jim bodo koristile tudi pri drugih predmetih in nalogah, kjer je uporaba umetne inteligence lahko v pomoč.

Na koncu so se strinjali, da je naloga, čeprav zahtevna, prispevala k njihovemu boljšemu razumevanju uporabe umetne inteligence in jim omogočila pridobitev dragocenih veščin za prihodnost.

2.3 UPORABA UMETNE INTELIGENCE PRI POUKU ANGLEŠČINE

Učenci tretjega razreda so pri pouku angleščine obravnavali sklop Pets ali domače živali. Najprej so ponovili osnovno besedišče o domačih živalih, nato so pripravili kratke govorne nastope o domačih živalih. Ker vsi niso imeli hišnih ljubljenčkov, smo se dogovorili, da bodo izdelali razredni plakat s hišnimi ljubljenčki, pri čemer pa ne bodo sami risali, ampak jim bo pomagala umetna inteligenca. Ker pa spletna stran uporablja ukaze le v angleškem jeziku, je bilo potrebno pripraviti pravilne besedne zveze, pri čemer se je učenje angleščine izkazalo za uporabno.

Na levo stran table so učenci zapisali poimenovanja za živali v tujem jeziku, nato pa so ponovili tudi angleške glagole, ki so jih zapisovali na desno stran table. Samostojno so tvorili različne kombinacije živali in dejanj ter jih zapisali na listič, npr. guinea pig eating, bunny jumping, dog running, cat sleeping. Sledilo je spoznavanje spletne strani Craiyon (https://www.craiyon.com/), ki omogoča brezplačno ustvarjanje slik s pomočjo umetne inteligence. V nižjih razredih se vedno znova izkaže, da je veliko lažje, če učenci dostopajo do aplikacij brez uporabniških računov. Spletna stran Craiyon je preprosto oblikovana, zahteva vpis ukaza in omogoča izbor različnih oblik prikazov grafične podobe: umetniška (Art), fotografija (Photo), risba (Drawing). Učenci so svoje angleške ukaze prenesli s papirja na spletno stran in oživeli svoje domače živali (Slika 6).



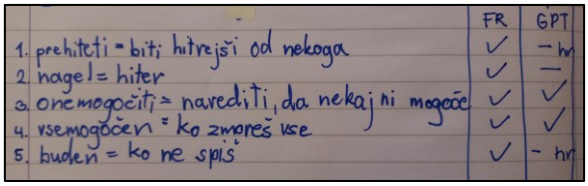
Slika 6: Primer izdelka z uporabo Craiyon

Po opravljenem izboru nastalih izdelkov so učenci natisnjene slike izrezali in ustvarili svoj plakat z naslovom Our Pets, ki je postal izhodišče za obravnavo in utrjevanje angleškega besedišča pri naslednjih urah. Učenci so se strinjali, da je spletna stran Craiyon uporabna tudi za izdelavo didaktičnega materiala in slikovnih prikazov. Ugotovili so, da Craiyon izvrši ukaz in ustvari sliko tudi pri nelogičnih ali neresničnih ukazih, kot na primer »mouse cooking« (Slika 6), kar pomeni, da je uporabnik tisti, ki mora vedeti, kako in zakaj uporablja neko spletno orodje.

2.4 UPORABA UMETNE INTELIGENCE PRI POUKU KNJIŽNIČNO-INFORMACIJSKIH ZNANJ

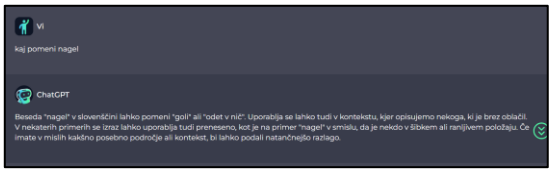
Učenci četrtega razreda se pri pouku slovenščine učijo tvoriti smiselno in zaokroženo besedilo. Tvorjenje besedil je ena težjih nalog, pri čemer so poleg slovničnih znanj potrebna tudi druga znanja in veščine. Pred samim tvorjenjem besedila pri pouku slovenščine smo izvedli uro knjižnično-informacijskih znanj, pri kateri smo preverjali poznavanje slovenskega besedišča. Najprej smo uporabili klasične slovarje v tiskani obliki, nato smo si na spletu ogledali slovarja Fran in Franček. Zanimalo nas je, kako dobro učenci poznajo pomen preprostih besed in kako bo besede razložil ChatGPT v odprti slovenski različici (https://talkai.info/sl/chat/).

Učenci so dobili primer krajšega umetnostnega besedila in ga prebrali. Izbrali so pet besed, ki so jih zapisali na listič in jih razložili po slovarskem sistemu (Slika 7).



Slika 7: Primer reševanja

Svoje lističe so prinesli k računalnikom v kotičkih in najprej preverili, na kakšen način ChatGPT razloži pomen besed. Ker pa se tudi ChatGPT zmoti ali pa je njegova razlaga nepopolna, so morali pomen besede preveriti še v spletnem slovarju. V nekaterih primerih odgovori ChatGPT niso bili več v slovenščini, saj je besedo prepoznal kot hrvaško ali srbsko. Učenci so svojo razlago primerjali z razlago ChatGPT in razlago slovarja. Po pregledu naključno izbranih besed so ugotovili, da ima ChatGPT omejeno razlago slovenskih besed, ki ni vedno pravilna, kar pa ne velja za spletne slovarje. Učenci so kot prednost ChatGPT navedli preprosto uporabo in ponujen odgovor, ki ga je potrebno samo prebrati. ChatGPT je pravilno razložil vsakdanje enopomenske slovenske besede, pri večpomenskih ali nevsakdanjih besedah pa je bila njegova razlaga nepopolna ali celo napačna, npr. nevsakdanji, nagel, ugnati (Slika 8).



Slika 8: Primer razlage besede s ChatGPT

Ob zaključku ure smo na tablo zapisali deset besed po izbiri učencev in označili, kateri spletni pripomoček je pravilno razložil besedo. Ko smo prešteli označbe, se je izkazalo, da so spletni slovarji bolje razložili posamezne besede. Po pregledu nabora izbranih besed so učenci prišli do sklepa, da se ChatGPT bolje obnese pri razlagi besed iz neumetnostnih besedil, kar so tudi preizkusili. Neumetnostna besedila vsebujejo več preprostih oz. enopomenskih besed, medtem ko umetnostna besedila vsebujejo ekspresivne in zastarele besede ter besede, ki imajo več pomenov. Najbolj zanimiva pa je bila ugotovitev, da nobena od tehnologij ne more nadomestiti branja, kjer bralci spoznavajo pomen besedišča v različnih kontekstih.

3 ZAKLJUČEK

Umetna inteligenca v šoli je uporabna na različnih predmetnih področjih in na različnih razvojnih stopnjah. Ne samo, da bi umetna inteligenca morala postati del digitalnih strategij šole, učenci bi morali poznati prednosti in slabosti nove tehnologije ter njene uporabnosti. Opisani primeri kažejo, da je uporaba tehnologij z umetno inteligenco preprosta in se jo da uporabiti na različnih področjih. Učenci z uporabo tehnologije dobijo vpogled v delovanje umetne inteligence na vsakodnevni ravni in spoznajo njene omejitve. Vzporedno s samo uporabo pa je potrebno ozavestiti vzgojni moment odgovornosti uporabnika umetne inteligence, ki se mora zavedati, v kakšen namen bo uporabljal določena spletna orodja. Navkljub omejitvam, s katerimi se šole soočajo, digitalne strategije in načrti za razvijanje digitalnih kompetenc, niso vedno vezani na samo opremo ali strokovna usposabljanja. Umetna inteligenca je postala del življenja sodobnega otroka, ki bo odraščal v hitro spreminjajoči se tehnološki družbi. Prav zato bi šole morale najti način, kako integrirati nova znanja v že obstoječi učni program, pokazati uporabnost in omejitve novih tehnologij, ki jih sodobni človek srečuje na vsakem koraku.

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Using Digital Analysis Skills for Description of Simple Pendulums – Interdisciplinary Example of Combining Physics, Mathematics and Computer Science

Uporaba digitalne analize pri opisu enostavnih nihal – Interdisciplinarni primer povezovanja fizike, matematike in računalništva

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ABSTRACT

In this paper, we describe creation of a digital environment for analysis of a physics experiments. ICT skills are essential in establishing the potential for automated or digital analysis in the observation of physics experiments. In the case of pendulum experiments where the oscillations take place on short time scale of tenth of a second, the use of ICT help us to track the pendulum movements in time. A video recording of a pendulum from a distant point was made and then analysed using different ICT tools. We studied the impact of different tension in the pendulum supporting string on the motion of pendulums and compared it with the theoretical prediction. With the help of independently created automated Python program and the OpenCV graphical library, using analytical tools such as ROOT, we showed the interdependence of the independent variable on the coupled pendulum movement.

KEYWORDS

Digital technologies, digital skills, data analysis, coupled pendulum, video recording, smart phone

POVZETEK

V tem prispevku opisujemo vzpostavitev digitalnega okolja za analitiko v fizikalnih eksperimentih. IKT spretnosti so bistvenega pomena pri ugotavljanju možnosti avtomatizirane ali digitalne analize pri opazovanju fizikalnih eksperimentov. Dokazali smo, da ta trditev velja v primeru sklopljenega nihala. Analiza videoposnetka sklopljenega nihala je bila narejena. Rezultati so bili med seboj primerjani glede na silo v vrvici na katero sta pritrjeni obe nihali. S pomočjo neodvisno ustvarjenega Python programa in grafične knjižnice OpenCV ter z uporabo analitičnega orodja ROOT, smo dokazali soodvisnost med spremenljivkami v gibanju sklopljenega nihala.

KLJUČNE BESEDE

Digitalna technologija, digitalne veščine, analiza podatkov, sklopljeno nihalo, video posnetek, pametni telefon

1 INTRODUCTION

In today's world, digital skills are becoming increasingly crucial for the development of the society. However, the integration of different fields of science – physics, chemistry, computer science – into educational system is still in development. It is important to make a connection between informational technology and science education, as the youth is the leading force of the world. In this context it is essential to present informational technology as a way of connecting education and science.

In this paper, we describe an experiment done as part of the International Baccalaureate at the Gimnazija Bežigrad. There were two aims to the experiment: Firstly, we wanted to determine how changing the tension in the supporting string of a coupled pendulum affects the behavior of the two pendulums; secondly, to learn about digital tools needed to conduct the experiment as a regular study.

The goal of this research was to determine the relationship between the tension in the supporting string and the period of energy exchange. We also explored the energy transfers between the pendulums and the effect of damping on the system.

The conducted experiment is based on the theory of coupled pendulums. In the high-school physics curriculum the equations of motion for a single mathematical pendulums are derived from a single differential equation. An interesting extension is an extension to two pendulums, which are connected by a common support string which produces a driving force depending on the position of one pendulum on another and enables the energy transfer between pendulums. The motion is in general not periodic, for certain conditions the energy is transferred between the pendula in a repeated manner. An interesting dependence on the tension in the string can be studied.

The movement of the pendulums was recorded using a smart phone camera. The acquisitions had to be taken in an controlled environment without shadows and homogeneous background without any visible features were preliminary to eliminate any potential errors in the detection of the pendulums.

During the analysis phase the positions of two masses were extracted from the video frames and analytical expression with free parameters fitted to the data. The fit parameters were then used to study the above dependence.

2 METHODS

The analysis of the movement of the coupled pendulum was made in two phases. The first part of the experiment was acquiring data in the form of video recording by a smart phone. The second part of our research was analytical.

2.1 Pendulum movement detection

2.1.1 A coupled pendulum setup

The setup of a coupled pendulum used in the experiment (see Figure1) consisted of two spheres of the same masses on strings of equal length, attached to a supporting string. The system is symmetrical so that lengths a and b are equal. One side of the string was passed over a pulley, under which a weight was hung. The force in the string was varied using weights of different masses.

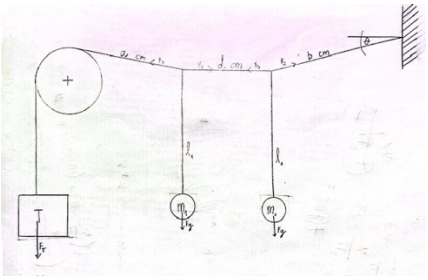

Figure 1. A coupled pendulum setup

2.1.2 Procedure

Firstly, it was ensured that the pendulums were of equal lengths and weights. One of the mass spheres was released from a small controlled angle, at different tensions in the string, and left to swing. The motion of both mass spheres was recorded with a camera so that exact position and energy dissipation could be analyzed via video analysis using a custom Python code. A video for tensions 2.5N, 5.0N, 7.5N, 10N, 12.5N, 15N, 17.5N, 20.0N, 22.5N and 25.0N in the string were made.

2.1.3 Theoretical background

Considering a simple harmonic motion of a simple mass-spring pendulum. The differential equation driving the motion can be written as

$$m\frac{d^2x}{dt^2} = -kx$$

, where the general solution of it gives us the equation of motion

$$x = x_0 sin(2\pi\nu t + \delta).$$

In a coupled pendulum, the situation is similar. However, there is an additional force of the supporting spring made by one pendulum on the other. On this case the differential equations of motion of the two oscillators are:

$$\begin{aligned} m_1\frac{d^2x_1}{dt^2} &= -k_1x_1 + k_3x_2 \quad , \\ m_2\frac{d^2x_2}{dt^2} &= -k_2x_2 + k_3x_1 \quad . \end{aligned}$$

Constants ν1, ν2 and μ are introduced as follows:

$$\begin{aligned} K_1 &= 4\pi^2\nu_1^2 m \quad , \\ K_2 &= 4\pi^2\nu_2^2 m \quad , \\ K_3 &= 4\pi^2\mu^2 m \quad , \end{aligned}$$

For a pair of coupled oscillators, where the conditions for simple harmonic motion apply, there are two ways that the system can oscillate; equal in magnitude and direction or equal in magnitude but opposite in direction – called normal modes. In case of ν1 = ν2 we get:

$$\nu_\pm = \nu_1 \pm \frac{\mu^2}{2\nu_1}$$

The solutions for equations are therefore:

$$\begin{aligned} x_1 &= x_0 cos\left(\frac{\pi\mu^2 t}{\nu_1}\right)\cos 2\pi\nu_1 t \\ x_2 &= x_0 \sin\left(\frac{\pi\mu^2 t}{\nu_1}\right)\ sin2\pi\nu_1 t \end{aligned}$$

From the equation, we can see that each oscillator has two oscillations; one with frequency ν_1, and another with frequency $\frac{\mu^2}{2\nu_1}$, which we annotate as frequency f. The reciprocal of frequency f is the period of energy exchange (P); the time one of the oscillators (when the motion starts at x1 = x0, and x2 = 0) takes to completely stop at x=0. It can be calculated as:

$$\mathrm{P} = \frac{2\nu_1}{\mu_2}.$$

2.1.4 Video recording of the pendulums

The detection of the motion was done by a digital camera. The camera was placed vertically above the setup and positioned close to the pendulums, because the measurements on the video would otherwise not be detected accurately and would get distorted. It was ensured that the material under the pendulums was uniform and that the environment was controlled in a way that all shadows were eliminated. The camera used in this experiment was smart phone iPhone 13 camera.

2.2 Analysis

The experiment was divided into three parts. Firstly, the motion of both spheres was recorded with a smart phone camera so that exact position and energy dissipation could be analyzed via video analysis using a custom Python code.

2.2.1 Python video to image processing

The photos taken by the camera were then transferred to a computer, where further analysis was carried out. The captures

were analyzed using OpenCV library [1] in Python, an open source software library for computer vision and machine learning. The video was divided into images, whereas the capture of photos was 33 frames per second. The pictures where then converted to greyscale, and a threshold was applied, so that the masses of pendulums could be recognized. The threshold was denoted in a binary system, where the colour of the picture was either black (1) or white (0). The image was divided into two regions corresponding to images of two masses. The base code was found on the internet and was then changed so that it suited our experiment's needs.

```
def get_pendulum_position(frame, threshold=127):
    # Convert frame to grayscale
    gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)

    # Apply threshold
    _, binary = cv2.threshold(gray, threshold, 255, cv2.THRESH_BINARY)
    h, w = binary.shape
    # two images for each of the masses
    imgs = [   binary[0:h, 10:int(w/2)] , binary[0:h, int(w/2):w] ]
```

Figure 2. A part of OpenCV Python code

2.2.2 Python [2] – calculating the center of the mass

The converted frame to a black-and-white image was then further analyzed, using the black pixels to calculate the center of both masses:

$$x_m = \frac{\sum_i^N x_i}{N}$$
$$y_m = \frac{\sum_i^N y_i}{N}$$

i runs over all the black pixels, and xi and yi are the pixel coordinates of the i-th pixel.

Video analysis data

#time	m1-y	m1-x	m2-y	m2-x
#(s)	(px)	(px)	(px)	(px)
0.033	105.95	356.69	352.75	334.88
0.067	106.02	356.41	353.46	335.93
0.100	105.95	356.25	354.04	337.19
0.133	105.97	356.02	354.53	338.86
0.167	106.33	355.66	355.56	340.90
0.200	106.49	355.53	356.22	342.94

Figure 3. Pendulum analysis

2.2.3 ROOT analysis

ROOT [3] was in this experiment used to determine:

- The average time between two frames,
- the difference between the two times,
- the difference in displacement

Using the obtained data the velocities were calculated as dx/dt. Further on, the kinetic and potential energies were calculated as $mv^2/2$ and mgh.

```
for (int k=0;k<gx->GetN()-1;k++){
   double t  = 0.5 *( xp[k+1]+xp[k] );
   double dt = xp[k+1]-xp[k];
   double dx = yp[k+1]-yp[k];
   double v  = (dt>0)?dx/dt:0;
   double h  = l*(1-cos(yp[k]/l));
   double energy = m*g*h+m*v*v/2;
   gv->AddPoint( t, v);
   ge[i]->AddPoint( t, energy*1e-3);
}
```

Figure 4.A part of ROOT code

3 RESULTS

3.1 Determining the displacement

Our initial goal was to describe the movement of coupled pendulums. We recorded 5 minutes long videos. After the acquisition, the analysis was carried out. The images were analyzed using the described digital tools. After the process of analyzing and converting the videos, a graph of the displacement of each pendulum, through time was drawn by fitting the function of a coupled pendulum equation on the graph. The graph drawn by the program is shown below:

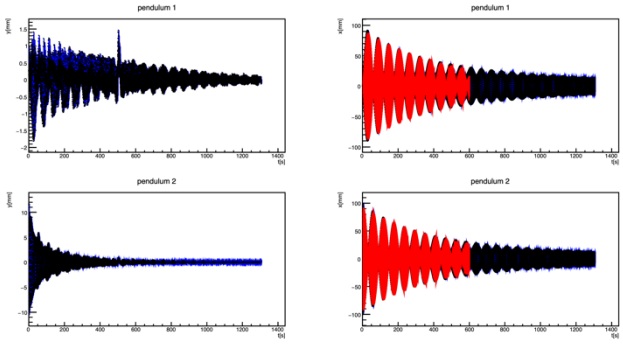

Figure 5. Displacement through time for Pendulum 1 and 2 in x and y direction

The movement was analyzed for pendulum1 and pendulum 2 in x and y directions. The movement in x direction is as expected a sinusoidal oscillation, while the movement in the y direction is a also sinusoidal with much smaller oscillation due to imperfect initial conditions, when the mass was released. On the graph it can be seen, that there are two frequencies with which the pendulums oscillate, the zoom of the motion in x is shown in Figure 6:

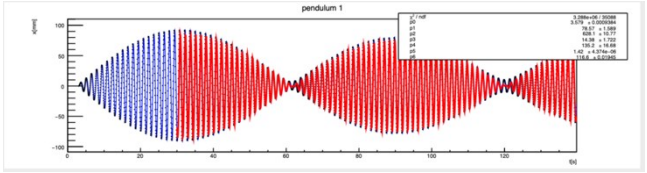

Figure 6. Displacement through time for Pendulum 1

The first frequency *v* presents a normal oscillation of a pendulum, while frequency *f* is a waving behavior of period of energy exchange.

3.2 Determining the velocity

From the graphs x(t) in the x and y direction, velocity of each pendulum was determined as the first derivative of displacement using ROOT.

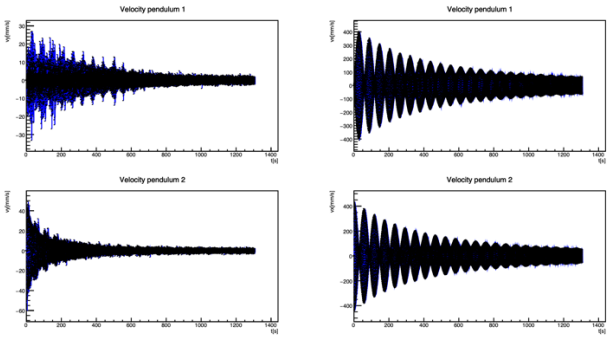

Figure 7. Velocity through time for Pendulum 1 and 2 in x and y direction

As expected, the amplitude of velocity of both pendulums in the x- direction is slowly decreasing, which is corresponding to the decreasing velocity. In the y direction, the error from the initial displacement becomes less evident, as the movement and therefore velocity settles down.

3.3 Energy of a coupled pendulum

Both kinetic and potential energy were calculated for each frame, so that a total energy could be plotted.

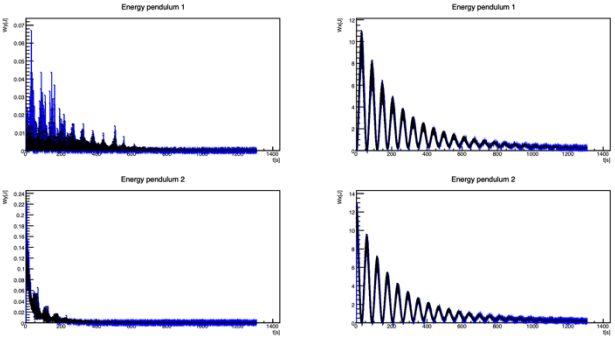

Figure 8. Energy through time for Pendulum 1 and 2 in x and y direction

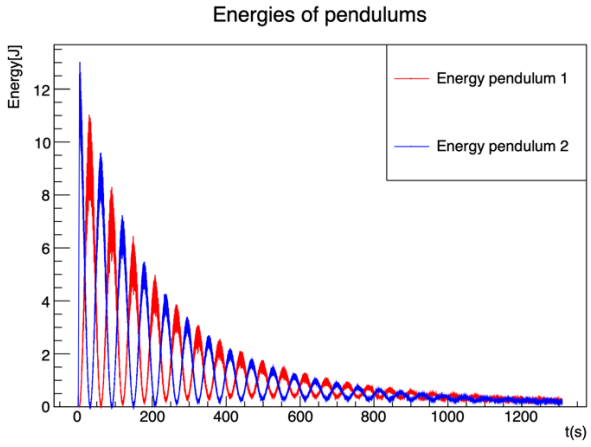

Figure 9. Energy through time for Pendulum 1 and 2 in x direction

Figure 3 and Figure 4 both show the energy of the Pendulums 1 and 2. Both pendulums are slowly decreasing in the energy, as some of the energy gets transferred into other forms of energy. The dissipation of energy is therefore clearly seen in the following graph.

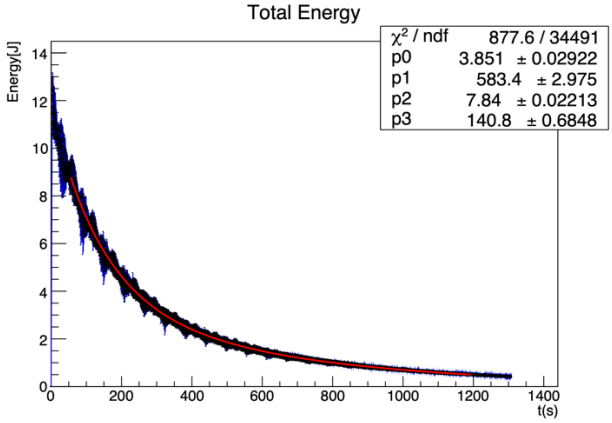

Figure 20. Total energy of the system

3.4 The effect of tension on the period of energy exchange

The system was tested under different initial conditions, where the tension in the supporting string has been changed. The effect of different tensions was tested in terms of period of energy exchange, the time the first pendulum needed to completely stop. The force in the string has therefore varied from 2.5N to 25N. When analyzing the video recording and fitting the right function on the graph, a period of energy exchange was also calculated for each tension. The results were obtained as follows and plotted in Excel:

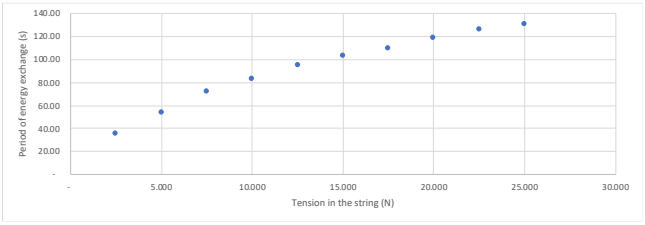

Figure 11. Period of energy exchange as a function of tension in the string

The interdependence found from the graph is almost linear. It can be seen that there are some errors to the result, which are a consequence of different distortions of the results.

4 DISCUSSION

After completing the experiment we have been able to make a few observations and address several improvements that could be made to increase the accuracy of the experiment.

Firstly, the smart phone camera could be positioned in a way that the distortion of the picture would not affect the results. This could be done by making a special set up for the camera to stabilize it, and insure the position of the camera was constant.

Further on, the length of the pendulums could be measured more accurately, to eliminate the errors due to uneven pendulums.

Lastly, the background on the video could be more even, to ease the conversion to black and white pixels.

In conclusion, the experiment could be performed more professionally and accurately.. However, in a high school setting, when students are limited by time and resources, we believe the experiments have been performed optimally.

5 CONCLUSION

The purpose of the work was to describe the movement of the coupled pendulum and to look at the correspondence between the tension in the string and the period of energy exchange.

For the purpose of the experiment a simple custom program has been used. The use of this program is a great base for further explanations and demonstrations of kinematics of oscillating systems. Basic knowledge is needed for the understanding of the program, which makes it perfect for teaching high school students, trying to connect their knowledge of physics, computer science and mathematics.

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Umetna inteligenca v izobraževalnem procesu – uporaba virtualnih laboratorijev pri kemiji

Artificial Intelligence in the Educational Process – The Use of Virtual Laboratories in Chemistry

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POVZETEK

Vpliv umetne inteligenca (UI) v izobraževalnem procesu je vedno večji, saj se je vključila že skoraj v vse pore šolstva. Elemente umetne inteligence lahko s pridom izkoristijo tako učitelji za pripravo učnih gradiv, kot učenci za samostojno delo, seveda pod budnim očesom učitelja. Članek poudarja prednosti personaliziranega učenja, interaktivnosti in takojšnih povratnih informacij, ki jih umogoča uporaba UI z uporabo virtualnih laboratorijev pri poučevanju kemije in sicer ChemCollective, za poučevanje kemijskih reakcij. S pomočjo raziskave v katero je bilo vključenih 57 dijakov, razdeljenih v testno in kontrolno skupino, je bilo ugotovljeno, da uporaba aktivnega laboratorija pri poučevanju kemijskih reakcij spodbuja boljšo angažiranost učencev, boljše razumevanje kompleksnih konceptov in boljše učne rezultate. Vključevanje UI v šolah zahteva temeljit premislek, vendar s smiselno in premišljeno uporabo prinaša veliko možnosti za obogatitev učnega procesa in nadgradnjo personaliziranega pristopa učenja.

KLJUČNE BESEDE

Umetna inteligenca, virtualni laboratoriji, personalizirano učenje

ABSTRACT

The impact of artificial intelligence (AI) in the educational process is growing, as it has become integrated into nearly every aspect of schooling. AI elements can be effectively utilized by both teachers for preparing instructional materials and students for independent work, all under the careful supervision of the teacher. This article highlights the advantages of personalized learning, interactivity, and immediate feedback enabled by AI through the use of virtual laboratories in teaching chemistry, specifically ChemCollective, for instructing on chemical reactions. A study involving 57 students, divided into test and control groups, found that the use of active laboratories in teaching chemical reactions promotes better student engagement, improved understanding of complex concepts, and enhanced learning outcomes. While the integration of AI in schools requires careful consideration, its thoughtful and deliberate application offers significant opportunities to enrich the educational process and enhance the personalized learning approach.

KEYWORDS

Artificial intelligence, virtual laboratories, personalized learning

1 Vloga UI v izobraževanju

Tehnologije UI že vplivajo na številne vidike izobraževanja, od administrativnih nalog do personaliziranih učnih izkušenj. Na nekaterih ključnih področjih je UI prinesla pomembne izboljšave. Personalizirano učenje je ena od teh, kjer sistemi UI analizirajo podatke o učencih in tako omogočajo prilagojene učne izkušnje, ki naslovijo posamezne prednosti in slabosti [1]. Povečana angažiranost učencev je še ena prednost, saj interaktivna orodja, kot so virtualni laboratoriji, spodbujajo motivacijo in večjo vključenost učencev [2]. Poleg tega UI omogoča dostop do širokega nabora izobraževalnih virov, kar olajša tako poučevanje kot učenje [3].

1.1 Uporaba virtualnih laboratorijev pri pouku kemije

Za dodatno obogatitev pouka z možnostjo večkratne ponovitve, so virtualni laboratoriji postali neprecenljiva orodja za učence. Eden izmed takšnih virtualnih laboratorijev, ki je brezplačen je ChemCollective, ki ponuja realistične simulacije kemijskih eksperimentov v angleškem jeziku. Številne šole se dandanes soočajo s prostorsko stisko in nimajo kemijskih laboratorijev, prav tako pa zaradi kadrovske podhranjenosti marsikatera šola nima asistentov za pripravo in pomoč pri izvajanju vaj. Določene vaje organske kemije, so za dijake nevarne, saj se pri reakcijah sproščajo strupeni plini. Aplikacija omogoča učencem izvajanje poskusov v varnem in nadzorovanem okolju. To je še posebej koristno pri poučevanju kemijskih reakcij, kjer je praktična izkušnja ključnega pomena za razumevanje.

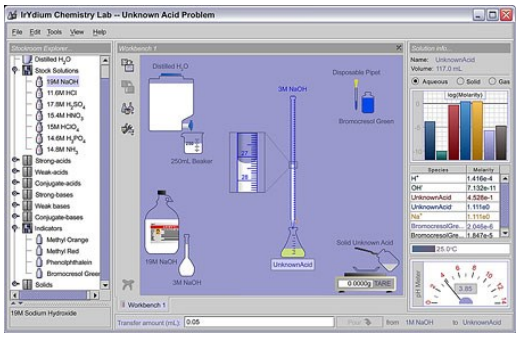
Z uporabo virtualnih laboratorijev zagotovimo varno okolje za učenje, saj lahko učenci izvajajo eksperimente brez tveganja za poškodbe ali škodo. Prav tako pa lahko eksperiment v primeru

neuspeha ponavljajo toliko časa, dokler ne osvojijo določenega znanja [4]. Realistične simulacije pomagajo učencem bolje razumeti zapletene koncepte kemijskih reakcij [5]. Ena izmed prednosti je tudi dejstvo, da lahko do virtualnih laboratorijev učenci pristopajo kjerkoli in kadarkoli – vse kar potrebujejo je pametni telefon, tablico ali računalnik. S tem je omogočeno, da učitelji prilagodijo učno uro glede na učilnico v kateri se nahajajo istočasno pa lahko učenci dostopajo do virtualnih laboratorijev tudi od doma, ko želijo določeno učno snov dodatno utrditi ali zgolj preveriti kakšno zakonitost [1]. Vritualni laboratorij, ki uporablja UI omogoča tudi takojšnje povratne informacije o uspešnosti eksperimentov, kar učencem pomaga pri učenju in odpravljanju napak v realnem času [6].

Uporaba virtualnih laboratorijev je v šolah smiselna, vendar se mora tudi smiselno uporabljati. Namen virtualnih laboratorijev ni popolna nadomestitev fizičnih laboratorijev, saj ne omogočajo urjenja ročnih spretnosti učencev, ki jih lahko pridobijo le z rokovanjem dejanske steklovine in uporabe ostalih pripomočkov za izvajanje kemijskih eksperimentov. Pred uporabo virtualnih laboratorijev je smiselno, da se učitelji dodobra naučijo določenega orodja/aplikacije, ki ga imajo namen uporabljati pri pouku. Na spletu lahko najdemo številna usposabljanja/vodiče za virtualne laboratorije, ki prikažejo učinkovito uporabo virtualnih laboratorijev in njihovo vključitev v svoj učni načrt [2]. Pri pripravi učnega načrta, naj bo glavna smernica ta, da v učni proces vključuje virtualne laboratorije na način, ki dopolnjuje tradicionalne metode poučevanja [7].

Slika 1: Prikaz Virtualnega laboratorija ChemCollective

Kljub očitnim prednostim virtualnih laboratorijev je potrebno pomisliti tudi na izzive. Kljub dejstvu, da imajo dandanes skoraj vsi učenci pametne telefone, ki brez težav omogočajo uporabo virutalnih laboratorijev, ne smemo pozabiti na tiste, ki zaradi takšnih ali drugačnih razlogov pametnih telefonov nimajo. V ta namen, je smiselno, da ima šola na voljo prenosne računalnike ali tablične računalnike, ki učencem omogočajo sledenje učni uri. V kolikor šola takšnih sredstev ne more zagotoviti, lahko učence razporedimo v dvojice ali manjše skupine, kjer na manjšem številu telefonov izvajajo vaje. [4]. Ker uporaba UI vključuje zbiranje in analizo podatkov o učencih, je pomembno, da ima šola zapisan informacijsko varnostni dokument, v katerem so določeni ukrepi za varstvo podatkov in za zaščito informacij o učencih [6]. Zaradi algoritmov UI je potrebna tudi previdnost in ozaveščanje učencev o uporbi "piškotkov", saj se UI uči od uporabnikov in shranjuje njihove pretekla iskanja. Previdno je treba obravnavati tudi potencialno prekomerno odvisnost od tehnologije [1].



Slika 2: Prikaz uporabe ChemCollective

1.2 Implementacija virtualnih laboratorijev pri pouku kemijskih reakcij

Da bi ugotovil uspešnost in smiselnost uporabe virtualnih laboratorijev na znanje in posledično učne rezultate učencev, sem izvedel raziskavo med dvema skupinama srednješolskih učencev pri pouku kemije. V raziskavi je sodelovalo 57 učencev, razdeljenih v dve skupini: testno skupino, ki je za izvajanje kemijskih eksperimentov uporabljala virtualni laboratorij ChemCollective, in kontrolno skupino, ki je delala v fizičnem laboratoriju. Testna skupina je štela 28 učencev, kontrolna pa 29. Študija je potekala v času ene učne konference. Učinke uporabe virtualnega laboratorija sem meril z izvedbo predtestov in zapoznelih testov, pri čemer sem uporabil orodje Kahoot za ocenjevanje znanja v obeh skupinah.

Slika 3: Prikaz uporabe ChemCollective v razredu

Rezultati, pridobljeni s pomočjo zapoznelega testa, opravljenega preko aplikacije Kahoot, so pokazali statistično pomembne razlike v znanju testne skupine v primerjavi s kontrolno skupino in sicer za kar 7%. Vprašanja, ki so se nanašala na odnos in ne na znanje učencev o kemijskih reakcijah pa so prikazale še večje odstopanje, saj je bilo dijakom takšno delo zanimivejše in so pokazali pozitivnejši odnos do učne snovi – učenci v testni skupini so bili bolj angažirani in motivirani. 92 % učencev testne skupine je poročalo, da jim je uporaba virtualnih laboratorijev naredila učenje bolj zanimivo in dostopno. Rezultati so pokazali, da so imeli učenci testne skupine globlje konceptualno razumevanje, saj so zaradi večjega števila ponovitev v virtualnih laboratorijih imeli bolje reševali probleme in imeli večjo sposobnost uporabe kemijskih konceptov v resničnih scenarijih. Povratne informacije iz testne skupine so

poudarile učinkovitost virtualnih laboratorijev pri zagotavljanju takojšnjega odziva.

Znaten napredek pri testni skupini in višja angažiranost med učenci testne skupine kažejo na (začetno) učinkovitost virtualnih laboratorijev pri omogočanju boljših učnih rezultatov. Eden izmed ključnih vidikov, ki prispevajo k temu uspehu je nedvomno interaktivno učenje, ki omogoča prilagajanje učenja potrebam učencev in prostoru in takojšnje povratne informacije. Dejstvo, da lahko virtualni laboratoriji prilagodi učno izkušnjo posameznim potrebam, omogoča učencem napredovanje v lastnem tempu in po potrebi tudi ponavljanje zahtevnih konceptov [1]. Realistične simulacij v virtualnih laboratorijih omogočijo interaktivno učno okolje, ki abstraktne kemijske koncepte naredilo bolj oprijemljive in razumljive [4].

1.3 Zaključek

Vključitev umetne inteligence v izobraževalni proces je zgolj vprašanje časa, saj ga že dandanes uporabljajo številni učenci za lažje pridobivanje informacij pri pouku ali učenju. Uporaba virtualnih laboratorijev pri poučevanju kemijskih reakcij pri pouku kemije, ponuja pomembne prednosti v smislu personaliziranega učenja, angažiranosti in konceptualnega razumevanja. Rezultati raziskave, ki jo opisujem v tem članku prikazujejo pozitiven vpliv virtualnih laboratorijev na učne rezultate učencev, kar spodbudno kaže na njihov potencial za prilagoditev tradicionalnih metod poučevanja. Trditi, da lahko virtualni laboratoriji nadomestijo fizične je seveda neprimerno in nesmiselno, saj ne nadomestijo pridobivanja ročnih spretnosti učencev.

S tem, da učitelji sprejmejo UI in so jo pri pouku pripravljeni tudi uporabljati kot dodatno spodbudo oz. način za boljše poučevanje, naredijo prvi korak k pripravi učencev na prihodnost, kjer je tehnološka pismenost ključnega pomena.

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Prednosti IKT tehnologije pri pouku športne vzgoje

Advantages of ICT Technology in Physical Education Lessons

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POVZETEK

V prispevku je predstavljeno, kako se lahko s pomočjo IKT tehnologije lotimo izziva prekomerne telesne teže dijakov in dijakinj ter spregovorimo o pomenu zdrave prehrane in presnove, ki je v času odraščanja za mladostnike ključnega pomena. Mladostniki se v našem učnem sistemu pogosto srečajo s pomenom zdrave prehrane, prav tako pa je zdrava prehrana pogosto tema v medijih. Kljub pogostemu omenjanju pomena zdrave prehrane, je raziskava pokazala, da mladostniki velikokrat posežejo po nezdravi hrani. Več kot polovica anketiranih mladostnikov je mnenja, da se prehranjujejo zdravo, vendar so rezultati pokazali, da je v resnici takšnih zgolj 28%. Potrošniki pogosto v trgovini kupujemo hrano glede na izgled embalaže, mladostniki pa so glede na vizualni izgled in oglaševanje določenega izdelka še bolj dovzetni. Posledično nezdravo hrano pogosto zamenjajo za zdravo in jo v prepričanju, da je zanje ustrezna, jedo. Da bi mladostnikom na drugačen način približali pomen zdrave prehrane, je bila opravljena raziskava, v kateri so dijaki najprej preverili svoje znanje o zdravi prehrani, izpolnili anketo o njihovih prehranjevalnih navadah in bili nato vključeni v delavnice o pomenu zdrave prehrane in presnove. Na delavnicah so dijaki s pomočjo aplikacije Energy for life na interaktivni način spoznali pomen zdrave prehrane in kako se hranila presnovijo v našem telesu. Svoje znanje so nato preverili z vprašalnikom. Na koncu delavnice so dijaki s pomočjo aplikacije Več kaj ješ? naredili primere zdravih jedilnikov.

KLJUČNE BESEDE

IKT tehnologija, zdrava prehrana, prekomerna telesna teža, delavnice, presnova, aplikacija

ABSTRACT

The article presents how we can tackle the challenge of excessive body weight in male and female students and address the importance of healthy diet and metabolism using ICT technology, which is crucial for adolescents during their growth. Adolescents are often confronted with the importance of healthy eating in our learning system, and healthy eating is often a topic in the media. Despite the frequent mention of the importance of a healthy diet, research has shown that adolescents often resort to unhealthy foods. More than half of the adolescents surveyed said they were eating healthy, but the results showed that only 28% actually did. Consumers often buy food at the store based on the appearance of the packaging, and adolescents are even more receptive to the visual appearance and advertising of a particular product. As a result, unhealthy foods are often mistaken for healthy foods and eaten in good faith. In order to approach adolescents in a different way the importance of a healthy diet for their development and metabolism, a study was conducted in which students first tested their knowledge of healthy eating, completed a survey of their eating habits, and then participated in workshops on the importance of healthy eating and metabolism. Through the Energy for life application, students learned the importance of a healthy diet and how nutrients are metabolised in our bodies, and then tested their knowledge with a questionnaire. At the end of the workshop, students used the application Več kaj ješ? and made examples of healthy menus.

KEYWORDS

ICT technology, healthy nutrition, overweight, workshop, metabolism, aplication

1 UVOD

Zdrava prehrana je nekaj o čemer se zadnje čase zelo pogosto govori. Pomen zdrave prehrane je ključen za zdrav razvoj, saj telo za izgradnjo notranjih ogranov, mišic, kostnine in živčevja nujno potrebuje hranila, ki jih vsebuje hrana. V zgodnjem otroštvu se običajno prehranjujemo bolj zdravo in uživamo raznoliko prehrano, ki nam omogoča zdrav razvoj. Otrokov jedilnik določajo starši oz. skrbniki in posledično ne moremo kot posamezniki vplivati na izbor hrane in uživati zgolj hrane, ki nam je všeč. V času pubertete, pa mladostniki počasi začnejo sami določati svoj jedilnik in pri tem večkrat ne upoštevajo smernic zdravega prehranjevanja. Nepravilen izbor živil in njihovo uživanje pa lahko pusti posledice, ki se pokažejo kot nepravilna, neenakomerna rast za vse življenje, prav tako pa lahko vpliva na oblikovanje prehranjevalnih navad v kasnejšem življenju. [6] Zaradi upada upoštevanja smernic zdrave prehrane skozi obdobje pubertete je bila posledično opravljena raziskava katere namen je ugotoviti prehranske navade mladostnikov, v kateri so sodelovali dijaki tretjih letnikov III. gimnazije Maribor. Dijaki so sprva izpolnili vprašalnik, ki je preveril njihove prehranske navade, nato pa so preko didaktične delavnice, pri katerih so uporabljali interaktivni aplikaciji, ki mladostnike spodbudita k boljšem razumevanju pomena zdrave prehrane in njene presnove, spoznavali načela zdravega prehranjevanja. Z vidika varovanja zdravja je namreč zdrava prehrana za mladostnike izredno pomembna, saj imajo ravno v tem obdobju veliko večje potrebe po beljakovinah, vitaminih in mineralih ter energiji. [1]

2 POMEN ZDRAVE PREHRANE

Mladostniki se že v času osnovne šole pri pouku gospodinjstva srečajo s pomenom zdrave prehrane, kjer se učijo o prehranski piramidi in različni pripravi hrane. Nato se o prehrani in presnovi učijo pri pouku biologije, kjer največ poudarka namenijo presnovi ter vgradnji hranil v človeško telo in posledicah nepravilne prehrane in prehranskih navad. Njihove prehranske navade so v času osnovne šole običajno dobre, vsaj v prvi in drugi triadi. V tretji trijadi pa mladostniki med glavnimi obroki pogosto uživajo prigrizke za katere je značilno, da vsebujejo veliko energije, zaradi prisotnosti sladkorjev in maščob, ne vsebujejo pa hranilnih snovi, ki jih telo potrebuje za krepitev odpornosti. Ena izmed praks mladostnikov v tretji triadi je opuščanje zajtrka in neustrezen ritem prehranjevanja ter premajhne količine zaužite zelenjave. Vendar se prehranske navade osnovnošolskih otrok v tretji triadi v veliki meri razlikujejo od navad srednješolskih otrok, saj le ti velikokrat nimajo primerne šolske malice. [5]

Zdravo prehrano bi lahko opredelili z naslednjimi smernicami:

- redna prehrana (vsaj 5 obrokov dnevno),
- uživanje hrane glede na prehransko piramido,
- raznolikost hrane,
- počasno uživanje hrane, ki jo dobro prežvečimo,
- izogibanje sladkim in mastnim jedem,
- izogibanje prigrizkom [2].

Iskanje krivca slabih prehranskih navad mladostnikov ni enostavno, saj na njihove navade vpliva mnogo različnih dejavnikov. Živimo v okolju, ki spodbuja debelost, saj smo kot družba izredno potrošniko naravnani in nam mediji dnevno posredujejo vedno nove in nove proizvode. Poleg tega, pa nas okolje spodbuja k temu, da smo vedno manj aktivni (električna kolesa, električni skiroji, uporaba osebnega vozila...). Podatki za Slovenijo kažejo naraščajoče gibanje prekomeno hranjenih in debelih mladostnikov in odraslih pri nas, kar kaže, da se navade pogosto prenašajo s starejše na mlajšo generacijo [7]. Debelost pri mladostnikih je namreč eden izmed največjih problemov današnjega časa, saj prekomerna telesna teža v mladostniškem obdobju zelo pogosto nakaže na prekomerno telesno težo tudi v odraslem obdobju. Pri mladostniku neuravnotežena prehrana povzroča manjšo delovno storilnost, utrujenost, manjšo sposobnost pomnenja in kronične bolezni. Strokovnjaki so ugotovili, da so številne bolezni neposredno povezane s hrano, kar pomeni da je od prehrane odvisno naše zdravje. Nepravilna prehrana pa je večkrat povezana z različnimi slabimi navadami kot je telesna neaktivnost in kajenje. Bolezni katere lahko neposredno povežemo s prehrano so:

- beri-beri (posledica, dolgoročnega pomankanja vitamina B1),
- skorbut (nastane zaradi pomanjkanja vitamina C v daljšem časovnem obdobju),
- hipertenzija (povišan krvni tlak zaradi hrane, ki vsebuje visoke vrednosti nitratov),
- zobna gniloba (posledica prekomernega uživanja sladke hrane in slabe ustne nege).

Obstaja še množica drugi bolezni, vendar njihovega nastanka ne morejo povezati izključno z slabimi prehranskimi navadami. [8]

Ker so bolezni, ki jih povzroča nezdrava prehrana velik javnozdravstveni problem, se veliko pozornosti namenja k omilitvami posledic le teh.

3 INTERAKTIVNO POUČEVANJE

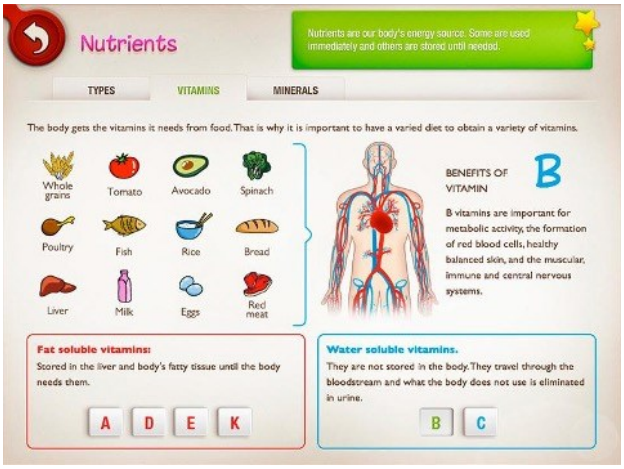
Ustaljena praksa poučevanja mladostnikov o pomenu zdrave prehrane, očitno ne prinaša dobrih rezultatov, saj se delež mladostnikov, ki imajo slabe prehranske navade in posledično zdravstvene težave, iz leta v leto povečuje. Razlog za slabe navade mladostnikov, bi lahko bili tudi zastareli načini poučevanja v šoli, saj so učenci zaradi uporabe interneta, mobitelov in televizije navajeni na interaktivno pridobivanje informacij. Frontalen način poučevanja, katerega uporablja večina učiteljev, v večini primerov ne doprinese k trajnostnem znanju, saj so učenci do takšnega pridobivanja informacij vedno manj motivirani pri učnem procesu [4]. Učitelj mora dan danes učence spodbujati, da sami pridejo do določenih spoznanj, ne da jim zgolj posreduje znanje. Z uporabo in upoštevanjem konstruktivističnega pristopa pri izkustvenem učenju lahko učitelj učencem pomaga povezati ugotovitve s praktičnimi zakonitostmi. Uporaba IKT (informacijsko komunikacijske tehnologije) lahko omogoči posredovanje učne snovi na bolj atraktiven način. Pri pouku lahko uporabimo tako računalnike, kot tudi mobilne telefone, sploh v primeru, ko imamo v vzgojno izobraževalnem zavodu težave zagotoviti primerno število računalnikov za večjo skupino učencev. Uporaba mobilnih telefonov pri pouku ima tudi svoje omejitve in predstavlja določene izzive, sploh od učiteljev. Prednost mobilnih telefonov je v tem, da jih ima večina učencev in da so običajno zmogljivejši od šolskih računalnikov [3].

4 APLIKACIJE ZA POUČEVANJE O ZDRAVI PREHRANI IN PRESNOVI

Na spletu je množica različnih aplikacij in spletnih strani, ki opisujejo zdravo prehranjevanje vendar je zgolj peščica didaktično primernih za uporabo v učnem procesu. Večina aplikacij je namenjena ali izobraževanju ali zabavi, vendar le malo je takšnih, ki bi združevale oba spektra. Ena izmed aplikacij, ki je tako poučna, da uporabnik pridobi in utrdi svoje znanje, kot tudi zabavna, da se ne naveliča in je pripravljen dlje časa ostati motiviran, se imenuje Energy for life. Aplikacija sicer ne ponuja uporabe v slovenskem jeziku, temveč je zgolj v angleškem in španskem jeziku. Posledično se lahko aplikacijo uporabi kot primer medpredmetnega povezovanja biologije in angleščine. Prednost aplikacije je tudi v tem, da je popolnoma brezplačna in omogoča več različnih učnih modulov. Aplikacija s pomočjo igrifikacije – uporaba dinozavra, ki pritegne pozornost uporabnika, uči novih konceptov in ga motivira za interakcijo, kar izboljša učni proces. Zaradi enostavnega umesnika je ta aplikacija dostopna vsem učencem različnih starosti, tako v osnovni, kot tudi v srednji šoli. Vizualen prikaz in strokovna natančnost izrazov, se določi s pismenimi sposobnostmi uporabnika. Velik poudarek je na znanstveni pismenosti, povezan z vizualnimi dražljaji, ki uporabnika spodbujajo k aktivni uporabi aplikacije. Aplikacija je zasnovana tako, da se jo lahko uporablja ob spremstvu vodje učnega procesa ali pa se jo uporablja samostojno. Slika 1 prikazuje dinozavra, ki

mladostnika nagovarja, kaj vse lahko s pomočjo aplikacije izve. Uporabnik lahko izbira med različnimi področji, ki jih lahko s pomočjo aplikacije osvoji in utrdi svoje znanje. Slika 2 prikazuje modul prebavil, katerega uporabnik lahko izbere v aplikaciji in s pomočjo njega pregleda kaj vse njegovo telo potrebuje za delovanje. Nato uporabnik preveri kaj se zgodi, če tega hranila ne dobi (nastanek različnih obolenj). Prav tako, ga aplikacija spodbuja k nadaljnjem razmišljanju in preizkušanju naučenega znanja.

Slika 1: Prikaz različnih modulov aplikacije



Slika 2: Prikaz modula hranila

Aplikacija Več kaj ješ? omogoča uporabniku preveriti energijsko vrednost hrane. Prav tako uporabniku omogoča, da s pomočjo prehranskega semaforja ugotovi, katerih živil naj se zaradi prekoračenih vrednosti določenih hranil izogiba. Namen aplikacije je pomoč pri sestavi jedilnika, katerega lahko vsak posameznik sestavi glede na svoje prehranske navade. Slika 3 prikazuje primer uporabe aplikacije na pametnem telefonu med opravljanjem nakupov. Aplikacija nam omogoča uporabo kamere pri pametnem telefonu in s tem skeniranje črtne kode izdelka, katerega prehransko vrednost želi uporabnik preveriti. Aplikacija nam nato s pomočjo barvnega semaforja prikaže katerih hranil je v izdelku v zadostnih, prekomernih ali premajhnih količinah. Pri sliki 4 lahko vidimo, kako je razčlenjen prehranski semafor, ki uporabniku sporoča še dopustno vrednost določenih hranil v izdelku. Aplikacija Več kaj ješ? ni namenjana zabavi in je posledično manj atraktivna kot aplikacija Energy for life, zato je vsaj uvodna uporaba aplikacije priporočljiva pod vodstvom učitelja. Učitelj mora pred uporabo mobilnih telefonov kot učnega pripomočka med poukom oceniti smiselnost, pri kateri učni snovi ga bo uporabil in katere učne cilje bo s pomočjo njih usvojil. Prav tako ni namen vsakodnevne uporabe mobilnih telefonov pri učnem procesu, saj bi s tem njegova atraktivnost izzvenela, prav tako pa bi lahko postal moteči faktor v razredu zaradi morebitne nedovoljene uporabe iz strani učencev.

Slika 3: Prikaz aplikacije Več kaj ješ?

5 RAZISKAVA

Da bi ugotovili odnos do zdrave prehrane mladostnikov in preverili znanje o pomenu zdravega prehranjevanja in presnove, je bila opravljena raziskava, v kateri so sodelovali dijaki tretjih letnikov III. gimnazije Maribor. Za namen raziskave je bilo izbranih 42 dijakov, ki so sprva izpolnili vprašalnik, ki je bil sestavljen iz 14 vprašanj, katerih namen je bil ovrednotiti znanje dijakov o zdravi prehrani in presnovi, prav tako pa je bil namen vprašalnika preveriti njihove prehranske navade. Nato so bile izvedene 3 učne ure, pri katerih so dijaki s pomočjo aplikacije Energy for life ugotovili pomen zdrave prehrane in presnove, nato pa so s pomočjo aplikacije tudi preverili svoje znanje. Pri učni uri je bila vloga učitelja zgolj kot usmerjevalec učnega procesa in ne posredovalca znanja. Po uporabi aplikacije so bili dijaki pozvani kakšne so njihove prehanske navade in opisu njihovega tedenskega jedilnika. Ker so imeli pri jedilniku večje težave, so nato s pomočjo aplikacije Več kaj ješ? preverili kakšne jedi so primerne za določen del dneva in katerih jedi se morajo izogibati pri svoji prehrani. Po zaključku dela z aplikacijo so dijaki s pomočjo razgovora posredovali kaj so se naučili in izročke oblikovane skupaj z učiteljem zapisali v zvezke. Nato so ponovno izpolnjevali vprašalnik, s katerim je bilo preverjeno, kaj so se naučili. Določeni rezultati vprašalnika so bili pričakovani, saj se je tako znanje kot tudi odnos do zdrave prehrane izboljšal. Presenetljivo je bilo to, da je bilo 54% odstotkov dijakov mnenja, da se prehranjuje zdravo, vendar je bilo nato v nadaljnjem delu rezultatov vprašalnika prikazano, da so zmotno prepričani v svoj zdrav način prehranjevanja. Kar 48% dijakov navaja premalo

časa kot glaven krivec za njihove slabe prehranske navade, 35% dijakov pa navaja, da stres močno pripomore k njihovim prehranskim navadam. Kot glaven razlog zakaj kupijo določen proizvod so dijaki podali izgled in njegovo oglaševanje. Večina dijakov ne pregleda hranilnih vrednosti pred nakupom produkta. Pri vprašanju katera pijača ima najvišjo vrednost sladkorja, je sprva od 42 dijakov pravilno odgovorilo zgolj 5 dijakov, kar nakazuje na njihovo zmotno znanje o hranilih v sladkanih pijačah. Pri zapoznelen vprašalniku pa je pravilno odgovorilo 18 dijakov. Večina dijakov, kar 34 od 42 je odgovorila pri zapoznelen vprašalnikov, da bodo več pozornosti namenili svojim prehanskim navadam.

6 ZAKLJUČEK

Ključno je, da se o zdravi prehrani začnemo pogovarjati čim prej v začetku izobraževalnega procesa. Vendar zgolj frontalno poučevanje ne prinaša željenih rezultatov, saj se delež prekomerno debelih otrok in mladostnikov v zadnjem času drastično povečuje. V raziskavi je predstavljen eden od načinov, kako lahko izobrazimo mlade o pomenu zdrave prehrane. Aplikacije, ki jih dan danes učenci uporabljajo pri pouku, so dostopne preko mobilnih telefonov, kar pomeni, da lahko tudi vzgojno izobraževalni zavodi z omejitvami pri omogočanju dovolj velikega števila računalnikov za vse učence, omogočijo svojim učencem izvedbo pouka na takšen način. Ali bo uporaba takšnih aplikacij drastično vplivala na prehranske navade učencev je neodgovorno trditi, vendar njihova uporaba lahko pripomore k boljšem ozaveščanju zdravega načina prehranjevanja in razumevanju presnove hranil ter zdravemu načinu življenja.

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Informacijska tehnologija pri inkluzivnem pouku tujega jezika

Information technology in inclusive foreign language lesson

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POVZETEK

Vključevanje digitalnih orodij kot so Animoto, Book Creator ter animacija lutk ali predmetov v ure angleščine omogoča ustvarjanje vključujočega učnega okolja za učence z različnimi potrebami. Animoto omogoča enostavno ustvarjanje in prilagajanje videoposnetkov, medtem ko animacija ponuja praktičen način za vizualno predstavitev idej v lastnem tempu. Book Creator omogoča ustvarjanje in deljenje digitalnih knjig ter spodbuja sodelovanje med učenci. Ta orodja spodbujajo kreativnost, učencem pa omogočajo prilagajanje učnih izkušenj lastnim individualnim potrebam, kar povečuje njihovo angažiranost in omogoča učinkovitejše učenje. Tako lahko učitelji ustvarijo okolje, kjer se vsi učenci lahko izražajo na njim najprimernejši način.

KLJUČNE BESEDE

Inkluzija, tuji jeziki, informacijska tehnologija, Animoto, animacija, Book Creator.

ABSTRACT

Integrating digital tools such as Animoto, Book Creator and stop-motion animation into English lessons creates an inclusive learning environment for students with diverse needs. Animoto allows for easy creation and customization of videos, while stop-motion animation offers a hands-on approach to visually presenting ideas at one's own pace. Book Creator enables the creation and sharing of digital books, encouraging collaboration among students. These tools foster creativity and allow students to tailor their learning experiences to their individual needs, thereby increasing their engagement and enabling more effective learning. This way, teachers can create an environment where all students can express themselves in the way that suits them best.

KEYWORDS

Inclusion, foreign languages, information technology, Animoto, stop-motion animation, Book Creator.

1 Integracija in inkluzija

Integracija in inkluzija sta precej podobna koncepta, ki se razlikujeta glede na različne poglede na obravnavano temo, nedvomno pa gre v obeh primerih za vključevanje otrok s posebnimi potrebami v šolo, pri čemer se jim nudi pomoč, prilagoditve in podporo na vseh ravneh.

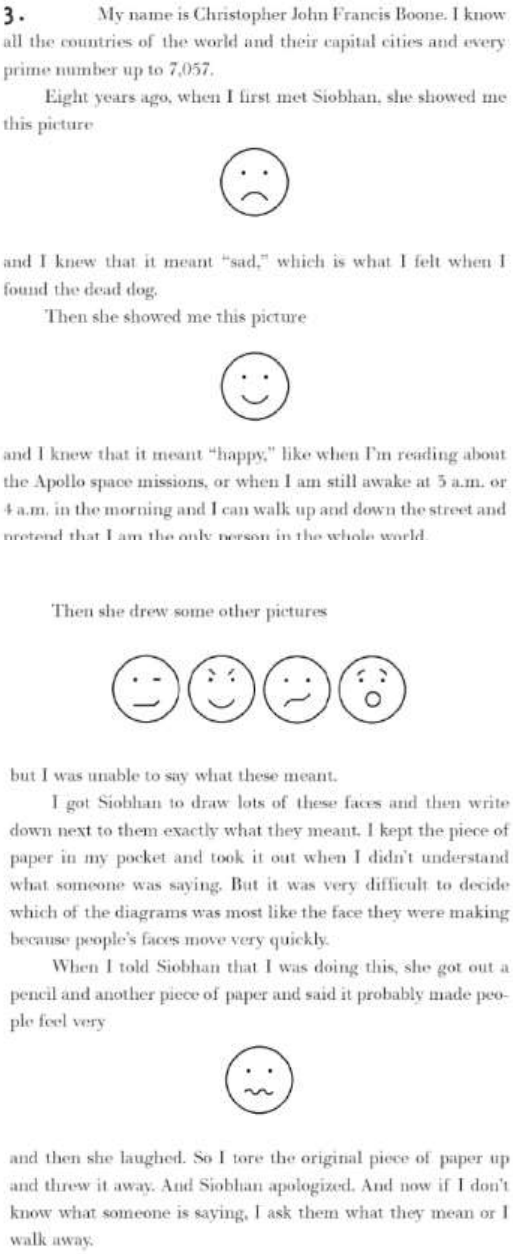
Zakonska podlaga **Error! Reference source not found.** določa vključevanja učencev s posebnimi potrebami v redne razrede, kar je v preteklosti vodilo k uvedbi koncepta integracije v naše šole. Koncept integracije pravzaprav izvira z Danske, kjer je bila posledica sprememb v vzgoji in izobraževanju oseb z motnjami v razvoju. Takratni danski minister je integracijo opredelil kot vključevanje oseb z razvojnimi izzivi v normalno okolje v največji možni meri. To je pomenilo selektivno vključevanje otrok in mladostnikov s posebnimi potrebami v redne vrtce in šole **Error! Reference source not found.**.

Opozoriti velja, da inkluzija ne vključuje le otrok, ki so prepoznani kot otroci s posebnimi potrebami, temveč tudi druge. To so otroci, ki izvirajo iz socialno depriviligiranih in subkulturnih okolij, otroci priseljencev ali beguncev, otroci, ki imajo težave s socialno integracijo **Error! Reference source not found.**, otroci iz etničnih manjšin ter otroci iz družin z nižjim socialno-ekonomskim statusom **Error! Reference source not found.**. Ti učenci se pogosto soočajo z izzivi v šolah zaradi jezikovnih ovir, pomanjkanja spodbud doma, drugačnih vrednot in zato potrebujejo znatno podporo tako s strani šole kot učiteljev **Error! Reference source not found.**. Lesar **Error! Reference source not found.** navaja, da inkluzivno izobraževanje zajema tudi otroke, katerih starši začasno delajo v tujini, ter otroke z različnimi spolnimi usmeritvami. Zakon o spremembah in dopolnitvah Zakona o osnovni šoli **Error! Reference source not found.** omenja tudi nadarjene učence, za katere mora šola zagotoviti ustrezno izobraževanje s prilagoditvijo učnih metod, oblik dela, vsebin in omogočiti njihovo sodelovanje v dodatnih urah ter drugih oblikah šolskih dejavnosti.

2 Inkluzija pri pouku tujega jezika

Čeprav je poučevanje tujega jezika z upoštevanjem inkluzije lahko zelo zahtevno, primer v nadaljevanju pokaže, kako inkluzijo lahko omogočimo s pomočjo informacijske tehnologije. Primer ure angleškega jezika v srednji šoli se osredotoča na roman "Skrivnostni primer ali Kdo je umoril psa" britanskega pisatelja Marka Haddona. Roman se osredotoča na protagonista in pripovedovalca, Christopherja Boonea, 15-letnika z avtizmom. Cilj pri načrtovanju ure je obravnavanje kompleksnosti avtizma, da bi se dijaki lažje spoprijeli z izzivi, ki jih postavlja ta zanimiva tema.

Ura je zasnovana z namenom, da bi dijaki prebrali kratek odlomek iz romana, izbrani izsek besedila pa izrecno poudarja, da ima glavni junak posebne lastnosti. Predstavljeni odlomek je tako za dijake kot za bralce tega članka v izvornem jeziku, torej v angleščini.



3. My name is Christopher John Francis Boone. I know all the countries of the world and their capital cities and every prime number up to 7,057.

Eight years ago, when I first met Siobhan, she showed me this picture

and I knew that it meant "sad," which is what I felt when I found the dead dog.

Then she showed me this picture

and I knew that it meant "happy," like when I'm reading about the Apollo space missions, or when I am still awake at 3 a.m. or 4 a.m. in the morning and I can walk up and down the street and pretend that I am the only person in the whole world.

Then she drew some other pictures

but I was unable to say what these meant.

I got Siobhan to draw lots of these faces and then write down next to them exactly what they meant. I kept the piece of paper in my pocket and took it out when I didn't understand what someone was saying. But it was very difficult to decide which of the diagrams was most like the face they were making because people's faces move very quickly.

When I told Siobhan that I was doing this, she got out a pencil and another piece of paper and said it probably made people feel very

and then she laughed. So I tore the original piece of paper up and threw it away. And Siobhan apologized. And now if I don't know what someone is saying, I ask them what they mean or I walk away.

Slika 1: odlomek iz romana "Skrivnostni primer ali kdo je umoril psa"

Ko dijaki besedilo preberejo, dobijo nalogo, da identificirajo ključne besede, ki opisujejo glavnega junaka, in ki poudarijo njegovo edinstvenost. Dijaki v parih primerjajo svoje sezname in svoje izbire predstavijo drugemu paru. V zadnjem delu so dijakom predstavljene tri možnosti, ki temeljijo na inkluziji, in sicer morajo ustvariti ilustracijo, ki prikazuje glavnega junaka Christopherja in njegov svet; odgovoriti na niz vprašanj; ali pa napisati kratek odstavek o srečanju s Christopherjem.

Te tri različne naloge so prilagojene različnim sposobnostim in preferencam dijakov. Izbrani pristop upošteva, ali so dijaki bolj spretni pri izražanju skozi vizualne ali besedne vsebine, prav tako pa se poglablja v širše vprašanje, ali se lahko vživijo in potencialno vzpostavijo povezave z nekom, ki ima avtizem.

2.1 Inkluzija z informacijsko tehnologijo

Kot učitelji smo dobro seznanjeni z edinstvenimi močmi in preferencami naših učencev ali dijakov. Glede na to da poučujem angleščino v programih, usmerjenih v računalništvo, pouk lahko popestrim z navodilom dijakom, naj pripravijo predstavitev Christopherja ali pa dela romana z uporabo enega od razpoložljivih informacijskih orodij. V nadaljevanju predstavljena orodja so zanimiva alternativa PowerPointu, saj so uporabniku prijazna in ponujajo zanimive rešitve.

2.1.1 Animoto

Animoto je vsestransko in brezplačno orodje za ustvarjanje videoposnetkov. Njegovi uporabniki lahko ustvarijo in delijo neomejeno število videoposnetkov na svojih računih, brez da bi bilo treba naložiti dodatno programsko opremo. Uporabniki projekt začnejo tako, da dodajo vse potrebne slike in posnetke, nato pa jih preprosto povlečejo in spustijo v nastajajoči video. Platforma ponuja vrsto oblikovalskih orodij, ki uporabnikom omogočajo, da prilagodijo barve, pisave, glasbo in še več. **Error! Reference source not found.**

2.1.2 Stop Motion Animation

Tako imenovana stop-motion animacija je tehnika, ki se uporablja v animaciji za oživitev statičnih predmetov na zaslonu. To se doseže z gibanjem predmeta v majhnih korakih, medtem ko se v vsakem koraku posname en kader. Ko se vsi kadri predvajajo v zaporedju, prikazujejo gibanje. V opisani animaciji se pogosto uporablja glinene figure, lutke in miniaturne figure, saj jih je mogoče enostavno upravljati in premikati. **Error! Reference source not found.**

2.1.3 Book Creator

Book Creator je digitalno orodje, ki uporabnikom omogoča ustvarjanje in branje multimodalnih digitalnih knjig, torej tudi spodbuja angažiranost učencev oziroma dijakov, ki lahko ustvarjajo zgodbe in jih multimedijsko oblikujejo. Pri ustvarjanju svojih knjig lahko uporabniki ustvarijo lastno vsebino (s pisanjem, risanjem ali nalaganjem lastnih videoposnetkov, zvočnih datotek in slik) ali pa izberejo spletne multimedijske vire z interneta. Book Creator se lahko uporablja tudi pri projektno usmerjenih učnih dejavnostih, saj omogoča sodelovanje več uporabnikov v realnem času pri ustvarjanju ene knjige. **Error! Reference source not found.**

Za nalogo, ki vključuje predstavitev Christopherja, lahko dijaki torej prilagodijo videz svojega izdelka, da se ujema s tematiko in njihovo individualno ustvarjalno vizijo.

3 Zaključek

Vključevanje digitalnih orodij kot so Animoto, Stop-motion animation in Book Creator v ure angleščine na sodoben in zanimiv način omogoči inkluzijo dijakov z različnimi sposobnostmi. Ta orodja ne omogočajo le kreativnega izražanja, temveč tudi opolnomočijo dijake, da prilagodijo svoje učne izkušnje svojim individualnim potrebam.

Uporabniku prijazen vmesnik Animoto omogoča enostavno ustvarjanje in prilagajanje multimedijskih predstavitev, s čimer zadovoljuje različne učne stile. Stop-motion animacija ponuja praktičen pristop, ki učencem omogoča, da vizualno predstavijo ideje v svojem tempu, kar spodbuja avtonomijo v učnem procesu. Book Creator s svojo vsestranskostjo ne podpira le ustvarjanja personaliziranih digitalnih knjig, temveč tudi spodbuja sodelovanje in omogoča različne načine izražanja. Z uporabo teh digitalnih orodij lahko učitelji omogočijo vključujoče učno okolje, v katerem lahko učenci in dijaki ne glede na svoje sposobnosti sprostijo svojo ustvarjalnost in se vključijo v učni proces na način, ki jim najbolj ustreza.

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Pomanjkanje kritičnega mišljenja je nevarnejše od umetne intelligence

Lack of Critical Thinking is More Dangerous than Artificial Intelligence

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POVZETEK

Kritično mišljenje igra ključno vlogo pri interpretaciji, ocenjevanju in uporabi informacij. Medtem ko umetna inteligenca (UI) predstavlja tehnološke priložnosti in potencialne nevarnosti, kot so zloraba podatkov, pristranskost algoritmov in avtomatizacija delovnih mest, se pravo tveganje skriva v nezmožnosti ljudi, da te informacije ustrezno presodijo in uporabijo.

Kritično mišljenje omogoča ljudem, da ločimo dejstva od dezinformacij, prepoznavamo skrite motive in analiziramo različne perspektive. Brez teh veščin smo bolj dovzetni za manipulacije, teorije zarot in napačne odločitve, kar lahko vodi do širših družbenih in političnih posledic.

UI je orodje, ki ga lahko oblikujemo in usmerjamo, vendar njegova uporaba in vpliv sta močno odvisna od kritičnega mišljenja uporabnikov. Če uporabniki nimajo teh veščin, lahko tehnologija poveča že obstoječe težave, kot so polarizacija, širjenje lažnih novic in krepitev predsodkov.

Ključnega pomena je izobraževanje in spodbujanje kritičnega mišljenja na vseh nivoji, saj omogoča odgovorno in premišljeno uporabo UI ter zmanjšuje tveganja, povezana z napačno uporabo tehnologije. Pomanjkanje teh veščin lahko vodi v večje in bolj daljnosežne posledice kot sama tehnologija.

V prispevku bodo izpostavljeni pomembni pedagoški vidiki kritičnega mišljenja, kot so: vloga učitelja, kurikuluma in interdisciplinarnega pristopa. Posebej bo poudarjen pomen veščin za 21. stoletje, kot so: digitalna pismenost, sistemsko mišljenje in razumevanje UI. Govor bo tudi o ustvarjanju podpornega okolja za kritično mišljenje.

ABSTRACT

Critical thinking plays a key role in interpreting, evaluating and applying information. While artificial intelligence (AI) presents technological opportunities and potential dangers, such as data misuse, algorithmic bias, and job automation, the real risk lies in the inability of humans to properly judge and use this information.

Critical thinking enables people to separate facts from misinformation, recognize ulterior motives, and analyse different perspectives. Without these skills, we are more susceptible to manipulation, conspiracy theories and wrong decisions, which can lead to wider social and political consequences.

AI is a tool that we can design and direct, but its use and impact depend heavily on the critical thinking of users. If users lack these skills, the technology can exacerbate already existing problems such as polarization, the spread of fake news, and the strengthening of prejudice.

Education and the promotion of critical thinking at all levels are of key importance, as it enables the responsible and thoughtful use of UI and reduces the risks associated with the incorrect use of technology. A lack of these skills can lead to bigger and more far-reaching consequences than the technology itself.

The contribution will highlight important pedagogical aspects of critical thinking, such as: the role of the teacher, the curriculum and the interdisciplinary approach. Special emphasis will be placed on the importance of 21st century skills such as: digital literacy, systems thinking and UI understanding. The talk will also be about creating a supportive environment for critical thinking.

Uporaba izobraževalnih aplikacij za prepoznavo travniških rastlin

The use of educational applications to identify meadow plants

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POVZETEK

V prispevku je predstavljena učinkovita uporaba izobraževalnih aplikacij za spoznavanje rastlin in primerjava le-teh glede na njihovo uporabnost in učinkovitost. Aplikacije so se izkazale kot odličen način za prepoznavo travniških rastlin in dober pripomoček pri obravnavi učne snovi. Kot najboljša aplikacija izmed preizkušenih se je izkazala aplikacija Pl@ntNet. Enostavna za uporabo, jasno in pregledno zastavljena, shranjuje vnesene rastline in je zelo bogato opremljena s fotografijami primerov, ki jih nalagajo uporabniki. Obenem ponuja tudi imena rastlin v slovenskem jeziku z možnostjo lastnega vnašanja predlogov in popravkov. Ob vpisu se je mogoče povezati z uporabniki s celega sveta. Zelo uporabna je tudi spletna stran aplikacije, ki ponuja dodatno izobraževanje s spoznavanjem rastlin po celem svetu. S pomočjo aplikacij je mogoče kvalitetno razvijati tehnike izkustvenega učenja.

KLJUČNE BESEDE

Izobraževalne aplikacije, travniške rastline, izkustveno učenje

ABSTRACT

The article presents the effective use of educational applications for learning about plants and their comparison in terms of their usefulness and effectiveness. The applications have proven to be an excellent way to identify meadow plants and a good aid in dealing with the learning content. The Pl@ntNet application proved to be the best application among those tested. Easy to use, clearly and transparently laid out, stores entered plants and is richly equipped with photos of examples uploaded by users. At the same time, it also offers the names of plants in the Slovenian language with the possibility of entering your own suggestions and corrections. Upon registration, it is possible to connect with users from all over the world. The website of the application is also very useful, offering additional education by learning about plants around the world. With the help of applications, experiential learning techniques can be developed qualitatively.

KEY WORDS

Educational applications, meadow plants, experiential learning

1 UVOD

Digitalna tehnologija je že vrsto let močno vpeta v delo učitelja, uporaba informacijsko-komunikacijske tehnologije (IKT) je postala tudi nepogrešljiv del pouka. Pri mlajših učencih v 1. triletju osnovne šole je vnašanje digitalnih vsebin prisotno v manjši meri kot pri starejših učencih, vendar je kljub temu, da šestletniki še niso vešči uporabe digitalne tehnologije in vsebin le-te, mogoče pri pouku uporabljati IKT. Pri tem je potrebno premišljeno izbirati snov in vsebine, ki jih lahko kvalitetno povežemo z uporabo tovrstne tehnologije.

Pomembno je tudi premišljeno zastaviti celotno obravnavo določene učne snovi in predvideti, v katerem delu obravnavane snovi bodo določene digitalne vsebine najbolj pripomogle k boljšemu razumevanju in najboljši možni zapomnitvi snovi.

Prepletanje digitalnih vsebin s preostalimi načini poučevanja je ob skrbnem načrtovanju lahko odličen način podajanja snovi in doseganja razumevanja naučenega pri učencih. Razvijanje računalniške pismenosti je z razpoložljivo tehnologijo možno v vseh fazah učnega procesa.

Izobraževalne aplikacije so pri delu z učenci eden od učinkovitih in zanimivih načinov uporabe digitalnih vsebin, s pomočjo katerih je lahko kvalitetno posredovano znanje ter dosežen željen nivo razumevanja.

Pri podjetju Lingvist, estonski jezikovni aplikaciji, trdijo, da je v določenih primerih lahko učenje preko matematično optimiziranih aplikacij bolj učinkovito kot klasično učenje v učilnicah. [7]

Aktivno učenje je način, s katerim dosežemo dobre rezultate pri znanju učencev. Učenci se ne naučijo veliko samo s tem, da sedijo v razredih in poslušajo učitelje, si zapomnijo vnaprej pripravljene naloge in podajajo odgovore. O tem, kar se učijo, se morajo pogovarjati, o tem pisati, to povezovati s preteklimi izkušnjami in uporabljati v vsakdanjem življenju. To, česar se naučijo, morajo ponotranjiti. Aktivno učenje se lahko zgodi tudi izven učilnice. [1]

Izkustveno učenje temelji na izkušnjah. To je oblika učenja, ki skuša povezati neposredno izkušnjo, opazovanje, spoznavanje (kognicijo) in ravnanje v neločljivo celoto. Tovrstno učenje se je razmahnilo v zadnjih letih, kot odgovor na pretežno na knjigah in učiteljevi besedi zasnovano učenje, ki razvija predvsem abstraktno simbolično znanje in kot izraz želje po tesnejši povezavi teorije in prakse. S pomočjo tehnologije je tehnike izkustvenega učenja smiselno izvajati tudi v e-izobraževanju.

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2 APLIKACIJE ZA PREPOZNAVO RASTLIN

Prvošolci so si na učnem sprehodu na travniku v času podaljšanega bivanja ogledali različne travniške rastline. Nekaj različnih vrst rastlin so tudi nabrali. S pomočjo različnih aplikacij smo prepoznavali njihova imena. Med vrsto ponujenih aplikacij na spletu so bile uporabljene tri aplikacije: Plantify, iNaturalist in Pl@ntNet.

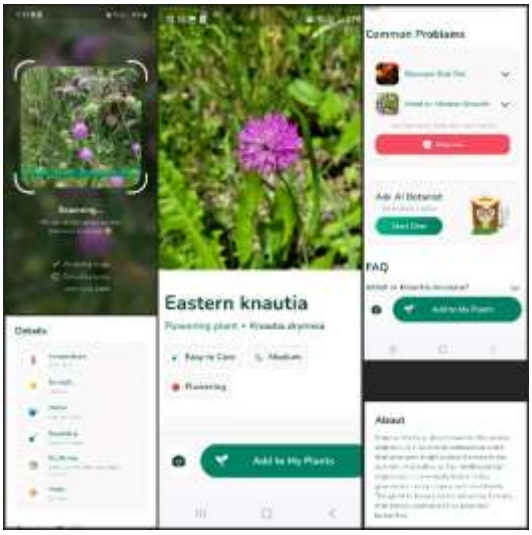
2.1 Plantify

Osnovna ideja podjetja, ki je ustvarilo aplikacijo Plantify, je iskanje načinov za vzpostavljanje stika z naravo.

V svetu, kjer se vse več časa preživi v zaprtih prostorih, je zlahka pozabiti na stik z naravo. Pozablja se, kako pomembna je skrb za rastline, ki nas obdajajo. Kaj pa, če bi se lahko z njimi pogovarjali? Kaj, če bi imeli način komunikacije z rastlinami in vzpostavitev osebne povezave z njimi? To je točno tisto, kar postaja resničnost z novo in inovativno aplikacijo "Plantify". [5]

Aplikacija je edinstven način povezovanja in komuniciranja z rastlinami. Preko aplikacije se je mogoče pogovarjati s sobnimi, vrtnimi, pa tudi divjimi rastlinami. Na vprašanje, kako se počutijo, kaj potrebujejo, se odgovor prikaže v aplikaciji v samo nekaj sekundah. Za izvedbo aplikacija uporablja edinstveno tehnologijo za prevajanje jezika rastlin in jih naredi razumljive ljudem. [5]

Delovanje aplikacije je bilo preizkušeno tudi v praksi. Pri prepoznavi rastlin ni bilo vedno možno natančno določiti vrste rastline. Ponuja samo latinska in angleška imena rastlin. Ne ponuja možnosti popravka določanja vrste rastline v brezplačni različici uporabe, kot je to mogoče pri drugih aplikacijah. Uporabniki, ki želijo aplikacijo izkoristiti za informacije o vzgoji določene sobne ali vrtne rastline, pa jo lahko koristno uporabijo.



Slika 1: Aplikacija Plantify. Lastni vir.

2.2 iNaturalist

iNaturalist pomaga prepoznati rastline in živali, hkrati pa ustvarja podatke za znanost in ohranjanje narave. S snemanjem in deljenjem opažanj uporabniki ustvarjajo podatke raziskovalne kakovosti za znanstvenike, ki si prizadevajo za boljše razumevanje in zaščito narave. [3]

Vizija kreatorjev aplikacije iNaturalist je svet, v katerem lahko vsakdo razume in vzdržuje biotsko raznovrstnost s prakso opazovanja divjih organizmov in izmenjavo informacij o njih. Njihovo poslanstvo je povezati ljudi z naravo ter pospešiti znanost in ohranjanje biotske raznovrstnosti.

iNaturalist.org se je leta 2008 začel kot zadnji magistrski projekt, šest let kasneje je postal pobuda Kalifornijske akademije znanosti in leta 2017 skupna pobuda z National Geographic Society. Lani je iNaturalist postal neodvisna neprofitna organizacija. Na mednarodni ravni sodeluje z več različnimi organizacijami prek mreže iNaturalist, da bi zagotovil lokalizirano izkušnjo skupaj z večjim dosegom in vplivom. [3]

Aplikacija se je izkazala kot uporabna pri prepoznavi travniških rastlin. Za bolj natančno poimenovanje rastlin je ravno tako potrebna registracija, ob prijavi pa lahko za rastline, ki jih ne prepoznamo, le-te poimenujejo drugi uporabniki, ki določeno rastlino prepoznajo in s tem širijo mrežo znanja in izpopolnjujejo virtualno knjižnico rastlin s celega sveta.

Slika 2: Aplikacija iNaturalist. Lastni vir.

2.3 Pl@ntNet

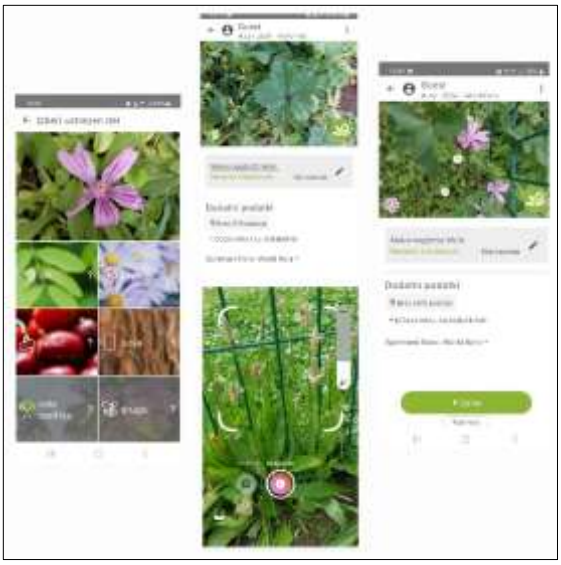
Pl@ntNet je platforma za znanost, ki uporablja umetno inteligenco (AI) za lažjo identifikacijo in popis rastlinskih vrst. Je eden največjih svetovnih observatorijev biotske raznovrstnosti z več milijoni sodelavcev v več kot 200 državah. [6]

Omogoča prepoznavanje več deset tisoč rastlinskih vrst. Najbolj usposobljeni s prispevki in pregledovanjem opazovanj prispevajo največ strokovnega znanja, povprečni poznavalci pa to znanje pridobijo z uporabo aplikacije Pl@ntNet. Pl@ntNet je zaradi aktivnih uporabnikov zbral že več kot milijardo slik rastlin.

Aplikacija je učinkovito orodje za prepoznavanje rastlin s pomočjo fotografij. Organizirana je po različnih tematskih in geografskih florah. Na seznamu je mogoče izbrati tisto, ki ustreza uporabnikovi regiji ali območju zanimanja. Če uporabnik ne ve, kaj izbrati, izbere "Svetovna Flora", ki ima najširšo pokritost, vendar bo dobil manj natančne rezultate kot z bolj natančno določeno lokacijo. [6]

Uporaba aplikacije je bila zelo pozitivna, saj je enostavna za prepoznavanje rastlin in ponuja širok spekter rastlinskih vrst in dodatno nadgradnjo znanja z vsebinami, povezanimi z rastlinami. Uporabljena je bila na začetku obravnave učne snovi,

kot tudi v nadaljevanju. Učencem se je zdela zanimiva, bili so dodatno motivirali za iskanje rastlin, njihovo spoznavanje in uporabnost.



Slika 3: Aplikacija Pl@ntNet. Lastni vir.

Slika 4: Aplikacija Pl@ntNet. Lastni vir.

3 AKTIVNOSTI

V nadaljevanju je sledilo spoznavanje rastlin na spletni strani Pl@ntNet. Na zemljevidu sveta so si učenci lahko ogledali, kje vse določena rastlinska vrsta uspeva. Izbrali so si tudi določeno državo in z navdušenjem spoznavali, kakšne rastline tam rastejo. Zanimivo je bilo ugotavljati, ali kakšna travniška rastlina uspeva tudi zelo daleč stran od Slovenije. Ugotovili so na primer, da navadni rman raste celo na nekaterih območjih Sibirije.

Na spletu so si ogledali Digitalni herbarij, ki ga je ustvarila slovenska ljubiteljica narave in fotografije in primerjali nabrane rastline ter si prebrali, kakšne lastnosti imajo.

Nabrane rastline so učenci zložili med časopisni papir, kasneje pa z nekaj pomoči ustvarili »Herbarij travniških rastlin«.

Slika 5: Izdelava herbarija. Lastni vir.

Igrali so se tudi igro »spomin«, na kateri so bile fotografije rastlin in njihova imena. Pri nastajanju igre so sodelovali tudi učenci. Z vsemi aktivnostmi in igrami, vključenimi v učni proces, so učenci zelo dobro sledili vsebini in si dobro zapomnili rastline, zanimala jih je tudi njihova uporabnost, zato so v knjigah in na spletu ob pomoči in dodatnih napotkih poiskali tudi te podatke.

Slika 6: Značilnosti rastlin. Lastni vir.

S pomočjo naučenega je sledilo ustvarjanje – slikanje travnika in izdelava slik iz posušenih travniških rastlin. Ustvarjene slike travnika so krasile učilnico do konca šolskega leta, uokvirjene slike s posvetilom pa so učenci podarili učiteljem ob koncu šolskega leta.

Poleg izvedenih dejavnosti je možnosti za aktivno učenje in poustvarjanje zelo veliko. Izbira didaktičnih iger in načina vključevanja aktivnega sodelovanja učencev je odvisna tudi od starosti učencev, saj je mogoče s skupinami starejših učencev učenje še bolj prenesti na učečega. Ravno tako je mogoče že izbrane dejavnosti in igre nadgraditi in prilagoditi starostni stopnji.

Slika 7: Poustvarjanje in izdelava slik. Lastni vir.

4 ZAKLJUČEK

Kljub starosti učencev, omejitvam zaradi začetnega opismenjevanja ter nepoznavanju digitalne tehnologije so učenci lahko sledili uporabi le-te, vsi deležniki uporabljene tehnologije so pripomogli k boljšemu razumevanju naučenega ter boljšemu pomnjenju snovi. Uporabljene izobraževalne aplikacije in druga digitalna tehnologija se je izkazala kot učinkovito učno orodje, ki odpira kritično razmišljanje, hkrati pa motivira in omogoča boljšo zapomnitev.

Predstavljen način spoznavanja novih vsebin se je izkazal kot zelo spodbuden in učinkovit, kar se je kazalo pri njihovi motivaciji, napredku in navdušenju za delo.

Izkustveno učenje povezuje teoretični in praktični del ter omogoča učinkovitejše dojemanje in spoznavanje snovi, učenci pa so v tem procesu v aktivni vlogi. Obenem učenci razvijajo tudi veščine komunikacije, sodelovanja, poslušanja. Ta način poučevanja zajema izkušnje, opazovanje, spoznavanje pojmov in uporabo znanja v novih situacijah. K temu zelo pripomore tudi telesno gibanje, uporaba pantomime, »brainstorming«, opazovanje, delo na terenu, različne didaktične naloge in igre.

Digitalno opismenjevanje je skozi igro mogoče v vseh fazah učenja. Uporaba IKT je lahko dobra motivacija skozi celoten učni proces, saj učenci radi posegajo po elektronskih napravah in lahko to s pridom izkoristimo za pritegnitev pozornosti za učenje novih vsebin pri pouku.

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Uporaba informacijsko komunikacijske tehnologije pri poučevanju slepih in slabovidnih otrok, mladostnikov ter izzivi, ki nastajajo pri tem

The Use of Information and Communication Technology in the Teaching of Blind and Partially Sighted Children and Adolescents and the Challenges that Arise in This

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POVZETEK

IKT oprema ima pri poučevanju slepih in slabovidnih otrok zelo velik pomen, saj se v današnjem času brez nje poučevanja teh otrok ne da izpeljati. Uporaba računalnikov, prenosnih računalnikov, brajevih zaslonov oziroma vrstic, raznih elektronskih lup in drugih elektronskih lup je nujna za učinkovito pedagoško delo in za napredek otrok s primanjkljaji vida. Ker imajo sodobni računalniki vse manj USB priključkov in ker je težava pri shranjevanju podatkov in zapiskov na te medije, smo se lotili reševanja tega izziva. V prispevku predstavljamo opremo, ki se uporablja pri poučevanju slepih in slabovidnih otrok in rešitev za shranjevanje podatkov in zapiskov, ki jo bodo uporabljali učenci pri pouku.

KLJUČNE BESEDE

IKT oprema, slepi in slabovidni ortoci, brajev zaslon, elektronska lupa, intune, oblačne storitve

ABSTRACT

ICT equipment plays a very important role in teaching blind and partially sighted children, because nowadays it is impossible to teach these children without it. The use of computers, laptops, braille displays, various electronic magnifiers and other electronic magnifiers is necessary for effective pedagogical work and for the progress of children with visual impairments. Since modern computers have less and less USB ports and because it is a problem to save data and notes on these media, we set out to solve this challenge. In this article, we present the equipment used in teaching blind and partially sighted children and the solution for storing data and notes, which will be used by students during lessons.

KEYWORDS

ICT equipment, blind and visually impaired individuals, Braille display, electronic magnifier, Intune, cloud services

1 IKT V ŠOLAH

Uporaba IKT opreme pri poučevanju je v slovenskem šolstvu, predvsem kar se tiče učiteljev, kar dobro uveljavljena na vseh ravneh izobraževanja. Veliko manj jo uporabljajo učenci v samem učnem procesu. Pri učencih, ki so slabovidni ali celo slepi pa je IKT oprema ključnega pomena pri njihovem izobraževanju tako v vrtcu, osnovni šoli, srednji šoli in naprej na fakulteti. V današnjem času si namreč ne moremo predstavljati, da otroci s primanjkljaji vida ne bi uporabljali prilagojenega tabličnega računalnika, prenosnega računalnika s posebno programsko opremo, raznih elektronskih lup za povečavo in izbiro kontrasta in pa seveda elektronskih brajevih vrstic.

2 TABLIČNI RAČUNALNIKI S TAKTILNO MREŽO

Slepi otroci, pa tudi otroci, ki so slabovidni in imajo diagnozo poslabšanja vida že v vrtcu, uporabljajo tablične računalnike, ki so nadgrajeni s posebno taktilno mrežo, ki uporabniku omogoči, da začuti kar je na zaslonu. To je predvsem uporabno v vrtcu, kjer imajo slepega otroka, saj lahko na ta način sam igra različne igre (npr. spomin), ki jih drugače ne bi mogel igrati oziroma bi jih lahko igral samo v primeru, da bi imeli za to prilagojene igrače. Na tabličnih računalnikih s taktilno mrežo je tudi veliko aplikacij, ki so prilagojene za slepe otroke. Otroci s tem vadijo svoje zaznavne sposobnosti, ki jih bodo v življenju še kako rabili. Tablica s taktilno mrežo je prav tako v veliko pomoč pri slepih otrocih, ki obiskujejo prvi razred osnovne šole, saj se na njih lahko učijo brajeve pisave.

3 PROGRAMI ZA PREVAJANJE BESEDILA V BRAILLOVO PISAVO

Pri slepih in slabovidnih otrocih z diagnozo poslabšanja vida že v prvi triadi osnovne šole začnejo z uporabo računalnika (stacionarnega ali prenosnega), ki ima prilagojeno programsko opremo za vsakega uporabnika posebej. Pri slepih je v prvi vrsti računalnik z operacijskim sistemom Windows v slovenskem jeziku, programska oprema JAWS (plačljiva programska

oprema), ki prevaja besedilo na zaslonu in tudi opise slik v brajevo pisavo. Potrebno je prilagoditi različne nastavitve, da lahko učenci poslušajo kaj je na zaslonu. V ta namen se lahko uporablja eBralec, ki je prilagojen za slovenski jezik, ali v zadnjem času tudi kar Windows govorec.

Slika1: Tablični računalnik s taktilno mrežo Feelife pro

Slika 2: Program JAWS

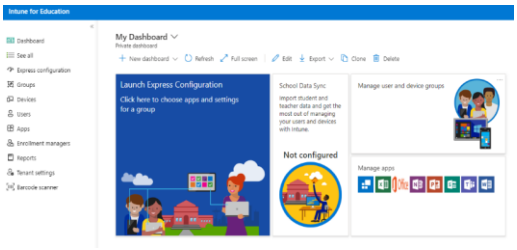
V slovenskih šolah se za predvajanje besedila na elektronsko brajevo vrstico uporablja program JAWS, ki je zelo drag, vendar omogoča prikaz vseh znakov in funkcij, ki se uporabljajo pri poučevanju. Obstaja tudi odprtokodna različica te rešitve, imenovana NVDA, ki je prevedena tudi v slovenščino. Ima pa ta program določene pomanjkljivosti. Prav zaradi tega so se na Zvezi slepih in slabovidnih Slovenije odločili, da se v šolstvu raje uporablja plačljiv program.

Slika3: Brajev zaslon oz vrstica

4 TEŽAVE S SHRANJEVANJEM PODATKOV

Pri uporabi računalnika s prilagojeno opremo v šoli pa se srečujemo z velikimi težavami pri shranjevanju podatkov oziroma vsebin, zapiskov, ki jih slepi in slabovidni učenci vnašajo v računalnik.

Na Centru IRIS, kjer izvajamo prilagojene izobraževalne programe za slepe in slabovidne od vrtca do srednje šole, smo do pred kratkim uporabljali USB ključke, na katere so si učenci shranjevali datoteke, mape itd., ki so jih potrebovali ali ustvarili pri pouku. Ker so se ključki izgubljali, kvarili, poleg tega pa je prihajalo tudi do poškodovanja USB vtičev na računalniku, smo pred dobrim letom in pol začeli razmišljati kako bi zadevo rešili. V ta namen smo za učence pridobili in jim dodelili Microsoft Office 365 licence A3, njihove računalnike povezali z njihovim Office365 računom ali enostavno dodali napravo v Intune. Otroke smo naučili kako se prijaviti v računalnik z Intunom, kako se prijaviti v spletno različico Office365 in kako le tega uporabljati. Na računalniku smo nastavili avtomatsko shranjevanje. Tako je odpadlo dodatno shranjevanje na zunanje medije, saj se vse, kar je narejeno s pomočjo programov, ki se nahajajo v okviru Microsoft Office avtomatsko shranjuje v oblak. Pri slepih in tudi slabovidnih učencih pride v poštev predvsem Microsoft Word, saj si med poukom pišejo na računalnik zapiske iz katerih se nato s pomočjo brajeve vrstice (slepi učenci) tudi učijo. Seveda je predpogoj uporabe tega, da se učenci naučijo uporabljati računalnik, da se znajdejo v okolju Windows, da poznajo ukaze za premikanje med mapami oziroma poznajo delo na računalniku brez miške in nenazadnje da se naučijo slepega tipkanja. Pri učencih, ki so slepi in nimajo pridruženih motenj, slepo tipkanje ne predstavlja neke velike težave, saj imajo razvite druge čute. Več težav je s slabovidnimi, ki se težje navadijo na tipkanje, predvsem v takih primerih, kjer so še kot otroci bolje videli, sedaj pa se jim vid slabša.



Slika 4: zaslonska slika Intune

Center IRIS je kot center za slepe in slabovidne otroke pristojen tudi za posojanje opreme za slepe in slabovidne otroke, ki se šolajo v šolah v domačem kraju. Oprema se posodi šoli in ne otroku, tako da imajo to opremo učenci v šolah in jo praviloma ne nosijo domov. V teh primerih mi kot center ne moremo dodeliti licenc Office 365 otrokom, saj je za to pristojna matična šola. V večini primerov se v teh šolah še vedno za shranjevanje uporabljajo USB ključki, ki se prenašajo iz šole domov in obratno. Ko se pripravi oprema za šolo, se namesti na prenosni računalnik ali program JAWS za slepe ali ZoomText za slabovidne učence. Uporabnikom se pusti administrativne pravice, da lahko njihovi računalnikarji naložijo določene programe, če bi se jih potrebovalo za delo v šoli.

Praksa je pokazala, da računalnikarji na matičnih šolah ne naredijo na teh računalnikih kaj več kot naložijo kak program, zato jih poskušamo preko naših mobilnih učiteljev vzpodbujati, da se lotijo tudi oblačnega shranjevanja podatkov. Dogaja se namreč, da se veliko opreme polomi (predvsem USB priključki), ki so vezani na matično ploščo, njihova zamenjava pa je draga oziroma v določenih primerih, ko je polomljeno več USB priključkov, tudi nesmiselna. USB priključki se namreč pri delu uporabljajo predvsem za povezavo prenosnega računalnika z brajevo vrstico in po navadi še za brezžično miško, ki je v pomoč spremljevalcu slepega učenca.

5 OPREMA ZA SLABOVIDNE

Pri slabovidnih otrocih pa se poleg računalnika z ustrezno programsko opremo uporablja tudi elektronska lupa, ki učencu omogoča, da prebere vsebino iz zvezka sošolcev, knjige ali table. Ker je slabovidnosti več vrst je pomembno, da taki učenci čimprej dobijo elektronsko lupo. Na elektronski lupi se nato nastavi kontrast, barva in druge specifike, ki učencem omogočajo, da lahko sledijo pouku.

Slika 5: Elektronska lupa

6 ZAKLJUČEK

IKT oprema na vseh ravneh pomaga ljudem s pomanjkljivostjo vida. Izkazalo se je, da so pri uporabi IKT opreme zelo dobrodošle oblačne storitve, saj slepim in slabovidnim učencem prihranijo marsikatero nevšečnost. Še vedno pa je zelo pomembno sočasno z učenjem o različnih predmetih učiti tudi, da je potrebno pomagati sočloveku, še posebej ranljivim skupinam, kar slepi in slabovidni so. Vedno se pojavijo kakšne težave, ki jih slepi učenci ne morejo rešiti sami. Takrat je res zelo pomembno, da so na voljo ali spremljevalci ali sošolci, ki pomagajo učencem pri reševanju težav.

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Izdelava videoposnetkov za lažje utrjevanje slovničnih struktur v tujem jeziku

The Use of Self-Recorded Videos to Facilitate Grammar Learning in an EAL classroom

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POVZETEK

Cilj sodobnega izobraževanja ni le prenos informacij, temveč tudi vzbujanje zanimanja in angažiranosti učencev in učenk, kar je pogosto težje dosegljivo pri učenju in utrjevanju slovničnih struktur v tujem jeziku. Uporaba inovativnih metod kot so snemanje videoposnetkov lahko ta proces naredi bolj dinamičen brez da bi ogrozil njegovo kvaliteto. Članek predstavlja, kako lahko projekt snemanja videoposnetkov med poukom pripomore k celostnem razvoju dijakov in dijakinj. Obravnava prednosti snemanja videoposnetkov kot metodo učenja pri pouku tujega jezika in na praktičnem primeru iz razreda prikazuje, kako lahko pripomore k nadgradnji jezikovnih spretnosti, večji motivaciji in angažiranosti ter razvoju digitalnih spretnosti. Prav tako na kratko predstavi in evalvira različna orodja za samostojno snemanje in montažo.

KLJUČNE BESEDE

Angleščina kot tuj jezik, učenje slovnice, videoposnetki, projektno delo

ABSTRACT

The aim of modern education is not only to transmit information, but also to arouse the interest and improve the engagement of students. This can be difficult to achieve when acquiring or consolidating grammatical structures in a foreign language. Using innovative methods such as recording videos can make this process more dynamic without compromising its quality. This article represents how self-recorded videos can contribute to the overall students' development. Furthermore, it discusses the benefits of video recording as a learning method in an EAL classroom. It uses a practical example to portray how it can help to improve language skills, increase motivation, and participation. Moreover, it briefly introduces and evaluates different tools for self-recording and editing.

KEYWORDS

EAL, grammar learning, self-recorded videos, project-based work

1 UVOD

Učitelji in učiteljice tujih jezikov se nemalokrat srečujemo z dilemo, kako oplemenititi pogosto monotono učenje in utrjevanje slovničnih struktur in ga nadgraditi na način, da je zanimivo, a vseeno učinkovito. Rešitev je iskanje metod, ki spodbujajo aktivno sodelovanje in praktično uporabo jezika. Ena izmed njih je zagotovo snemanje videoposnetkov, ki jih ustvarjajo učenci in učenke samostojno. Predstavljeni projekt snemanja potopisov osmišlja učenje slovnične strukture trpnika in združuje več področij povezanih s pisnim in ustnim izražanjem v tujem jeziku ter rabo tehnologije za snemanje in montiranje posnetkov.

2 RABA VIDEOPOSNETKOV KOT METODA UČENJA PRI POUKU TUJEGA JEZIKA

Raba videoposnetkov pri pouku ni nič novega. Učitelji in učiteljice pogosto v pouk vključijo informativni video z namenom poglobitve znanja in popestritve pouka. Tovrstna raba videoposnetkov postavlja dijake in dijakinje v pasiven položaj, saj se od njih večinoma pričakuje pasivno sprejemanje informacij ali urjenje slušnih spretnosti. Zaradi tega učenje na tak način ni vedno tako efektivno kot bi si želeli in posledično spravlja rabo videoposnetkov med poukom na slab glas.

Drugače je z videoposnetki, ki jih ustvarijo dijaki in dijakinje. Pri pouku tujega jezika si prizadevamo, da so aktivno udeleženi v učni proces, kar od njih zahteva aktivno produkcijo jezika. S projekti, kot je snemanje lastnih videoposnetkov, jim omogočimo prav to in raziskave kažejo, da je učenje bolj učinkovito, če so neposredno vključeni v proces ustvarjanja videoposnetka. [1]

Lepota takšnih projektov je njihova vsestranskost in zmožnost, da jih lahko navežemo na praktično katerokoli tematsko enoto in slovnično strukturo. Dijakom in dijakinjam omogoča, da urijo svoje jezikovne spretnosti na kreativen in kontekstualiziran način, zaradi česar so dokazano bolj motivirani za učenje. [2] Pri pisanju scenarija urijo svoje pisne spretnosti in rabo slovničnih struktur, medtem ko pri snemanju vadijo govorno izražanje, s poudarkom na intonaciji in naglaševanju. S

tem ko večkrat poslušajo lasten govor ali govor sošolca oz. sošolke, lahko kritično ovrednotijo svoje govorne spretnosti [3], kar prispeva k boljši ozaveščenosti tujega jezika in njegovi rabi. Na ta način nadgrajujejo tako pisno kot tudi ustno izražanje v ciljnem jeziku.

Kljub temu, da je primarni cilj te dejavnosti nadgradnja jezikovnega izražanja, ponuja tak projekt še veliko več, saj obenem urijo svoje veščine uporabe tehnologije za snemanje, obdelavo in montažo videoposnetkov in se spoznavajo s principi dobrega snemanja (kadri, svetloba, zvok ipd.) ter reševanje morebitnih tehničnih težav v vseh fazah projektnega dela. Prav tako na različne načine razvijajo lastno ustvarjalnost na več področjih. [4] Pri pisanju scenarija krepijo zmožnosti kreativnega pisanja, pri čemer morajo upoštevati, da mora biti sporočilo jasno, informativno, zanimivo in predstavljeno v omejenem času. Enako morajo ubrati kreativen pristop pri vizualni zasnovi kadrov, tempa in prehodov tako med snemanjem kot tudi montažo.

Obenem razvijajo spretnosti sodelovanja in dela v skupini. [4] Predvsem sodelujejo pri pisanju scenarija in montaži, kar od njih zahteva učinkovito komunikacijo, delitev dela in usklajevanje različnih mnenj. Poleg tega morajo reševati potencialne konflikte in sprejemati skupne odločitve glede končnega izdelka.

Vse to dokazuje, da gre za večplasten in kompleksen projekt, ki združuje različne veščine tako na jezikovnem kot digitalnem področju.

3 IZVEDBA PROJEKTA SNEMANJE POTOPISA

3.1 Določitev teme in navodila

Projekt snemanja potopisov smo izvedli z dijaki in dijakinjami 2. letnika programa umetniška gimnazija ob zaključku 8. učne enote, ki se je osredotočala na temo in besedišče potovanj ter slovnično strukturo trpnika. Projekt je kulminacija njihovega znanja, kreativnosti in jezikovnih spretnosti, saj so morali uporabiti novo besedišče in naučeno slovnico v praktičnem in ustvarjalnem kontekstu.

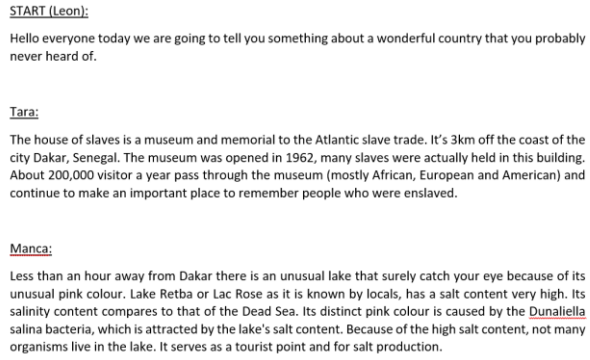
Skupine so izbirale med obstoječimi destinacijami (npr. Senegal), dovoljeno pa jim je bilo ustvariti tudi potopis o izmišljeni destinaciji. Tako so nekatere skupine izbrale fantazijske destinacije, kot so npr. Atlantida, dežela Smrkcev ali pa ustvarile povsem svojo.

Projekt je potekal v več fazah: pisanje scenarija, pregled in popravljanje scenarija, snemanje, montaža in predstavitev.

3.2 Pisanje scenarija

V skladu z navodili so morali pripraviti scenarij, ki je za vsakega posameznika oz. posameznico vključeval vsaj minuto govora. Prav tako so morali napisati uvod in zaključek. Besedilo je moralo vsebovati trpnik v različnih časih in čim več različnih ostalih slovničnih struktur. Vsaka oseba je morala predstaviti eno od zanimivosti izbrane destinacije. Ker je šlo za potopis, so pisali v prvi osebi.

Pisanju scenarija smo namenili eno šolsko uro, lahko pa so ga izpopolnili tudi doma.



START (Leon):

Hello everyone today we are going to tell you something about a wonderful country that you probably never heard of.

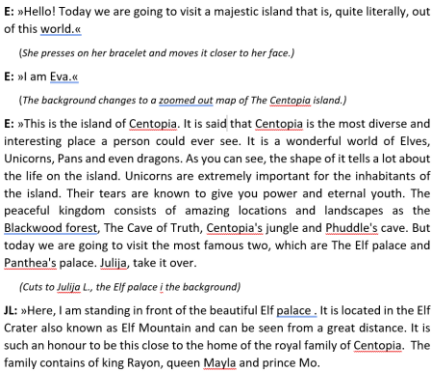
Tara:

The house of slaves is a museum and memorial to the Atlantic slave trade. It's 3km off the coast of the city Dakar, Senegal. The museum was opened in 1962, many slaves were actually held in this building. About 200,000 visitor a year pass through the museum (mostly African, European and American) and continue to make an important place to remember people who were enslaved.

Manca:

Less than an hour away from Dakar there is an unusual lake that surely catch your eye because of its unusual pink colour. Lake Retba or Lac Rose as it is known by locals, has a salt content very high. Its salinity content compares to that of the Dead Sea. Its distinct pink colour is caused by the Dunaliella salina bacteria, which is attracted by the lake's salt content. Because of the high salt content, not many organisms live in the lake. It serves as a tourist point and for salt production.

Slika 1: Del scenarija o Senegalu (VIR: lasten, zajem zaslonske slike)



E: »Hello! Today we are going to visit a majestic island that is, quite literally, out of this world.«

(She presses on her bracelet and moves it closer to her face.)

E: »I am Eva.«

(The background changes to a zoomed out map of The Centopia island.)

E: »This is the island of Centopia. It is said that Centopia is the most diverse and interesting place a person could ever see. It is a wonderful world of Elves, Unicorns, Pans and even dragons. As you can see, the shape of it tells a lot about the life on the island. Unicorns are extremely important for the inhabitants of the island. Their tears are known to give you power and eternal youth. The peaceful kingdom consists of amazing locations and landscapes as the Blackwood forest, The Cave of Truth, Centopia's jungle and Phuddle's cave. But today we are going to visit the most famous two, which are The Elf palace and Panthea's palace. Julija, take it over.

(Cuts to Julija L., the Elf palace i the background)

JL: »Here, I am standing in front of the beautiful Elf palace . It is located in the Elf Crater also known as Elf Mountain and can be seen from a great distance. It is such an honour to be this close to the home of the royal family of Centopia. The family contains of king Rayon, queen Mayla and prince Mo.

Slika 2: Del scenarija o izmišljeni deželi Centopia (VIR: lasten, zajem zaslonske slike)

3.3 Pregled in popravljanje scenarija

Že med samim pisanjem so dijaki in dijakinje med sabo sodelovali ter popravili napake in na podlagi medsebojne povratne informacije nadgradili vsebino. Prav tako je vsaka skupina dobila še mojo pisno povratno informacijo na podlagi katere so svoje scenarije izpopolnili. Sama sem se predvsem osredotočala na primerno rabo slovničnih struktur in edinstvenost napisanega. V primeru plagiatorstva so bili sestavki zavrnjeni.

3.4 Snemanje

Skupine so zavoljo večjega miru, svobode in časa potopise snemale po šoli v prostem času. Rok za oddajo končnega izdelka je bil dva tedna, kar jim je omogočilo dovolj časa za snemanje in montažo videoposnetkov.

Glede na to, da so v projekt bili udeleženi dijaki in dijakinje umetniške gimnazije, smer gledališče in film, večjih težav s snemanjem ni bilo, saj so dovolj znanja pridobili pri pouku praktičnih predmetov. Snemanja so se lotili na različne načine, in sicer: snemanje s fotoaparati, ki so si jih lahko izposodili v šoli, s pametnimi telefoni, s kamerami na prenosnih računalnikih preko ZOOMa.

3.4.1 Snemanje s pametnimi telefoni

Pametni telefon je vsekakor najenostavnejši za snemanje videoposnetkov, saj omogoča enostavno snemanje na različnih lokacijah. Dijaki in dijakinje so zaradi osebne rabe izkušeni v

njegovi uporabi, kar omogoča hitro in učinkovito snemanje brez dodatnega usposabljanja. Prav tako trenutni pametni telefoni zagotavljajo zadovoljivo kakovost slike. Vsekakor pa obstajajo različne pomanjkljivosti, kot so pomanjkanje stabilnosti pri snemanju, slabša kakovost zvoka in pomanjkanje naprednih snemalnih nastavitev (osvetlitev, ostrina ipd.)

3.4.2 Snemanje s kamerami na prenosnih računalnikih preko ZOOMa

Zaradi koronavirusne pandemije je ZOOM dijakom in dijakinjam dobro poznan, zato je dobra izbira za snemanje videoposnetkov. Njegova velika prednost je možnost sodelovanja več oseb na daljavo in razne vgrajene funkcije. Pri snemanju potopisov se je še za posebej uporabno funkcijo izkazala možnost dodajanja virtualnih ozadij, kar je dijakom in dijakinjam omogočalo, da z izbiro primernega ozadja ustvarijo iluzijo, kot da so dejansko prisotni na izbrani destinaciji. Ker pa je ZOOM vezan na internetno povezavo, se lahko zgodi, da je kakovost slike in zvoka slabša, saj je odvisna od pasovne širine in kompresije pri prenosu podatkov. Tu veliko vlogo igra tudi kvaliteta kamere na prenosnem računalniku.

3.4.3 Snemanje s fotoaparatom ali kamero

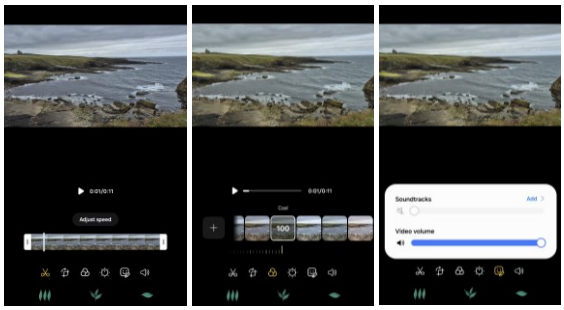
Snemanje s fotoaparatom ali kamero vsekakor zagotavlja visoko kakovost slike in zvoka ter ponuja večji spekter naprednih funkcij, a zaradi svoje cene niso vsakomur dostopni. Prav tako raba fotoaparata terja več znanja in izkušenj ter morebitno dodatno opremo (stojala, mikrofoni, luči).

3.5 Montaža in produkcija videa

Po snemanju so skupine prešle na fazo montaže. Proces je vključeval izbiro najboljših posnetkov, primernega zaporedja, urejanje zvoka in morebitno dodajanje ostalih grafik. Dijaki in dijakinje so uporabile različne programe za montažo, od najbolj enostavnih (privzeti urejevalnik na telefonu ali prenosnem računalniku, TikTok ipd.) do bolj zahtevnih (Adobe).

3.5.1 Montaža s privzetim urejevalnikom na telefonu

Tudi v tej fazi se je pametni telefon dobro izkazal, saj že njihovi privzeti urejevalniki dopuščajo brezplačno, hitro in preprosto montažo brez potrebe internetne povezave ali kakršnekoli druge opreme. A pogosto ponujajo zgolj osnovne funkcije z omejeno kakovostjo, kar lahko vpliva na kvaliteto končnega izdelka.



Slika 3: Privzeti urejevalnik na pametnem telefonu Samsung (VIR: lasten)

3.5.2 Montaža s TikTok-om

V nasprotju s privzetim urejevalnikom TikTok ponuja velik spekter raznih vizualnih učinkov, ki lahko posnetek naredijo privlačnejši. Njegova enostavna in intuitivna uporaba s številnimi predlogami omogoča hitro ustvarjanje dinamičnih videov brez posebnega znanja montaže. Uporabniki in uporabnice lahko dodajo tudi glasbeno podlago ali zvočne učinke. TikTok je predvsem primeren za kratke in nezahtevne videe z omejeno kakovostjo slike.

Slika 4: Uporabniški vmesnik TikToka za obdelavo videov (VIR: https://p16-va-tiktok.ibyteimg.com/obj/musically-maliva-obj/226f6a7aa05db59c0030aa434d2623ec.png)

3.5.3 Montaža z naprednimi orodji

Profesionalna orodja kot so Adobe Premiere Pro ali DaVinci Resolve ponujajo široko paleto funkcij za obdelavo videa na visoki ravni in dopuščajo urejanje videoposnetkov visoke kakovosti. Prav tako podpirajo različne formate in dolžine videoposnetkov. Zaradi svoje kompleksnosti zahteva več znanja, še posebej za uporabo naprednih funkcij. V nasprotju s prej omenjenima možnostma, napredni programi običajno niso v celoti brezplačni in zahtevajo zmogljivo računalnik in veliko prostora za shranjevanje podatkov. Delo s takšnimi programi je primerno za tiste z več znanja in interesa za tovrstno področje.

Slika 5: DaVinci Resolve (VIR: https://www.newsshooter.com/wp-content/uploads/2023/04/DaVinci-Resolve-18-Edit-2-740x410.jpg)

3.6 Predstavitev potopisov

Ko so bili potopisi pripravljeni, smo eno šolsko uro namenili predstavitvi in ogledu njihovih zaključnih izdelkov. Potopisi so bili odlično sprejeti, dijaki in dijakinje so bili navdušeni in zadovoljni, da so se lahko učili na tak način.

Slika 6: Primer potopisa o Finski (VIR: lasten, zajem zaslona)

Slika 7: Primer potopisa o Senegalu (VIR: lasten, zajem zaslona)

Slika 8: Primer potopisa o Senegalu (VIR: lasten, zajem zaslona)

4 ZAKLJUČEK

Vključevanje videoposnetkov, ki jih ustvarijo dijaki in dijakinje, v učni proces pouka tujega jezika ima številne prednosti. Ne samo, da so dijaki in dijakinje aktivno vključeni v nadgrajevanje svojega znanja in posledično izboljšajo svoje pisne, slušne in jezikovne spretnosti v angleščini, temveč tudi razvijajo svoje digitalne spretnosti in krepijo lastno ustvarjalnost ter zmožnosti timskega dela. Tak pristop k učenju jim dopušča veliko svobode, zaradi česar so bolj motivirani in angažirani. Obenem jim tudi omogoča, da urijo ciljne slovnične strukture v angleščini na zanimiv in kontekstno bogat način. Vsekakor je velika prednost, če dijaki in dijakinje že znajo uporabljati opremo za snemanje in montiranje videoposnetkov, vendar lahko tudi tisti brez predhodnih veščin s pomočjo natančnih navodil usvojijo nove veščine. Uporabljajo lahko različna orodja in programe, ki so prilagojeni njihovi stopnji znanja in izkušenj na tem področju. Kljub temu, da gre za večplastni projekt, ki vključuje različne veščine, je potrebno zagotoviti, da je primarni cilj (tj. urjenje določenih jezikovnih spretnosti) dosežen in se ne izgubi v številnih drugih aspektih projekta.

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Izpopolnjevanje jezikovnih in digitalnih veščin s projektnim delom: Ustvarjanje razrednega tabloida s platformo Canva

Honing Language and Digital Skills through Project-based Learning: Creating a Class Tabloid with Canva

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POVZETEK

V čedalje bolj razvijajočem svetu je pomembno, da v pouk premišljeno vključimo inovativne pristope in uporabna orodja, s katerimi dijaki in dijakinje razvijajo ključne veščine za prihodnost. Sem spada tudi spretna uporaba sodobnih tehnologij, ki posameznikom in posameznicam pomagajo pri vsakodnevnih izzivih. V prispevku bom predstavila ključne prednosti učenja s projektnim delom, spletno platformo Canva in njene odlike ter praktičen primer, kako lahko združimo učenje tujega jezika in digitalnih spretnosti z implementacijo prej omenjene spletne platforme za grafično oblikovanje.

KLJUČNE BESEDE

Projektno delo, angleščina kot tuj jezik, pisne spretnosti, Canva, grafično oblikovanje

ABSTRACT

In an increasingly evolving world, it is imperative to thoughtfully integrate innovative approaches and useful tools into the classroom to assist students develop key skills for the future. This encompasses the skilful use of modern technologies to help individuals meet everyday challenges. This paper presents the key benefits of project-based learning, the Canva online platform and its strengths, along with a practical example of how to combine learning a foreign language with acquiring digital skills through the use of the aforementioned online graphic design platform.

KEYWORDS

Project-based learning, EAL, writing skills, Canva, graphic design

1 UVOD

Pisno izražanje v tujem jeziku predstavlja svojevrsten izziv za učence in učenke, ne glede na to, da se učijo angleščine že od osnovne šole dalje. [1] Zato je še toliko bolj pomembno, da jim omogočimo ustrezne aktivnosti, ki spodbujajo razvoj njihovih jezikovnih spretnosti v ustreznem avtentičnem kontekstu. Eno izmed orodij je vsekakor projektno delo, ki zaobjema širok spekter področij in kompetenc ter dopušča, da dijaki in dijakinje uporabijo svoje praktično znanje v realnih situacijah. S projektom izdelave razrednega tabloida preko platforme Canva, sem poskusila povezati dve področji, ki sta izredno pomembni v današnjem svetu: pisno izražanje v tujem jeziku in digitalne spretnosti.

2 UČENJE S PROJEKTNIM DELOM

Učenje s projektnim delom (*ang. Project-based learning*) je multidimenzonalen pristop k usvajanju znanja tujega jezika, ki vključuje aktivno raziskovanje in reševanje kompleksnih izzivov, obenem pa udeležencem in udeleženkam omogoča, da poglobijo svoje jezikovne veščine in jih uporabijo v praktičnem kontekstu. Poleg tega je idealna priložnost za povezovanje različnih spretnosti in področij, v našem primeru področja angleščine in grafičnega oblikovanja.

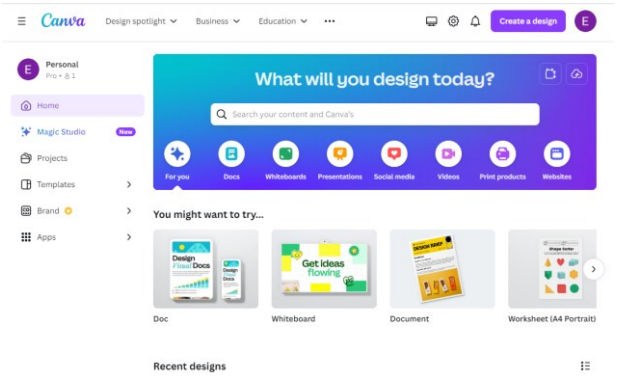
Projektno delo je pogosto premalo uporabljeno, saj je pogosto po krivici razumljeno kot zgolj priložnost za razvedrilo ali premor od vsakodnevne razredne rutine. Posledično se učenci in učenke predvsem ukvarjajo z vizualno privlačnostjo svojih projektov in pri tem zanemarijo razvoj svojih jezikovnih spretnosti. A, če je projekt načrtovan premišljeno, ima neverjeten potencial za razvoj jezikovnih veščin, vsebinskega znanja, metakognitivne zavesti, kritičnega mišljenja in socialnih spretnosti. [2] Poleg tega narava tovrstnega pristopa zahteva, da učenci in učenke prevzamejo odgovornost za svoje učenje in sodelujejo z drugimi, s čimer izboljšajo svoje spretnosti raziskovanja in reševanja problemov. [3]

Ker projektno delo pogosto zaobjema veliko različnih kompetenc, se ga je smiselno poslužiti ob zaključku obravnave posamezne učne enote ali več njih. Pri pouku tujega jezika to dijakom in dijakinjam omogoča, da v kontekstu uporabijo čim več elementov tujega jezika (npr. tematsko besedišče,

obravnavane slovnične strukture ipd.). Na ta način lahko preverimo njihovo celostno obvladovanje tujega jezika.

3 SPLETNA PLATFORMA CANVA

Canva je spletna platforma za oblikovanje, ki je začela delovati leta 2013 v Avstraliji in cilj katere je opolnomočiti vsakogar za samostojno oblikovanje vizualnih vsebin, med drugim tiskovin, objav za socialna omrežja, predstavitve, plakate, videov ipd. [4] Zaradi svojega uporabniku prijaznega vmesnika in številnih predlog je dobra izbira za vse, ki se z grafičnim oblikovanjem srečujejo prvič. Platforma ponuja številna osnovna in napredna orodja za urejanje, poleg tega pa nudi številne videoposnetke in informativne članke, ki uporabnikom in uporabnicam pomagajo izboljšati svoje spretnosti. Velika prednost platforme je možnost sodelovanja v realnem času, kar pomeni, da lahko več ljudi hkrati ureja posamezen dokument, zaradi česar je dobra izbira za timsko delo. Na voljo sta brezplačna in plačljiva različica. Slednja omogoča še več naprednih funkcij in večjo knjižnico grafičnih elementov, vendar je brezplačna različica v večji meri povsem zadostna. Ob prijavi lahko uporabnik izbira med več jeziki, vendar so dijakinje zaradi narave predmeta za jezik vmesnika izbrale angleščino.



Slika 1: Uvodni zaslon v Canvi (VIR: lasten, zajem zaslonske slike)

4 IZVEDBA PROJEKTA USTVARJANJA RAZREDNEGA TABLOIDA

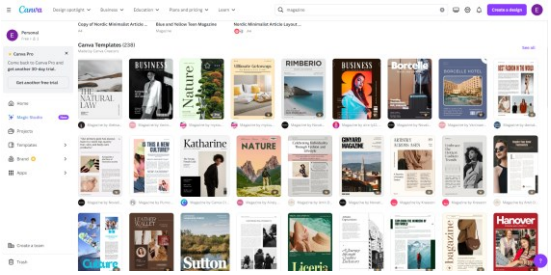
Projekt izdelave razrednega tabloida smo izvedle z dijakinjami 2. letnika programa predšolske vzgoje ob zaključku 10. učne enote, cilja katere sta med drugim bila usvojiti besedišče povezano s področjem medijev in raba trpnih glagolskih oblik. Projektu smo namenile štiri šolske ure, od tega dve uri za načrtovanje dela in pisanje prispevkov ter dve uri za spoznavanje s programom Canva in grafično oblikovanje prispevkov.

Do tedaj so se dijakinje spoznale s sedanjimi, preteklimi in prihodnjimi slovničnimi časi, glagolniki, nedoločniki in trpniki v present simple, past simple in present perfect simple. Eden izmed ciljev projekta je bil tudi ustrezna uporaba čim več prej omenjenih slovničnih struktur v lastnih besedilih.

Ker je avtonomija učenca ena izmed pomembnih elementov za kakovostno izvedeno projektno delo [5], so dijakinje prejele možnost izbire ustvarjanja netabloidne ali tabloidne publikacije in se odločile za slednjo. Z obema tipoma so se že seznanile v predhodnih urah, zato so znale razlikovati med vsebino, naslovnikom in načinom pisanja, ki pritiče tabloidnim publikacijam. Vsaka skupina je podala predlog naslova časopisa, ki je nato bil izbran z glasovanjem. Prav tako je vsaka posameznica sama izbrala vsebino njihovega lastnega prispevka.

Kljub temu, da je vsaka morala pripraviti lasten prispevek, so delale v skupinah, saj jim je to v skladu z načeli projektnega dela omogočilo skupinsko refleksijo napisanega, izmenjavo mnenj, medsebojno pregledovanje (ang. *peer review*) ter posledično izboljšanje končnega izdelka.

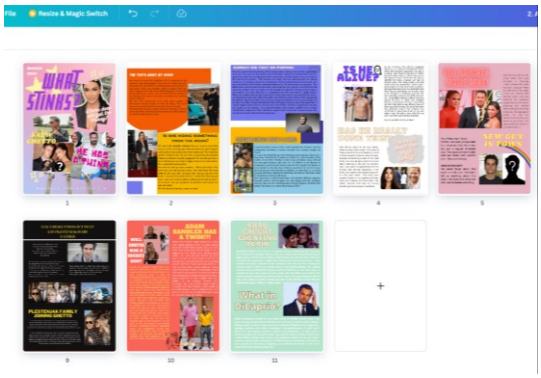
Sledil je kratek praktičen uvod v spletno platformo Canva. Ker se je večina dijakinj s platformo srečala prvič, sem jim ponudila možnost uporabe že obstoječih predlog, do katere so dostopale preko iskalnika, lahko pa so ustvarile lastno. Tako so se seznanile, kako lahko prilagodijo že obstoječe predloge s spremembo pisav, barvne sheme in ostalih elementov. Poleg tega so se spoznale tudi z drugimi funkcionalnostmi platforme kot so iskanje in nalaganje fotografij, oblikovanje besedila in raba dodatnih elementov (oblike, okvirji, grafike, nalepke ipd.).



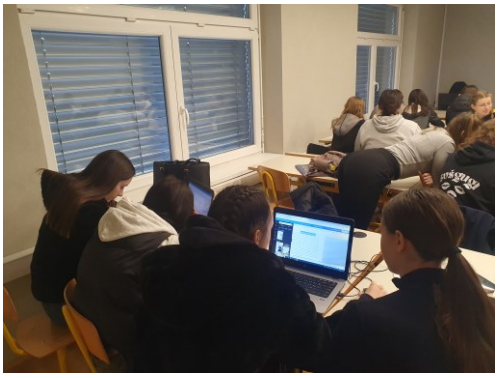
Slika 2: Primer že pripravljenih predlog (VIR: lasten, zajem zaslonske slike)

Prednost Canve je zagotovo njena intuitivnost in ‘povleci in izpusti’ način dela, zato so dijakinje usvojile osnovne funkcije ter jih uspešno implementirale v svoje projekte. Bolj spretne dijakinje so se preizkusile tudi v enostavni obdelavi fotografij, ki so jih priredile, da so ustrezale vsebini njihovih člankov. Posamezne strani so bile nato združene v celoto z ujemajočo naslovnico.

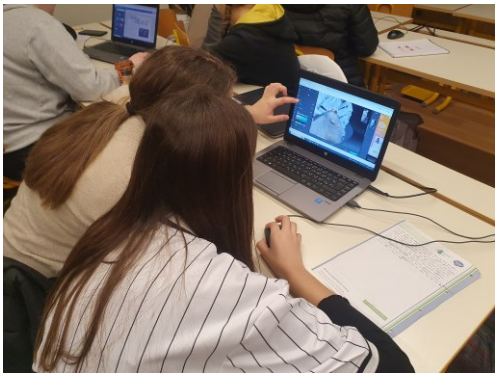
Na ta način niso utrjevale zgolj lastnih pisnih veščin, temveč so tudi izboljšale svoje digitalne spretnosti, saj so se naučile uporabljati različna orodja za oblikovanje in obdelavo digitalnih vsebin. Hkrati so pridobile znanje na področju iskanja virov, organizacije in načrtovanja projektov v Canvi ter na področju grafičnega oblikovanja, saj so pridobile osnovno razumevanje zakonitosti grafičnega oblikovanja, kot so kompozicija, kontrast, barvna shema, poravnava besedila ipd.



Slika 3: Primer naslovnice in posameznih strani (VIR: lasten, zajem zaslonske slike)



Slika 4: Ustvarjanje prispevkov v Canvi (VIR: lasten)



Slika 5: Izdelava fotomontaže (VIR: lasten)

5 ZAKLJUČEK

Projektno delo dopušča hkratno izpopolnjevanje pisnih in digitalnih kompetenc, saj s svojim celovitim in integrativnim pristopom k učenju povezuje različna področja. To je idealno za pouk tujega jezika, ki že sam po sebi združuje različna področja, teme in spretnosti. Obenem moramo biti pozorni, da projekt primerno osmislimo, saj so na ta način dijaki in dijakinje bolj motivirani za delo, končni izdelek pa je bolj kakovosten in v skladu z zastavljenimi cilji. Tako so bile spretnosti pisnega izražanja v tujem jeziku postavljene v ustrezen kontekst, zaradi česar so bili učni rezultati uspešnejši. Prav tako so dijakinje z uporabo Canve nadgradile svoje digitalne kompetence, predvsem na področju urejanja besedil in grafičnega oblikovanja. Zaradi svoje preglednosti in enostavnosti za uporabo je Canva idealna za izdelavo tovrstnih projektov. V prihodnje bi tovrsten projekt lahko nagradili še z medpredmetnim povezovanjem z informatiko in likovno vzgojo, saj bi tako pridobile dodatno znanje na področju oblikovanja. Tovrstno znanje lahko nato unovčijo v vsakdanjem življenju, na primer za oblikovanje predstavitev, tiskovin, življenjepisov in drugih dokumentov za osebno in profesionalno rabo.

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Uporaba aplikacije Stanford Cable TV News Analyzer v visokem šolstvu

Using the Stanford Cable TV News Analyzer in Higher Education

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POVZETEK

V tem prispevku podajamo primere uporabe aplikacije Stanford Cable TV News Analyzer v visokem šolstvu, pri čemer se osre-dotočamo na predavanja iz ekonomije. Ugotovili smo, da je apli-kacija koristen pripomoček za izobraževalce, pa tudi izobraže-vance.

KLJUČNE BESEDE

Analiza, analizator, ekonomija, kabelska novica, predavanje

ABSTRACT

In this paper, we provide examples of the use of the Stanford Ca-ble TV News Analyzer in higher education, focusing on econom-ics classes. We have found that the application is a useful tool for educators, as well as students.

KEYWORDS

Analysis, analyzer, economics, cable news, lecture

1 UVOD

Umetna inteligenca vpliva tudi na (visokošolske) izobraževalne ustanove (izobraževalni proces). Uvedba klepetalnega robota ChatGPT je med njimi povzročila potrebo po prilagajanju novim razmeram, kar smo pričakovali glede na njegov uspeh. Izkušnje učijo, da ni (visokošolskega) izobraževalca, ki ne bi slišal za kle-petalni robot ChatGPT, ki ga je razvilo podjetje OpenAI. Hitro po njegovi uvedbi novembra 2023 se je pokazalo, da je klepetalni robot ChatGPT za (visokošolske) izobraževalce izziv, ki mu ni para, kar nas ne preseneča glede na njegovo zmogljivost [1, 2]. Nasprotujoča si stališča do uporabe klepetalnega robota ChatGPT v (visokošolskem) izobraževanju so (visokošolske) iz-obraževalce razdelila v dva tabora: na zagovornike in nasprot-nike njegove uporabe v (visokošolskem) izobraževanju [3].

V literaturi srečujemo različne primere uporabe klepetalnega robota ChatGPT v (visokošolskem) izobraževanju [4, 5, 6], ne srečujemo pa različnih primerov uporabe aplikacije Stanford Ca-ble TV News Analyzer (analizatorja kabelskih novic), ki tudi te-melji na umetni inteligenci. Tako bomo v tem prispevku več po-zornosti posvetili aplikaciji Univerze Stanford, ki so jo razvili Hong idr. [7] in je prosto dostopna na https://tvnews.stanford.edu. Trdimo lahko, da je ta aplikacija koristna za oblikovalce politike in raziskovalce, pa tudi izobraževalce, ki jo lahko uporabljajo v izobraževalnem procesu. Dejstvo je, da z novimi tehnologijami nastajajo tudi nove priložnosti, ki jih lahko izkoriščamo ali pa tudi ne [8].

Ta prispevek je strukturiran tako, da ima še pet poglavij. V poglavju 2 predstavljamo namen, v poglavju 3 metode, v poglavju 4 rezultate, v poglavju 5 predloge, v poglavju 6 pa sklep.

2 NAMEN

Namen prispevka je srednje- in visokošolskim učiteljem ekono-mije predstaviti tri primere uporabe analizatorja kabelskih novic in zapolniti vrzel v literaturi o (visokošolskem) izobraževanju (v dobi umetne inteligence), ki je nastala z njegovo uvedbo. To apli-kacijo smo izbrali zato, ker omogoča analizo kabelskih novic o kakem aktualnem dogodku, zanimiva pa ni samo za srednje- in visokošolske učitelje ekonomije, ampak npr. tudi za srednje- in visokošolske učitelje statistike, ki lahko podatke aplikacije upo-rabijo pri računanju srednje vrednosti ali drugih statistik.

Prednost aplikacije, ki jo uporabljamo v tem prispevku, je, da omogoča interaktivno delo z dijaki in/ali študenti, tako domačimi kot tujimi, kar je razvidno tudi iz primerov, ki jih predstavljamo v nadaljevanju.

3 METODE

V tem prispevku uporabljamo metodi kompilacije in študije pri-mera (angl. case study), pri čemer se omejujemo na

predstavitev aplikacije Stanford Cable TV News Analyzer, ki omogoča ana-lizo kabelskih novic od januarja 2010, in primerov njene uporabe na predavanjih iz ekonomije. Uporabljamo tudi metodi analize in sinteze.

Posebnost aplikacije je, da temelji na uporabi umetne inteligence, ki je tudi v visokem šolstvu aktualna tema.

4 REZULTATI

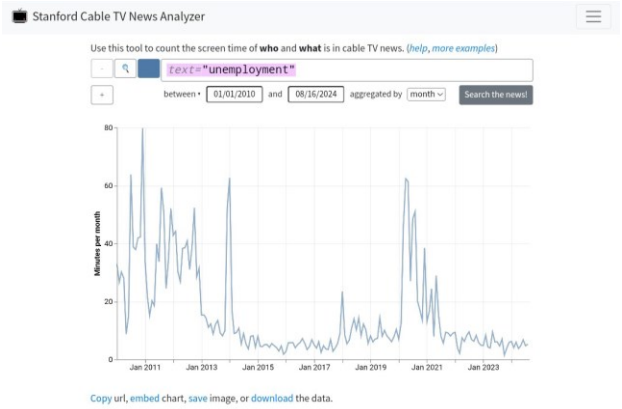
V tem poglavju predstavljamo tri primere uporabe analizatorja kabelskih novic, za katere menimo, da lahko koristijo srednje- in visokošolskim učiteljem ekonomije, saj lahko ti z njegovo upo-rabo popestrijo pouk ekonomije in nenazadnje pritegnejo pozor-nost dijakov oz. študentov. V ta namen smo izbrali tri pojme: brezposelnost (angl. unemployment), inflacijo (angl. inflation) in ekonomsko politiko (angl. economic policy), ki so tudi navedeni v Predmetnem izpitnem katalogu za splošno maturo 2024 – eko-nomija [9].

Vsak primer vsebuje eno ali več slik, njuno analizo in eno ali več vprašanj za študente. Čeprav so primeri namenjeni visokošolskim učiteljem, jih lahko uporabljajo tudi srednješolski učitelji, pri čemer morajo analizo prilagoditi srednješolskemu izobraževanju.

4.1 Primer 1: Brezposelnost

Analizator kabelskih novic kaže čas zaslona (angl. screen time) (v sekundah, minutah itd.), v katerem je bila v podnaslovu nave-dena kaka angleška beseda (npr. economy) ali kaka besedna zveza (npr. economic policy) oz. v katerem je bila na zaslonu prikazana kaka znana oseba (npr. Donald Trump, Joe Biden, Kamala Harris), kar pomeni, da ne kaže čas poročanja o kakem (aktualnem) dogodku ali osebi. Lahko pa domnevamo, da daljši ko je čas zaslona, daljši je čas poročanja.

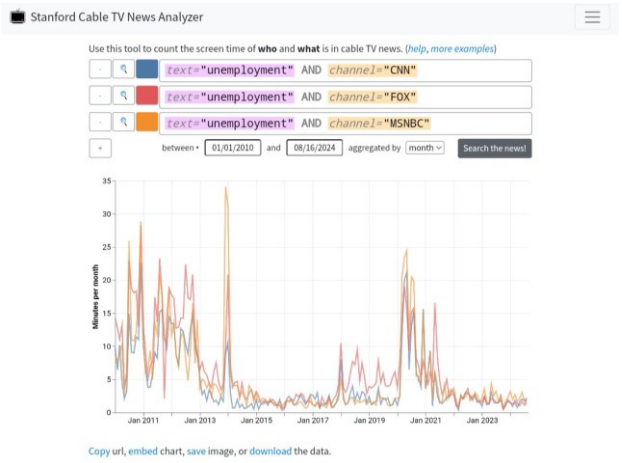
V tem podpoglavju grafično prikazujemo rezultate analize kabelskih novic o brezposelnosti, ki smo jo naredili s pomočjo aplikacije Univerze Stanford. Grafikon na sliki 1 smo dobili tako, da smo v iskalno polje vtipkali text=unemployment, grafikon na sliki 2 pa tako, da smo v prvo iskalno polje vtipkali text="unemployment" AND channel="CNN", v drugo text="unemployment" AND channel="FOX", v tretje pa text="unemployment" AND channel="MSNBC".



Slika 1: Posnetek zaslonske slike v primeru besede unemployment na dan 16. 8. 2024 (čas zaslona v minutah) [7, 10].

Analiza slike 1: Iz grafikona na sliki 1 lahko domnevamo (sklepamo), da so v opazovanem obdobju ameriški mediji, natančneje kabelske televizije CNN, FOX in MSNBC, o brezposelnosti največ poročale do (vključno) leta 2014 in od leta 2020 do (vključno) leta 2022, tj. med zdravstveno krizo (epidemijo covida-19).

Vprašanja za študente: 1. Kaj je bil razlog za to, da so med epidemijo covida-19 ameriški mediji veliko poročali o brezposelnosti? 2. Ali in kako lahko podatki o času zaslona, v katerem je bila v podnaslovu navedena angleška beseda unemployment, koristijo oblikovalcem politike? 3. Ali in kako lahko poročanje ameriških medijev o brezposelnosti vpliva na razpoloženje Američanov, pri čemer upoštevajte, da ločimo dobre in slabe novice?

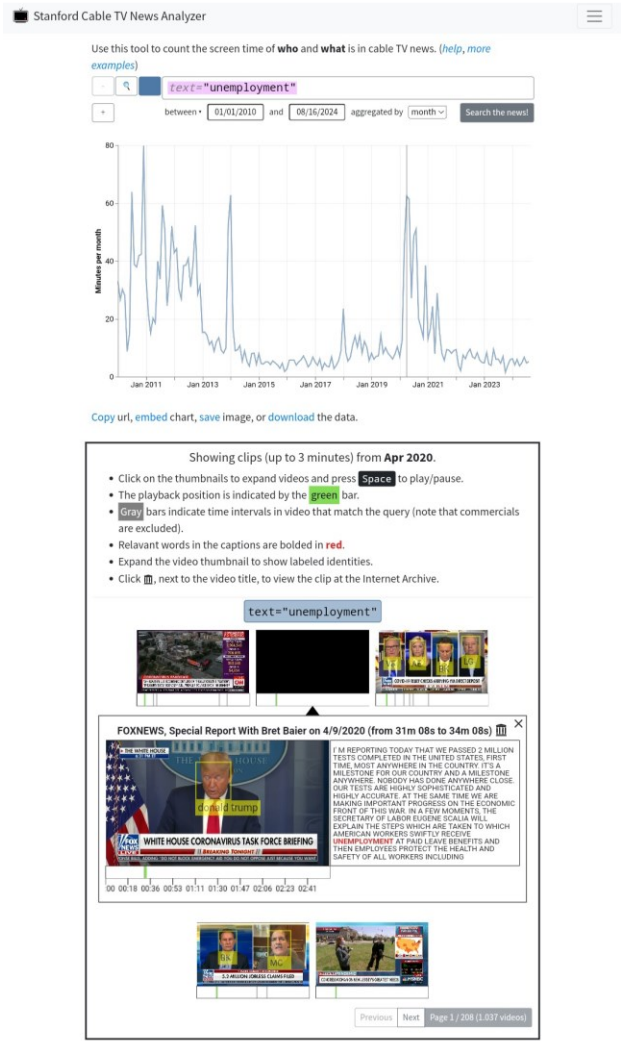


Slika 2: Posnetek zaslonske slike v primeru besede unemployment na dan 16. 8. 2024 (čas zaslona v sekundah po TV-postajah) [7, 10].

Analiza slike 2: Iz grafikona na sliki 2 lahko domnevamo (sklepamo), da sta v opazovanem obdobju o brezposelnosti (naj)več poročali kabelski televiziji FOX in MSNBC.

Vprašanje za študente: Ali in kako lahko razlike v poroča-nju ameriških medijev o brezposelnosti vplivajo na razpoloženje članov (podpornikov) demokratske in republikanske stranke?

Sliki 1 in 2 lahko analiziramo na predavanju in/ali seminarskih vajah, na katerih obravnavamo brezposelnost. Pri tem je pomembno, da uporabimo interaktivno spletno stran, ki nam omogoča, da ne analiziramo samo gibanja časa zaslona, ampak tudi kabelske novice. (S klikom na točko na krivulji se namreč prikažejo vse kabelske novice o kaki stvari, ki se obravnava – gl. sliko 3.) Poleg tega lahko uporabimo tudi druge, strožje (iskalne) kriterije, s čimer lahko vsebino predavanja približamo potrebam. To je zlasti dobrodošlo pri delu v majhnih skupinah, ko lahko uporabljamo tudi na študenta osredotočeni pristop.



Slika 3: Posnetek zaslonske slike v primeru besede unemployment, potem ko smo kliknili na točko na krivulji (april 2020) (čas zaslona v minutah) [7, 10].

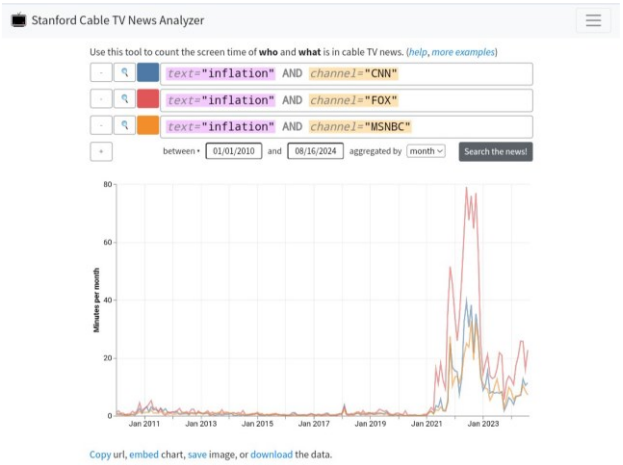
4.2 Primer 2: Inflacija

V tem podpoglavju grafično prikazujemo rezultate analize kabel-skih novic o inflaciji. Grafikon na sliki 4 smo dobili tako, da smo v iskalno polje vtipkali text=inflation, grafikon na sliki 5 pa tako, da smo v prvo iskalno polje vtipkali text="inflation" AND chan-nel="CNN", v drugo text="inflation" AND channel="FOX", v tretje pa text="inflation" AND channel="MSNBC".

Analiza slike 4: Iz grafikona na sliki 4 lahko domnevamo (sklepamo), da so ameriški mediji o inflaciji največ poročali po letu 2020, v katerem je prišlo do izbruha epidemije covida-19.

Vprašanja za študente: 1. Kaj je bil razlog za to, da so po izbruhu epidemije covida-19 ameriški mediji veliko poročali o inflaciji? 2. Ali in kako lahko podatki o času zaslona, v katerem je bila v podnaslovu navedena angleška beseda inflation, koristijo oblikovalcem politike? 3. Ali in kako lahko poročanje ameriških medijev o inflaciji vpliva na razpoloženje Američanov?

Slika 4: Posnetek zaslonske slike v primeru besede inflation na dan 16. 8. 2024 (čas zaslona v minutah) [7, 10].



Slika 5: Posnetek zaslonske slike v primeru besede inflation na dan 16. 8. 2024 (čas zaslona v sekundah po TV-postajah) [7, 10].

Analiza slike 5: Iz grafikona na sliki 5 lahko domnevamo (sklepamo), da je v opazovanem obdobju o inflaciji (naj)več poročala kabelska televizija FOX.

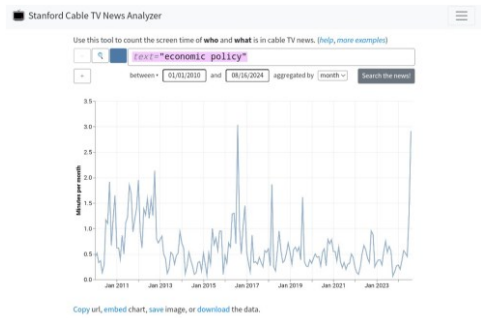
Vprašanje za študente: Ali in kako lahko razlike v poroča-nju ameriških medijev o inflaciji vplivajo na razpoloženje članov (podpornikov) demokratske in republikanske stranke?

Sliki 4 in 5 lahko analiziramo na predavanju in/ali seminarskih vajah, na katerih obravnavamo inflacijo, pri čemer lahko podatke o gibanju časa zaslona, v katerem je bila v podnaslovu navedena angleška beseda inflation, primerjamo s podatki o gibanju stopnje inflacije v ZDA. To lahko naredimo tudi pri brezpo-selnosti, kjer lahko podatke o gibanju časa zaslona, v katerem je bila v podnaslovu navedena angleška beseda unemployment, pri-merjamo s podatki o gibanju stopnje brezposelnosti v ZDA.

4.3 Primer 3: Ekonomska politika

V tem podpoglavju grafično prikazujemo rezultate analize kabel-skih novic o ekonomski politiki. Grafikon na sliki 6 smo dobili tako, da smo v iskalno polje vtipkali text="economic policy", grafikon na sliki 7 pa tako, da smo v prvo iskalno polje vtipkali text="economic policy" AND channel="CNN", v drugo

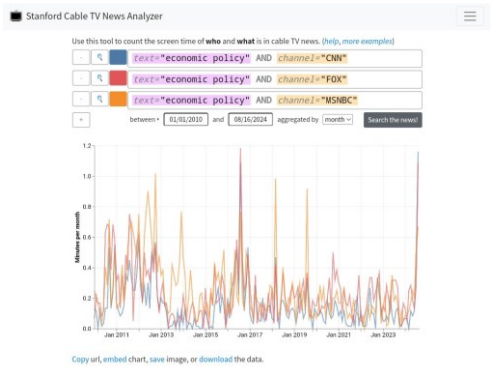
text="economic policy" AND channel="FOX", v tretje pa text="economic policy" AND channel="MSNBC".



Slika 6: Posnetek zaslonske slike v primeru besedne zveze economic policy na dan 16. 8. 2024 (čas zaslona v minutah) [7, 10].

Analiza slike 6: Iz grafikona na sliki 6 lahko domnevamo (sklepamo), da so ameriški mediji o ekonomski politiki največ poročali leta 2016 in 2024.

Vprašanje za študente: Kaj je bil razlog za to?



Slika 7: Posnetek zaslonske slike v primeru besedne zveze economic policy na dan 16. 8. 2024 (čas zaslona v sekundah po TV-postajah) [7, 10].

Analiza slike 6: Iz grafikona na sliki 7 lahko domnevamo (sklepamo), da sta v opazovanem obdobju o ekonomski politiki (naj)več poročali kabelski televiziji FOX in MSNBC.

Vprašanje za študente: Ali in kako lahko razlike v poroča-nju ameriških medijev o ekonomski politiki vplivajo na razpolo-ženje članov (podpornikov) demokratske in republikanske stranke?

Sliki 6 in 7 lahko analiziramo na predavanju in/ali seminar-skih vajah, na katerih obravnavamo ekonomsko politiko. Po-datke o gibanju časa zaslona, v katerem je bila v podnaslovu na-vedena angleška besedna zveza economic policy, lahko primer-jamo s podatki o gibanju ekonomskopolitične negotovosti v ZDA.

5 PREDLOGI

Srednje- in visokošolskim učiteljem ekonomije predlagamo, da razmislijo o uporabi analizatorja kabelskih novic pri pouku eko-nomije in da skupaj z dijaki oz. študenti analizirajo poročanje ka-belskih postaj o kakem (aktualnem) dogodku, pa tudi da dijake oz. študente usmerijo k njegovi uporabi pri pisanju seminarskih nalog. Predlagamo jim tudi, da primerjalno analizirajo poročanje kabelskih postaj CNN, FOX in MSNBC ter da uporabijo tudi druge, strožje (iskalne) kriterije.

6 SKLEP

Nasploh lahko trdimo, da je analizator kabelskih novic koristen pripomoček. V podkrepitev te trditve smo navedli tri (praktične) primere njegove uporabe na predavanjih iz ekonomije, ki lahko drugim visokošolskim učiteljem ekonomije služijo kot ilustra-cija. To velja tudi za srednješolske učitelje ekonomije. Upošte-vati moramo, da so pripadniki generacije Z drugačni od pripadni-kov prejšnjih generacij, kar povzroča potrebo po prilagajanju iz-obraževalnega procesa njihovim (dejanskim) potrebam in že-ljam. Izkušnje (iz Slovenije) učijo, da moramo visokošolski uči-telji na predavanjih več pozornosti posvečati (praktični) uporab-nosti znanja, saj lahko s tem izboljšamo izobraževalni proces.

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Razvijanje socialno-emocionalnih veščin z uporabo animiranega filma v predšolskem obdobju

Developing Social-Emotional Skills through Animated Film in Early Childhood

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POVZETEK

Socialno-emocionalne veščine, kot so prepoznavanje in izražanje čustev, empatija, reševanje konfliktov in samoregulacija, so bistvene za uspešen razvoj otrok. V predšolskem obdobju otroci razvijajo te veščine skozi interakcijo z vrstniki, odraslimi in okoljem. Poleg tega lahko različni mediji, kot so animirani filmi, igrajo pomembno vlogo pri krepitvi teh veščin.

V začetku vrtčevskega leta je bilo opaziti, da otroci ne pospravljajo igrač, neprimerno rokujejo z igračami v različnih kotičkih in nimajo razvitega čuta za odgovornost do materiala v vrtcu in ne navezujejo stikov z vrstniki. Da bi spremenil te vzorce, sem se odločili zrcaliti otroška dejanja, kar je vodilo do ideje o Trmici. To je kvačkana okrogla žogica z nogami, rokami in obrazom, ki ne govori na glas, ampak šepeta otrokom na uho, tako dobre kot slabe stvari. S svojim nagajivim vedenjem spodbuja otroke k prepoznavanju čustev in reševanju konfliktov. Nered ustvarja le v času odsotnosti otrok iz vrtca. Trmica predstavlja trmastega otroka, ki misli, da lahko počne karkoli brez posledic za svoja dejanja.

Cilj tega članka je raziskati in spremljati vedenje otrok po vključitvi Trmice v skupino ter oceniti, kako lahko uporaba animiranih filmov s Trmico pomaga pri razvijanju socialno-emocionalnih veščin pri predšolskih otrocih. Raziskava se osredotoča na opazovanje otrok med gledanjem animiranih filmov, analizo njihovega vedenja ter zbiranje povratnih informacij od staršev in vzgojiteljev, da bi ocenili učinke teh filmov na razvoj socialno-emocionalnih veščin.

KLJUČNE BESEDE

Socialno-emocionalne veščine, predšolski otroci, animiran film, Trmica, prepoznavanje čustev, samoregulacija, empatija, reševanje konfliktov, odgovornost

ABSTRACT

Social-emotional skills, such as recognizing and expressing emotions, empathy, conflict resolution, and self-regulation, are essential for the successful development of children. In the preschool period, children develop these skills through interactions with peers, adults, and the environment. Additionally, various media, such as animated films, can play a significant role in enhancing these skills.

At the beginning of the kindergarten year, educators observed that children were not tidying up their toys, mishandling toys in different play areas, and lacking a sense of responsibility for the kindergarten materials. To address these challenges, the idea was conceived to mirror the children's actions, leading to the creation of Trmica. Trmica is a crocheted round ball with legs, arms, and a face, which does not speak but whispers both good and bad things to the children. Through its mischievous behavior, Trmica encourages children to recognize emotions and resolve conflicts. Trmica represents a stubborn child who believes they can do anything without facing consequences.

The aim of this article is to investigate and monitor the behavior of children after the introduction of Trmica into the group, and to assess how the use of animated films featuring Trmica can help in developing social-emotional skills in preschool children. The research focuses on observing children while watching the animated films, analyzing their behavior, and collecting feedback from parents and educators to evaluate the effects of these films on the development of social-emotional skills.

KEYWORDS

Social-emotional skills, preschool children, animated films, Trmica, emotion recognition, self-regulation, empathy, conflict resolution, responsibility

1 UVOD

Razvoj socialno-emocionalnih veščin v predšolskem obdobju je ključen za celostni razvoj otrok. Te veščine vključujejo sposobnost prepoznavanja in izražanja čustev, empatijo, reševanje konfliktov ter samoregulacijo, ki so bistvene za uspešno interakcijo z vrstniki in odraslimi. V predšolskem obdobju otroci te veščine razvijajo predvsem skozi interakcije z okoljem in drugimi osebami [1]. Vendar pa sem v začetku leta opazil težave, kot so neprimerno rokovanje z igračami, neprijaznost do vrstnikov in vzgojiteljev ter pomanjkanje odgovornosti. Da bi učinkovito reševal te izzive, sem se odločil

preizkusiti uporabo animiranih filmov (stop motion pictures), kot orodja za izboljšanje socialno-emocionalnih veščin, pred uporaba filma sem z otroki izvedel različne dejavnosti, ki povezujejo skupino, krepijo samopodobo posameznika in celotno skupino ter širši krog ljudi s katerim se otroci dnevno družijo.

V tem članku bom predstavil primere dejavnosti za prepoznavanj neprimernega vedenja, prepoznavanje in izražanje čustev ter uporabe lika Trmica (slika 1), kvačkane žogice z rokami, nogami in obrazom, ki sem ga uvedel v igralnico, da bi otroke spodbudil k refleksiji o njihovem vedenju in razvoju potrebnih veščin. Proučil sem, kako so otroci reagirali na spremembe v okolju, kako je Trmica vplivala na njihovo vedenje ter kakšne so bile posledice za njihov socialno-emocionalni razvoj.

Slika 1: Trmica se igra z igračami

2 RAZUMEVANJE ANIMIRANIH FILMOV V PREDŠOLSKEM OBDOBJU

Animirani filmi lahko v predšolskem obdobju pripomorejo pri razvoju otrokove socialno-emocionalne pismenosti, kognitivnih veščin in ustvarjalnosti. Takšne vsebine omogočajo otrokom, da se identificirajo z liki in situacijami v filmih, kar jim pomaga razumeti in izražati svoja čustva ter razviti empatijo do drugih. Vključevanje animiranih filmov v izobraževalne dejavnosti lahko pozitivno vpliva na medosebne odnose otrok ter sposobnosti reševanja konfliktov, saj jim ponuja vpogled v različne čustvene izkušnje in socialne dinamike. Kakovost izobraževalnih vsebin in pristopov, vključno z uporabo animiranih filmov, ima pomembno vlogo pri zagotavljanju visoke kakovosti vzgoje in izobraževanja v vrtcih in šolah, kar potrjujejo smernice in raziskave na tem področju [2].

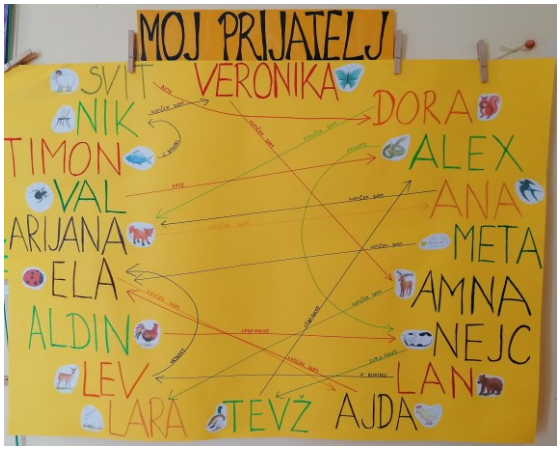
Poleg tega animirani filmi spodbujajo otroško ustvarjalnost in kognitivni razvoj. Domišljijski elementi v animiranih filmih omogočajo raziskovanje novih idej ter razvoj kritičnih miselnih sposobnosti. Zgodbene vsebine, ki vključujejo reševanje problemov in prepoznavanje vzorcev, pripomorejo k razvoju otrokove sposobnosti razmišljanja in reševanja težav. Takšne vsebine spodbujajo kognitivni razvoj in kreativnost otrok ter prispevajo k njihovemu celostnemu razvoju. Vključevanje kakovostnih animiranih filmov v izobraževalne programe je v skladu z najboljšimi praksami za zagotavljanje kakovosti izobraževalnega procesa, kot je navedeno v smernicah za kakovost v vrtcih in šolah [2].

Poleg tega ima dodano vrednost posnetek, ki je narejen v igralnici. V kolikor lahko vključiš rekvizite s katerimi otroci dnevno rokujejo in z njimi preživijo večino dneva je to dodana vrednost. Takšne vsebine omogočajo vključitev tematik, ki so trenutno najbolj zaželene, pereče ali bodo otrokom in vzgojiteljem pomagale pri uspešni realizaciji zastavljenih ciljev.

Pomembno pa je poudariti, da posnetki, filmi in podobne vsebine ne smejo biti edini vir spodbude za otroke. Gre le za eno izmed mnogih orodij, ki jih je treba skrbno vključiti v celoten pedagoški pristop, kjer so na prvem mestu neposredne izkušnje in interakcije z okoljem in sovrstniki.

3 UVAJANJE AKTIVNOSTI ZA RAZVOJ SOCIALNO-EMOCIONALNIH SPRETNOSTI IN SAMOREGULACIJE

Pred začetkom uporabe lika Trmica v programu sem se osredotočil na dejavnosti, ki so prispevale k razvoju socialno-emocionalnih veščin otrok. Vpeljal sem različne aktivnosti, ki so omogočile raziskovanje in izražanje čustev ter izboljšanje sposobnosti samoregulacije in empatije.



Slika 2: Moj prijatelj - plakat

Slika 3: Srce – moja družina

Med njimi je bila izdelava plakatov o najboljših prijateljih, kjer so otroci zapisali imena svojih prijateljev in opisali najljubše trenutke z njimi, kar je spodbujalo refleksijo in razvoj empatije. Po izdelanem plakatu (slika 2) so se odšli otroci igrati s svojim najljubšim prijateljem. Seveda to ni bilo povsem izvedljivo, saj so se med seboj imena ponavljala. Težavo so rešili s skupno igro. Poleg tega so otroci ustvarili plakate v obliki srca (slika 3), kjer so risali najljubše osebe v družini in med prijatelji, kar je krepilo občutek ljubezni in pripadnosti. Med risanjem plakata so opisovali dogodke, se spominjali lepih trenutkov in z nasmehom opravili nalogo. Za prepoznavanje čustev sem uporabil slikovne kartice, ki so prikazovale različna čustva, ter aktivnosti, kjer so otroci označevali svoje počutje na pripravljeni šabloni. To je prispevalo k razvoju čustvene pismenosti in samorefleksije. Dejavnosti smo izvajali v dopoldanskem času med prihodom v vrtec in v popoldanskem času med odhajanjem domov. V primeru neželenega dogodka v skupini, sem med pogovorom vprašal otroka o njegovem počutju, tako da so lahko te občutke označili na listih. Sčasoma so jih usvojili z besedami, tako da niso več potrebovali slikovne opore. V sklopu aktivnosti za razvoj samoregulacije sem se osredotočil na učenje in vadbo besednih ukazov ter gest za obvladovanje čustev in vedenja. Otroci so se učili uporabljati fraze, kot so "stop," "to mi ni všeč," "nehaj takoj" v konfliktnih situacijah in vadili uporabo geste z dlanjo za prekinjanje neželenega vedenja.

Dnevno smo izvajali pretvarjanja situacij v skupini, ki so najpogosteje vodile v konflikt. Pretvarjanje je potekalo tako, da sva s sodelavko zaigrala njihov primer, se o njem pogovorili in ga nato še enkrat zaigrala s predlogi otrok, da rešiva nastalo situacijo. Kasneje so tudi otroci igrali igre pretvarjanja. Uporabil sem vizualne pripomočke, kot so plakati in kartice z navodili, da sem podprl učenje teh veščin, otroci pa so jih redno uporabljali v vsakodnevnih situacijah znotraj učnega okolja. Te dejavnosti so bile ključne za pripravo otrok na delo z likom Trmica, saj so prispevale k njihovemu boljšemu razumevanju in izražanju čustev ter spodbujanju pozitivnega vedenja v skupini.

4 ZRCALJENJE OTROŠKIH DEJANJ IN ISKANJE KRIVCA: UPORABA LIKA TRMICE

Da bi otroke pritegnil in jih spodbudil k razmišljanju o svojih vedenjskih vzorcih, sem v skupino začel vnašati rahle spremembe, kot so razmetane barvice, pomešane igrače, neurejeni delovni zvezki, izginule igrače, prestavljeni predmeti (stenkska ura, stoli, kotički, znaki otrok itd.). Vsako jutro, ko so prišli v igralnico in naleteli na nered ali izginotje predmetov, sem jih vprašal: "Kdo od vas ni včeraj pospravil igrač?" Vsak dan je bil odgovor enak - vsi so trdili, da so vse pospravili. Ko so ugotovili, da se te stvari dogajajo v času njihove odsotnosti iz vrtca, so predlagali, da ponoči postavimo kamero v sobo, da bi videli, kdo povzroča ta nered. Kamero smo naredili iz kartona in jo postavili na najvišjo omaro, tako da je zajela celotno igralnico. Nato smo čakali. Napetost je rasla in vsak dan smo preverjali, ali je v kameri kakšna slika.

Nekega dne smo dejansko našli sliko. Na njej je bil le del Trmice in razdejanje, ki ga je povzročila. Otroci niso mogli ugotoviti, kdo je to, zato se je napetost še povečala. Ko so se slike vrstile več tednov in nihče ni mogel ugotoviti, kdo je to, so predlagali, da pripravimo past in ulovimo nepridiprava. Tako smo iz kartona spletli mrežo in jo postavili nad čokolado, ki je bila na mizi. Naslednji dan je bila past sprožena, a o čokoladi ni bilo ne sluha ne duha. Na mizi je bila le rdeča lisa.

Nekaj dni, pred ogledom videa o Trmici, smo prebrali zgodbo "Zmajček in Trmica," kjer se je otrokom že začela sestavljati celotna slika. Ugotovili so, da bi bil nepridiprav lahko prav ta Trmica iz zgodbe. Po več tednih ugotavljanja je napočil čas, ko v kameri na listku ni bilo slike, ampak je pisalo "video." Otroci so ugotovili, da moramo kamero priklopiti na računalnik. To smo naredili in začel se je predvajati posnetek (stop motion picture) s Trmico v glavni vlogi. Kamera jo je posnela, kako je razmetavala stole v igralnici, raztresala različne igrače, plezala po omarah in brskala po predalih. V sobi je zavladala tišina. Otroci so nemo gledali posnetek in komentirali dogodke. Ta dan so končno ugotovili, kdo jim povzroča nered v igralnici.

5 SPOZNAVANJE LIKA TRMICE

Ko smo Trmico locirali in našli, je vsa prestrašena skočila meni v naročje (slika 4). Z otroki smo si v krogu ogledali Trmico in jo vprašali, od kod je prišla in ali je ona tista, ki je delala nered v naši igralnici. Nič ni odgovarjala, le gledala nas je. Kmalu smo ugotovili, da govori le na uho, zato sem jaz prvi poslušal njene ideje in moram reči, da so bile zelo nagajive (Trmica govori na uho tako, da si sam izmišljaš kaj ti govori). Seveda nam je tudi odgovorila na vsa naša vprašanja. Trmico smo si podajali naprej, tako da so jo vsi pozdravili in se z njo pogovorili. Otroci so imeli zelo zanimive ideje o tem, zakaj je razmetavala sobo in prestavljala igrače. Po končanem pogovoru smo ji poiskali mesto v igralnici in se dogovorili, da jo lahko vsak vzame v naročje, če bo le lepo rokoval z njo, vendar se mora vedno vrniti na dogovorjeno mesto. Tako je Trmica postala del naše skupine.

Slika 4: Našli smo Trmico

6 SODELOVANJE LUTKE V SKUPINI

Trmica je dnevno sodelovala v jutranjih krogih in v vseh drugih delih dneva. Kljub temu, da smo jo vključili v našo rutino, nam je še vedno nagajala; ponoči je razmetavala igralnico, zjutraj pa je tiho opazovala naše odzive. Kadar se kakšna igračka ali igralni kotiček nista primerno uredila, smo prosili Trmico, da nam pomaga urediti kotičke. Otroci so z njo bolj zagreto pospravljali in brez dodatnih spodbud izvajali vodene dejavnosti

v času bivanja v vrtcu. Trmica je postala kot nagrada za druženje po dobro opravljenem delu, kar je še dodatno motiviralo otroke pri njihovih nalogah. Negativni vedenjski vzorci otrok so se skoraj popolnoma prekinili, saj so otroci začeli uporabljati Trmico kot izgovor za neprimerno vedenje, češ da jim je Trmica rekla naj naredijo kakšno neumnost. Kljub temu so bili otroci zelo ljubeznivi do lutke, kar je pripomoglo k temu, da je večina negativnih dejanj izvenela. V prvem tednu prisotnosti Trmice je bilo opaziti več skupne igre, saj so otroci vključevali lutko v svoje najljubše kotičke, kar je dodatno spodbujalo sodelovanje in pozitivno interakcijo med njimi (slika 5).

Slika 5: Trmica posluša zgodbo z otroki

7 ODZIV STARŠEV PPRED IN PO SPREJEMU TRMICE V SKUPINO.

Starši so pred uvedbo Trmice v skupino opažali, da se otroci doma pogosto niso želeli soočiti z odgovornostmi, kot so pospravljanje svojih igrač, oblačil in opravljanjem osnovnih domačih nalog, kot je urejanje postelje ali obutve. Po sprejemu Trmice v skupino so začeli opažati zanimivo spremembo v vedenju svojih otrok. Kadar otroci doma naredijo kakšno neumnost ali ne opravijo svojih nalog, krivijo Trmico, saj naj bi jim ona rekla, naj ne opravijo svojih obveznosti. To je postal pogost izgovor pri otrocih. Starši hkrati opažajo, da otroci zdaj veliko več govorijo o neprimernih vedenjih Trmice in o tem, kaj je prav in kaj ne.

Poleg tega so starši opazili, da otroci pogosto omenjajo, kako se Trmica v vrtcu obnaša in kaj vse se je naučila. To je spodbudilo zanimive pogovore doma, kjer otroci sami sebe opozarjajo, da se "ne smejo obnašati kot Trmica." Starši sporočajo, da otroci, ki so bili prej zadržani pri izražanju svojih čustev, zdaj bolje ubesedijo svoje občutke in razpravljajo o nastalih situacijah, kar nakazuje, da so razvili večjo zavest o pravilnem in nepravilnem vedenju.

Zanimivo je tudi to, da so starši začeli opažati, da otroci zdaj pokažejo več empatije do drugih članov družine. Včasih, ko pride do nesoglasij, jih poskušajo reševati na mirnejši način, kot so to počeli prej. Opažajo, da otroci zdaj več in bolj temeljito pospravljajo svoje stvari kot prej, ter se trudijo slediti dogovorom doma. Čeprav se morda še vedno poskušajo izogniti odgovornosti, pa je očitno, da so sprejeli sporočilo Trmice in postali bolj vestni in odgovorni pri svojih vsakodnevnih opravilih, kar je prineslo pozitivne spremembe tako v vrtcu kot tudi doma.

8 ZAKLJUČEK

Vpeljava lika Trmice v skupino predšolskih otrok se je izkazala kot učinkovit pristop za spodbujanje razvoja socialno-emocionalnih veščin. Otroci so skozi interakcijo z lutko Trmico in spremljanje njenih domnevnih dejanj pridobili globlje razumevanje čustev, empatije, odgovornosti in pravilnega vedenja.Ta inovativni pedagoški pristop je pripomogel k temu, da so otroci začeli bolj zavzeto pospravljati svoje stvari, se bolj angažirano vključevali v skupinske dejavnosti in razvijali sposobnost reševanja konfliktov na miren način.

Starši so opazili, da so otroci doma bolj odprti za razprave o svojih čustvih in vedenju, kar kaže na širši vpliv Trmice izven vrtčevskih okvirov. Kljub temu, da so otroci včasih Trmico uporabili kot izgovor za lastne pomanjkljivosti, so se pri tem učili pomembnih življenjskih lekcij o odgovornosti in posledicah svojih dejanj. S tem so postali bolj vestni in samostojni, kar se kaže tudi v njihovem vedenju doma.

Uporaba animiranih filmov in zgodb, skupaj z uporabo lutke kot interaktivnega orodja, se je izkazala kot učinkovit način za podporo celostnemu razvoju otrok. Trmica je tako postala pomemben del skupinskega življenja, ki ne le zabava, temveč tudi uči in vodi otroke k bolj zrelim in odgovornim osebam. Prepoznanje in naslavljanje otrokovih čustev ter vedenj preko likov, kot je Trmica, ponuja vrtcem in šolam priložnost za nadgradnjo tradicionalnih vzgojnih metod z inovativnimi pristopi, ki so prilagojeni potrebam sodobnih otrok.

VIRI

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Psihologija barv na tečaju grafičnega oblikovanja

The Psychology of Colors in Graphic Design Course

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POVZETEK

V digitalni dobi ima grafično oblikovanje ključno vlogo pri ustvarjanju vizualno prepričljivih sporočil, ki presegajo jezikovne meje in dosegajo globalno občinstvo. Projekt RaSTKo, sofinanciran s strani Ministrstva za vzgojo in izobraževanje RS ter EU, si prizadeva povečati vključenost odraslih v vseživljenjsko učenje in izboljšati njihove kompetence. V sklopu projekta se izvajajo brezplačni tečaji, vključno z izobraževanjem o grafičnem oblikovanju. Le ta je namenjen različnim poklicnim profilom, ter pokriva temeljne in napredne vidike oblikovanja in uporabo grafičnih programov. Poseben poudarek je na vplivu barv na čustva in vedenje uporabnikov, kjer se udeleženci naučijo strateške uporabe barv za učinkovito vizualno komunikacijo.

Empirični del, ki vključuje anketo med udeleženci tečaja, potrjuje, da barve močno vplivajo na čustvene reakcije in vedenje uporabnikov, pri čemer sta bila rdeča in modra ocenjeni kot najbolj učinkoviti barvi za jumbo plakate. Članek zaključuje s priporočilom za sodelovanje med grafičnimi oblikovalci in psihologi, kar bi lahko izboljšalo učinkovitost vizualnih komunikacijskih rešitev.

KLJUČNE BESEDE

Grafično oblikovnaje, barve, psihologija, tečaj, RaSTKo

ABSTRACT

In the digital age, graphic design plays a crucial role in creating visually compelling messages that transcend language barriers and reach a global audience. The RaSTKo project, co-financed by the Ministry of Education of the Republic of Slovenia and the EU, aims to increase adult participation in lifelong learning and enhance their competencies. As part of the project, free courses are offered, including training in graphic design. These courses are designed for various professional profiles, covering fundamental and advanced aspects of design and the use of graphic software. Special emphasis is placed on the impact of colors on emotions and user behavior, where participants learn the strategic use of colors for effective visual communication.

The empirical part, which includes a survey among course participants, confirms that colors significantly influence emotional reactions and user behavior, with red and blue being rated as the most effective colors for billboards. The article concludes with a recommendation for collaboration between graphic designers and psychologists, which could improve the effectiveness of visual communication solutions.

KEYWORDS

Graphic design, colors, psychology, course, RaSTKo

1 UVOD

V digitalni dobi, ki jo živimo, je moč vizualne komunikacije postala neprecenljiva. Grafično oblikovanje je postalo ključno orodje za ustvarjanje močnih, prepričljivih sporočil, ki segajo preko jezikovnih meja in nagovarjajo občinstvo na globalni ravni.

Beseda »grafično« izvira iz grške besede »graphein« in pomeni pisanje oz. označevanje. Beseda oblikovanje oz. v angleščini »design« izvira iz francoskega izraza »dessiner«, kar pomeni risanje, načrtovanje, skiciranje in oblikovanje. Iz tega lahko sklepamo, da je v svojem primarnem pomenu grafično oblikovanje smiselno »pisanje« informacij in pretvorba le-teh [1].

Od podjetij do posameznikov se vedno več ljudi zaveda pomena estetike in funkcionalnosti, ki ju prinaša dobro oblikovanje. V tem kontekstu je znanje grafičnega oblikovanja postalo izjemno cenjeno in iskano, saj omogoča ustvarjanje vizualnih izdelkov, ki izstopajo in imajo trajen vpliv.

Kakovostni izobraževalni viri se včasih izkažejo za nedostopne zaradi finančnih omejitev. Tukaj pa marsikomu lahko pomagajo brezplačni tečaji, ki so preko projektov financirani ali sofinancirani s strani državnih inštitucij ali evropskih sredstev. Te ne le odpirajo vrata kakovostnemu izobraževanju, ampak tudi omogočajo inovativnost in kreativni razvoj med udeleženci, ki se izobraževanj sicer ne bi udeležili.

2 PREDSTAVITEV PROJEKTA

RaSTKo - Razvoj spretnosti in temeljnih kompetenc je projekt, ki ga sofinancirata Ministrstvo za vzgojo in izobraževanje Republike Slovenije in Evropska unija iz Evropskega socialnega sklada plus, njegov namen pa je povečati vključenost odraslih v vseživljenjsko učenje (VŽU) ter izboljšati kompetence, ki jih odrasli potrebujejo zaradi potreb na trgu dela, večje zaposljivosti in mobilnosti ter osebnega razvoja za delovanje in odzivanje na tehnološke, demografske in podnebne spremembe v sodobni družbi.

Ljudska univerza Kranj je na javnem razpisu Temeljne kompetence 2023-2029 Ministrstva za vzgojo in izobraževanje pridobila finančna sredstva za izvajanje tega projekta, ki se bo s

pomočjo konzorcijskih partnerjev (Šolski center Kranj in Biotehniški center Naklo) izvajal do junija 2029. Med načrtovanimi kazalniki je izvedba 248 izobraževalnih programov, od tega 28 javnoveljavnih, vključenih pa naj bi bilo 1942 udeležencev.

Programi, ki se s strani vseh sodelujočih izvajajo v sklopu projekta, so za udeležence brezplačni. Pri izvajanju programov bodo sodelovali različni izvajalci in strokovni delavci, ki bodo skušali pokriti različna področja za dvig spretnosti in kompetenc odraslih, še posebej ranljivih skupin. Ciljna skupina so odrasli, med katerimi bodo zajeti tudi tisti iz ranljivih skupin: nižje izobraženi, aktivni, ki so stari 55 let ali več, ter tujci.

3 TEČAJ GRAFIČNEGA OBLIKOVANJA

Cilji projekta so pridobitev in izboljšanje temeljnih kompetenc ter splošne izobraženosti odraslih. Za doseganje teh ciljev, je bilo pripravljenih več izobraževanj iz različnih področij. Eno od področij je bilo tudi pridobivanje digitalnih kompetenc, v katero sodi tudi grafično oblikovanje.

Program je namenjen vsem odraslim osebam, ki že delajo v industriji oblikovanja ali umetnosti in bi lahko izobraževanje uporabili za izboljšanje svojih tehničnih veščin in obogatitev svojega portfelja:

- podjetnikom, ki pogosto potrebujejo znanje grafičnega oblikovanja za ustvarjanje marketinških materialov, logotipov, spletnih strani in drugih vizualnih vsebin za svoje podjetje,
- marketinškim strokovnjakom, ki bi znanje grafičnega oblikovanja lahko uporabili za izdelavo privlačnih marketinških materialov, kot so letaki, oglasi, digitalne objave in druge promocijske vsebine,
- fotografom, ki bi izobraževanje lahko izkoristili za izboljšanje svojih veščin obdelave fotografij, kar jim pomaga pri izboljšanju kakovosti svojih del in trženju,
- učiteljem in izobraževalcem, ki poučujejo umetnost, grafično oblikovanje ali sorodne predmete, ki bi lahko izobraževanje uporabili za pridobitev novih orodij in znanja za poučevanje,
- samostojnim ustvarjalcem, ki želijo razvijati svoje spretnosti iz hobija ali kot dodaten vir dohodka in bi lahko tečaj izkoristili za izboljšanje svojih veščin.

Cilji izobraževalnega programa pa so bili sledeči:

- Razumevanje osnov grafičnega oblikovanja: Udeleženci se naučijo osnovnih načel oblikovanja, kot so kompozicija, tipografija, barvna teorija in vizualna hierarhija.
- Obvladovanje grafičnih programov: Znanje uporabe različnih grafičnih programov, kot so Adobe Photoshop, Illustrator, InDesign, Lightroom in druge specializirane programske opreme za grafično oblikovanje in obdelavo fotografij.
- Razvoj kreativnih sposobnosti: Spodbujanje kreativnega razmišljanja in inovativnosti pri ustvarjanju vizualnih rešitev za različne medije in platforme.
- Razumevanje vizualne komunikacije: Poudarek na razumevanju, kako vizualne elemente uporabljati za učinkovito komunikacijo sporočil in idej.
- Teoretično znanje: Razumevanje zgodovine in teorije grafičnega oblikovanja ter obdelave fotografij, vključno s preučevanjem pomembnih gibanj, slogov in oblikovalskih trendov.
- Praktične veščine: Razvijanje tehničnih in praktičnih veščin, ki so potrebne za izvedbo različnih projektov, vključno z oblikovanjem publikacij, embalaže, oglasnih sporočil, spletnih strani in drugih vizualnih medijev.
- Kritično razmišljanje: Spodbujanje analitičnega in kritičnega razmišljanja pri evalvaciji lastnih del in del drugih oblikovalcev, kar pomaga pri izboljšanju kakovosti in učinkovitosti oblikovalskih rešitev.
- Etična in profesionalna vprašanja: Učenje o etičnih standardih v industriji grafičnega oblikovanja in obdelave fotografij ter razumevanje profesionalnih praks in norm.

Končni cilj tečaja je bil, da znajo tečajniki izdelati svoj oglas z uporabo teoretičnih in praktičnih veščin, ki so jih pridobili na tečaju. Krmelj pravi, da nastanek enega oglasa zahteva ljudi z znanjem s področja ekonomije, oblikovanja, fotografije, filma, psihologije, jezikoslovja, umetnosti, kulture, računalništva... [2], zato smo pri načrtovanju vsebin tečaja moči združili strokovnjaki iz različnih področij.

4 VPLIV BARV NA ČUSTVA IN VEDENJE UPORABNIKOV

V tečaju grafičnega oblikovanja, ki so ga izvajali na Šolskem centru Kranj, sem vsebine obogatila z vlogo barv, ki so pomemben zunanji dejavnik pozornosti, in pomagala doseči cilj razumevanja vizualne komunikacije, konkretneje, kako vizualne elemente uporabljati za učinkovito komunikacijo sporočil in idej preko barv in njihovega odnosa do realnosti.

4.1 Barva kot fizični fenomen in njena vloga v kulturi

Pri zaznavanju realnosti so izredno pomembni predvsem: oblika zaznanih predmetov, njihov relief, njihova voluminoznost in njihovi prostorski odnosi z drugimi predmeti. Toda barva ima kljub temu mnogo globlji pomen, saj je njen vpliv sila razprostranjen v različnih sferah subjektovega psihičnega (predvsem čustvenega) dogajanja [3].

Barva, za razliko od oblike, dodaja predmetom še določeno čustveno vsebino. Simbolika barv ima tako pomen v vseh oblikah človekove kulturne dejavnosti, saj spodbuja subjektovo intuitivnost, ga sili k spoznavanju in omogoča doživljajsko polnost, ki temelji na aktivaciji mnogih psihičnih procesov na več ravneh [3].

4.2 Psihološko-simbolični učinki nekaterih barv ter vpliv na doživljanje in vedenje uporabnikov

Rdeča je bila prva barva, ki jo je človek poimenoval [3]. Psihološko-simbolični učinek doseže zaradi fizične povezanosti z ognjem in krvjo. A z redečo moramo biti pri vizualni komunikaciji precej previdni, saj je zelo vpadljiva barva, ki lahko v določenih okoliščinah deluje precej nasilno. Opazovalec jo bo pogosto implicitno interpretiral kot nevarnost ali prepoved, saj

vedno izstopi iz svojega naravnega okolja. Presoditi moramo torej, ali jo lahko uporabimo kot orodje za aktivnost, privlačnost, dinamičnost ali pa bo v kontekstu delovala neresno in površinsko in bo posledično opazovalec spregledal njeno sporočilo.

Zelena se v naravi pojavlja v izredno velikih količinah, a je običajno stopnja njene zasičenosti nizka, tako da je njen vpliv na človeka običajno ugoden [3]. Pogosto jo povezujemo s svobodo. Nenazadnje tudi zelena luč pomeni prosto pot. Pri vizualni komunikaciji moramo upoštevati pomirjevalni vpliv na organizem, a z zavedanjem, da je vpliv na posameznika odvisen predvsem od drugih barv, ki se pojavljajo skupaj z njo. Če jo kombiniramo z modro in belo, sporoča pozitivne, s črno, rumeno in vijoličasto pa negativne lastnosti.

Kljub temu, da rumeno barvo največkrat asociiramo s soncem, ki simbolizira svetlobo, vedrino in optimizem, je potrebno biti pazljiv pri uporabi te barve, saj njena simbolika ni vedno tako optimistična. Pogosto so jo uporabljali kot nevarno opozorilo ali neprijetna čustva (npr. kugo, karanteno, izdajalstvo; izmed čustev pa zavist, ljubosumnost in skopost). Z rumeno v kombinaciji s črno bo učinek kar »zbodel v oči«, sploh, če bo sporočilo v daljavi (npr. plakat), bo pa asociacija pri ljudeh verjetno »nevarno, strupeno« [3].

Modro povezujemo z daljavo in neskončnostjo, saj z oddaljevanjem skoraj vsi predmeti dobijo modrikast odtenek, saj jih postopoma prekrijejo zračne plasti [3]. Poleg oddaljenosti simbolizira prosojna modrina še velikost, saj optično povečuje predmete. Dodaja pa modra implicitno atribute božanskosti, saj jo najdemo v simboliki kar nekaj religij. Vseeno ne smemo mimo občutka hladnosti, ki jo vzbudi moder prostor, ljudje, ki jih osvetlimo z modro barvo pa izgledajo bledi in bolehni [3].

5 NEPRAVILNA IN PRAVILNA UPORABA BARV NA PRIMERU

Na tečaju grafičnega oblikovanja, so bila tečajnikom jasno predstavljena prej zapisana teoretična izhodišča v povezavi z vplivom barv na čustva in vedenje uporabnikov. Predstavljen je bil tudi primer na osnovi izdelanega jumbo plakata.

Sliki 1 in 2 prikazujeta primer, ko pri oblikovanju jumbo plakata niso bili dovolj upoštevani psihološki in simbolni učinki barv, da bi dosegli učinkovito vizualno komunikacijo. To je privedlo do zelo ne opaznega plakata. Zeleni grafični elementi so se preveč zlili z okolico (travo in nebom), kar je zmanjšalo njegovo vidnost in učinkovitost pri pritegnitvi pozornosti.

Nasprotno pa Sliki 3 in 4 prikazujeta primer uspešnega plakata, kjer so bile barve izbrane in uporabljene strateško. Še vedno sicer prevladuje zelena barva, ki je povezana z celostno grafično podobo šole. Pristovnik pravi, da je celostna grafična podoba sestavljena iz imena, simbola in/ali logotipa, tipografije, barve, slogana in pogostokrat tudi drugih grafičnih elementov [4]. Dodana pa je tudi rdeča barva, ki pritegne pozornost in plakat loči od pokrajine.

Končni jumbo plakat je bil vizualno privlačen in čustveno učinkovit. Uporabljene barve so pomagale pritegniti pozornost, komunicirati sporočilo in vzbuditi pozitivne občutke pri gledalcih.

Udeleženci tečaja so skozi ta proces pridobili praktično znanje o pomenu in uporabi barv v grafičnem oblikovanju, kar bo koristilo njihovim prihodnjim projektom.

Slika 1: Kreativa jumbo plakata iz leta 2022

Slika 2: Zelo ne opazen jumbo plakat zaradi pomanjkanja nevpadljivih barv

Slika 3: Kreativa jumbo plakata iz leta 2023

Slika 4: Zelo opazen jumbo plakat zaradi pravilne izbire barv

6 EMPIRIČNI DEL

Za boljše razumevanje vpliva barv na zaznavanje in učinkovitost jumbo plakatov, smo izvedli kratko anketo med udeleženci tečaja. Cilj ankete je bil raziskati, kako so različne barve povezane s čustveno reakcijo in zaznavno interpretacijo uporabnikov ter ugotoviti, katere barve so najbolj primerne za uporabo na jumbo plakatih glede na mnenja udeležencev.

Anketa je bila sestavljena iz vprašanj, povezanih z zaznavanjem barv in njihovo povezavo s čustvi in subjektivno interpretacijo. Udeleženci so ocenjevali občutke in vrednotili različne barve in kombinacije barv na lestvici od 1 (zelo negativno) do 5 (zelo pozitivno). Skupno je sodelovalo 15 udeležencev, ki so izpolnili anketo ob zaključku tečaja.

Rezultati ankete glede na percepcijo barv so navedeni v tabeli 1, rezultati glede na kombinacijo barv, pa v tabeli 2.

Glede na vrednosti v tabelah, bi lahko zapisali naslednjo interpretacijo rezultatov:

- Rdeča: Udeleženci so rdečo barvo ocenili kot zelo čustveno močno in privlačno. Verjetno izstopa zaradi svoje visoke vidljivosti in jasnosti sporočila.
- Modra: Modra je bila ocenjena visoko zaradi svoje umirjenosti in profesionalnega videza. Kombinacije modre in bele so bile po mnenju udeležencev zelo učinkovite.
- Zelena: Medtem ko zelena barva prinaša občutek svobode in narave, je bila ocenjena nižje zaradi nizke zasičenosti in očitno manjše privlačnosti.
- Rumena in Črna: Kombinacija teh dveh barv je bila ocenjena kot zelo učinkovita za jasnost sporočila, vendar nekoliko nižje za privlačnost, mogoče tudi zaradi asociacij na nevarnost.

Rezultati ankete kažejo, da so različne barve in barvne kombinacije očitno povezane s specifično čustveno reakcijo in zaznavno interpretacijo uporabnikov. Barve, ki so po mnenju udeležencev raziskave najboljša izbira za jumbo plakate, so bile rdeča in modra, zlasti v kombinaciji z belo. Ugotovitve ankete bodo uporabljene za nadaljnje izboljšanje vsebinskega dela tečaja grafičnega oblikovanja, z namenom izobraževanja udeležencev o strateški uporabi barv za učinkovito vizualno komunikacijo.

Tabela 1: Ocene barv glede na čustveni vpliv in zaznavanje

Barva	Čustveni vpliv	Privlačnost	Jasnost sporočila
Rdeča	4.3	4.1	4.7
Zelena	3.7	3.5	3.4
Modra	4.0	4.0	4.2
Rumena	3.4	3.8	3.9
Črna	3.2	3.3	3.7
Bela	3.1	3.2	3.3

Tabela 2: Ocene kombinacij barv glede na učinkovitost jumbo plakatov

Kombinacija	Privlačnost	Jasnost sporočila
Rdeča in Bela	4.4	4.8
Modra in Rumena	4.1	4.3
Zelena in Črna	3.3	3.4
Rumena in Črna	3.5	4.1
Modra in Bela	4.0	4.2

7 ZAKLJUČEK

Tečaj grafičnega oblikovanja, izveden v sklopu projekta, je poudaril pomembnost razumevanja barv in njihovega vpliva na vizualno komunikacijo. Barve igrajo ključno vlogo pri oblikovanju in prenašanju sporočil, saj imajo močne psihološke in simbolične učinke, ki vplivajo na čustva in vedenje uporabnikov. Razumevanje teh učinkov je nujno za ustvarjanje učinkovitih vizualnih sporočil, vendar je pogosto zapleteno in zahteva globoko strokovno znanje.

Glede na kompleksnost vplivov barv na čustva in vedenje uporabnikov je priporočljivo, da se grafični oblikovalci pri svojih projektih posvetujejo s psihologi. Psihologi lahko ponudijo dragocen vpogled v miselne in čustvene odzive, ki jih različne barve lahko povzročijo pri občinstvu, ter pomagajo oblikovalcem izbrati barvne sheme, ki bodo najbolje komunicirale želena sporočila in vzbudile pričakovane reakcije.

Sodelovanje med grafičnimi oblikovalci in psihologi lahko vodi do bolj premišljenih in učinkovitih vizualnih rešitev. Psihološko utemeljeno oblikovanje ne le izboljša estetsko vrednost, ampak tudi poveča učinkovitost komunikacije in dosega večji vpliv na občinstvo. Takšen interdisciplinarni pristop omogoča oblikovalcem, da ustvarjajo vizualna sporočila, ki ne le izstopajo, ampak tudi trajno vplivajo na gledalce.

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S kvizom spoznajmo živali na travniku

Let's Get to Know the Animals on the Meadow with a Quiz

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POVZETEK

V prispevku je predstavljeno, kako smo v skupini 3 letnikov z uporabo IKT- tehnologije, popestrili vzgojno delo in otroke usmerili v nov učni pripomoček, ki jih je motiviral in umiril.

Otroci so že v preteklih mesecih pokazali veliko zanimanja za uporabo računalnika. Tako smo tudi v naši skupini na področju IKT- tehnologije namenili pomembno mesto in širili znanje, ter njeno smiselno uporabnost. Osredotočili smo se na Google Crome, kjer smo si pogledali živali, ki živijo na travniku in jih otroci poznajo. Na Youtube kanalu smo si zavrteli nekaj pesmi teh živali (metulja, krta, mravlje, polža in pikapolonice) in jih večkrat predvajali, saj jih otroci zelo radi poslušajo. Otrokom sem pripravila kratek kviz z vprašanji o travniških živalih, uganke in igro spomin. Najprej so odgovorili na 6 vprašanj o teh živalih, potem so odgovorili na 3 uganke, pokazali kje posamezne živali živijo in zaključili s spominom. Vprašanja so bila vnaprej posneta. Odprli smo PowerPoint in se prepustili kvizu, ki nas je z nekaj pravilnih klikov pripeljal do konca.

Omenjen didaktični pripomoček je otroke motiviral, bili so bolj zbrani in osredotočeni na naloge, ki so jih čakale. Sprva smo jih reševali skupaj, potem pa je delo potekalo individualno z vsakim posameznikom. Vzgojiteljici sva bili ves čas prisotni, saj so bili otroci stari 3 leta in so potrebovali pomoč pri rokovanju z ikt orodjem. Pri reševanju kviza so poslušali vprašanja vzgojiteljice, spremljali drsnike, podali pravilen odgovor ali s prstom pokazali na računalniški ekran, kjer je bil odgovor na vprašanje. Reševanja se niso naveličali. Dejavnosti smo izvajali cel teden. V kviz smo dodali tudi njihovega priljubljenega junaka Marshalla, ki nastopa v risanki Tačke na patrulji. On jih je vodil skozi vsa vprašanja in jih dodatno spodbudil, da je bilo reševanje lažje.

Zavedali smo se, da je IKT del vsakdanjega okolja tudi predšolskih otrok, ki ga je smiselno uporabiti v učno-vzgojnem procesu in jih podučiti o njeni didaktični vrednosti in izkoristiti priljubljenost elektronskih naprav.

KLJUČNE BESEDE

Učenje skozi igro, predšolsko obdobje, IKT, sodelovanje

ABSTRACT

The article presents how, in a group of 3-year-olds, we used ICT technology to diversify the educational work and direct the children to a new learning aid, which motivated and calmed them. The children have already shown a lot of interest in using the computer in the past months. Thus, in our group, we also devoted an important place to the field of ICT technology and spread knowledge and its meaningful applicability. We focused on Google Chrome, where we looked at animals that live in the meadow and that children know. We played some songs of these animals (butterflies, moles, ants, snails and ladybugs) on the YouTube channel and played them several times, because children love to listen to them. I prepared a short quiz for the children with questions about meadow animals, riddles and a memory game. First, they answered 6 questions about these animals, then they answered 3 riddles, showed where individual animals live and ended with a memory. The questions were prerecorded. We opened PowerPoint and indulged in a quiz that took us to the end with a few correct clicks. The mentioned didactic aid motivated the children, they were more collected and focused on the tasks that awaited them. At first we solved them together, but then the work was done individually with each individual. The teachers and I were present the whole time, as the children were 3 years old and needed help handing ICT tools. When solving the quiz, they listened to the teacher's questions, followed the sliders, gave the correct answer or pointed their finger at the computer screen where the answer to the question was. They didn't get tired of the rescue. We carried out activities throughout the week. We also added their popular hero Marshall, who appears in the Paw Patrol cartoon, to the quiz. He guided them through all the questions and further encouraged them to make the solution easier.

We were aware that ICT is part of the everyday environment of preschool children, which makes sense to use in the educational process to teach them about its didactic value and take advantage of the popularity of electronic devices.

KEYWORDS

Learning through play, preschool period, ICT, collaboration

1 UVOD

Sodobna tehnologija na vsakem koraku kroji naš vsakdan, tako v naših službenih okoljih kot zasebnem življenju. Posledično je tudi vsaka generacija naših najmlajših, ki jih vleče zgled staršev, starejših sorojencev, vzgojiteljev, vse bolj spretna pri rokovanju s t. i. pametnimi napravami. Za uporabo moderne tehnologije so zelo motivirani, saj jih privlačijo številni multisenzorični dražljaji.

Digitalni mediji so kulturno orodje, ki močno vplivajo na naš način razmišljanja. Delujejo kot okoljska spodbuda, ki oblikuje našo možgansko strukturo. Preko računalnika otroci prejemajo različne nasprotujoče iztočnice, ki vplivajo na njihovo vedenje in posledično na razvoj njihovih možganov. Če digitalno tehnologijo uporabljamo zmerno, le-ta otrokom zelo koristi. Pozitivno vpliva na fizični, kognitivni in čustveni razvoj otroka [1].

V kurikulumu za vrtce je navedeno, da se digitalna tehnologija vedno bolj uporablja na različnih področjih in okoljih (doma, v vrtcu…) in za različne namene (zabavo, učenje…). Predšolski otrok se dnevno srečuje z IK sredstvi (opazuje, posluša odrasle, rokuje…), zato sem se kot vzgojiteljica odločila, da otrokom ponudim različne možnosti in izzive (otroke učimo uporabljati IK sredstva, jim približamo internet) in tako ozaveščamo svoj odnos do nje [2].

2 POTEK DELA V SKUPINI

2.1 Uvodna motivacija

Z otroki smo se zbrali pred računalniškim zaslonom in si preko Google Croma pogledali živali, ki živijo na travniku. Sami so predlagali, katero žival naj poiščemo. Poiskali smo polža, mravljo, pikapolonico, krta in metulja. Otroci so navdušeno opazovali ekran in miško in ugotovili, da lahko na računalniku poiščemo vse, kar nas zanima. Tako smo odprli še YouTube kanal in predvajali pesmi o izbranih živalih. Izbire je bilo veliko. Nekatere pesmi smo predvajali večkrat.

2.2 Glavni del dejavnosti- reševanje kviza

Osredotočili smo se na glavno dejavnost in začeli z reševanjem kviza (slika 1). Sledila so vprašanja (slika 2): Klikni na žival in poslušaj kako se imenuje, klikni na žival, ki ni travniška, koliko travniških živali vidiš, katera žival prinaša srečo, katera žival prideluje med, katera žival nosi vedno hiško s seboj?

Za tem so sledile uganke (slika 3):

Ko je majhen, je buba, ko odraste, leti, na rožah poseda, poleti živi?

Iz smrečja igel dom imajo, nič iger,- delo le poznajo?

V črni zemlji dan za dnem, rije varno vsem očem, če pokuka, kje na plan, s kupčkom zemlje je izdan?

Slika 1: Reševanje kviza

Slika 2: Vprašanje o živalih

Slika 3: Uganka

Po rešenih ugankah so otroci povedali, kje domuje čebela, mravlja in krt. Na koncu pa so se preizkusili še s kvizom. Vsem otrokom so bila vprašanja jasna in odgovori so bili pravilni. Junak Marshall jim je bil posebno všeč (Slika 4). Motiviral je tudi ostale, da so lažje sedeli na stolu in sledili celotnemu kvizu. Z vsakim dnem jim je šlo lažje. Postali so bolj samozavestni. Tudi otroci, ki v prvih dneh niso bili dovolj aktivni, so postali bolj sproščeni in so se lahko vključili med ostale otroke in sodelovali. Za njih je bilo to nekaj novega, neznanega. Učenje preko igre jih je navdušilo.

Slika 4: Otroci si ogledujejo Marshalla, ki nastopa v kvizu

3 ZAKLJUČEK

Projektno delo s kvizom spoznajmo živali na travniku, se je izkazalo kot uspešen primer dobre prakse. Vsekakor je omenjeni didaktični pristop popestril naše vzgojno delo. Otroci so se v vrtcu prvič srečali z IKT-tehnologijo in vsekakor ne zadnjič.

Otroci so si s tem razširili splošno razgledanost, logično mišljenje, ter krepili spomin. Vse to, jim lahko v prihodnje pomaga in zmanjša ovire pri socialni interakciji. Tudi najmlajšim tako zagotovimo vključitev v porajajočo se digitalno pismenost in jim zagotovimo enake možnosti in zmanjšamo razlike med njimi. Računalnik je močno motivacijsko sredstvo, ki ne potrebuje posebnih stimulacij za delo. Otroci so videli, da nam naprava ponuja veliko možnosti. Ob njej se lahko zabavamo, sprostimo in kaj novega naučimo.

Slika 5: Igra spomin na koncu kviza

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E-branje in e-knjige: posebnosti in izzivi v šolski praksi

E-reading and E-books: Specifics and Challenges in School Practice

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POVZETEK

V prispevku predstavljamo e-knjige in e-branje v šolski praksi. Osredotočamo se na posebnosti in izzive, ki se porajajo pri njihovem vključevanju v pouk slovenščine. Povzemamo nekatere raziskave e-branja, njegove specifike in možnosti, ki jih nudi za bralno motivacijo pri današnjih šolajočih se generacijah, ki so v digitalni svet vpete praktično na vseh korakih.

KLJUČNE BESEDE

E-knjiga, e-branje, pouk slovenščine, motivacija za branje, digitalna generacija

ABSTRACT

In this paper we present e-books and e-reading in school practice. We focus on the specifics and challenges that arise, when we include them in Slovenian language lessons. We summarize some research of e-reading, its specifics and the possibilities, that e-books offer for reading motivation among today's school-age generations, who are embedded in the digital world at practically every step.

KEYWORDS

E-book, e-reading, Slovene language lesson, reading motivation, digital generation

1 BRANJE IN E-BRANJE: PODOBNOSTI IN RAZLIKE

1.1 Opredelitev (e-)branja

Pri strokovnih (in znanstvenih) razpravah o (e-)branju je vedno potrebno vzeti v obzir čas in s tem družbene okoliščine, znotraj katerih se pogovarjamo o branju. Prav tako je potrebno jasno definirati, o katerem segmentu branja oz. stopnji razvoja bralne zmožnosti razpravljamo.

Če se dotaknemo opredelitve branja, gre za proces dekodiranja/prepoznavanja zapisanih črk in njihovega pretvarjanja v glas, tj. izgovorjave. Gre za človeku specifično dejavnost, ki nam ni dana, ampak se je (na)učimo. Da postane avtomatiziran proces, je potrebno (dovolj) vaje. Kot tako predstavlja najučinkovitejše sredstvo usvajanja znanja. Učenje branja poteka stopenjsko (več o tem v [18]).

Če se osredotočimo na namene prispevka, bomo v nadaljevanju s pojmom "branje" zajeli opredelitev, uveljavljeno v slovenistični stroke. Ta branje[1] razume kot temeljno dejavnost, ki vodi k bralni pismenosti [5].

1.2 Kratek pregled raziskav e-branja

V slovenskem prostoru je relativno malo raziskav, ki bi se osredotočale na raziskovanje razlik med "klasičnim" branjem, tj. branjem s papirja, in med "digitalnim" oz. e-branjem. Med raziskavami izstopa S. Pečjak [20], ki s sodelavko ugotavlja, da je generacija Y[2] pri e-branju nekoliko hitrejša od branja s papirja, kar pripisuje verjetnemu pogostemu pregledovanju družabnih omrežij, brskanju po spletu in branju informativnih vsebin, pri čemer zaradi same narave tovrstnih besedil redkeje uporabljajo metakognitivne strategije in torej manj preverjajo svoje razumevanje med samim branjem. Posledično lahko z računalnika berejo hitreje kot s papirja, vendar manj natančno in imajo zato več težav s ponovnim iskanjem informacij, porabijo več časa za naloge bralnega razumevanja in odgovarjanjem na vprašanja. Glede razumevanja prebranega pa med tistimi, ki so brali s papirja, in tistimi, ki so brali na zaslonu, ni pomembnih razlik [20].

Za primerjavo z rezultati slovenske raziskave naj navedemo še primer raziskave na Norveškem, ki jo je s sodelavci izvedla E. Mangen [4]. Ugotovili so, da so učenci, ki so brali besedila s papirja, dosegli boljše rezultate pri nalogah bralnega razumevanja od tistih, ki so brali besedila na zaslonih. V tem segmentu se raziskavi med seboj razlikujeta.

A. Kepic Mohar [1] pa ugotavlja, da je proces pridobivanja znanja in s tem celotnega razvoja posameznika, za katerega je v preteklosti veljalo, da potekalo (s knjigami in) z branjem, dandanes le še pot do pragmatičnega cilja, torej orodje za lažji vstop na trg delovne sile. Novi digitalni mediji, ki praktično vsakodnevno vstopajo v vse sfere našega življenja, vplivajo in

[1] V prispevku se bomo osredotočili na branje digitalnega bralnega gradiva in ga mestoma primerjali s (klasičnim) tiskanim. Stroka pa poleg teh dveh med vrste bralnih gradiv uvršča še zvočne in interaktivne (za več glej razvojni projekt Bralna pismenost in razvoj slovenščine – OBJEM (Ozaveščanje, Branje, Jezik, Evalvacije, Modeli), ki je potekal pod okriljem Zavoda Republike Slovenije za šolstvo).

[2] Tudi t. i. digitalna generacija, ki je odraščala v drugačnih okoliščinah in je bolj vajena branja z računalniškega zaslona, zato ima tudi najbrž temu primerno razvite bralne strategije [20].

spreminjajo oblike sporazumevanja/komunikacije, jezik, ki ga pri tem uporabljamo, značilnosti pisanja in podobno, nenazadnje pa tudi naše zmožnosti sprejemanja besedil različnih vrst, kamor spada branje.

1.3 Posebnosti branja elektronskih besedil

Digitalizacija je spremenila naš vsakdan in močno posegla tudi v šolstvo. Ne le da je omogočila hiter dostop do velike količine informacij, spremenila je tudi naš način razmišljanja ter branja in posledično učenja, če ostajamo na predpostavki, da je branje (še vedno) najučinkovitejši način usvajanja znanja, čeprav se učenci več ne učijo samo s papirja, ampak tudi z zaslona.[3]

Da bi lahko razumeli posebnosti branja elektronskih besedil in jih upoštevali v svoji praksi, je potrebno poznati značilnosti digitalnih virov. Ti imajo dve temeljni značilnosti:

(1) nematerialnost oz. neoprijemljivost in
(2) večzaznavno naravo interakcij.

Učenec torej pri uporabi digitalnih virov nima konkretnih oz. oprijemljivih predmetov za manipulacijo (prijemanje, premikanje …), poleg tega pa je v digitalnem okolju prekinjena prostorsko-časovna povezanost med aktivnostjo učenca in njegovim zaznavanjem. Digitalna/elektronska besedila zmanjšujejo eno ključnih navigacijskih sposobnosti bralca, tj. nadzor nad branjem, ki je ena od osrednjih regulacijskih sposobnosti [19].

A. Kepic Mohar [1] (po Kovač in van der Well 2018) povzema tri načine branja, ki so posledica digitalizacije in ki so povezani z dolžino besedil ter medijem, na katerem beremo:

(1) branje s preletom (angl. *skimming*);
(2) vživeto branje (angl. *immersive/absorbed reading*), ki poteka pri branju žanrskega leposlovja;
(3) poglobljeno/globoko branje (angl. *in-depth/deep reading*), ki pa je kognitivno zahtevnejše oz. študijsko branje in vključuje predznanje.[4]

Da je e-branje drugačno od branja s papirja, je pokazala tudi mednarodna raziskava *Spretnosti odraslih* (PIAAC), kakor povzema njene rezultate P. Javrh [15]. Že sama narava elektronskih besedil narekuje "drugačno" branje, je potrdila raziskava. Poleg tega pa je za učinkovito obdelavo informacij v digitalnem okolju predpogoj dobro usvojena bralna tehnika/veščina. Ta je namreč potrebna, da lahko pri e-branju in obdelavi e-gradiv stečejo zahtevnejši kognitivni procesi.

2 E-KNJIGA IN ZVOČNA KNJIGA: ISTA STVAR, RAZLIČNO POIMENOVANJE?

V šolski praksi se pogosto dogaja, da se uporabljata dva različna izraza za isto stvar, kar vnaša marsikatero zmedo in nejasnost. Tudi kar zadeva e-branje (ali elektronsko branje), ki se odvija v e-knjigah (ali elektronskih izdajah knjig), se dogajajo (napačne) interference z drugim pojmom. Gre za t. i. zvočne knjige, ki v zadnjih letih (zlasti po epidemiji covida) vedno bolj prodirajo v vsakdanje življenje in šolsko prakso, zato je prav, da nekaj mesta namenimo tudi razmejitvi teh dveh pojmovanj.

2.1 Opredelitev e-knjige

Slovar slovenskega knjižnega jezika (dostopen na fran.si v nadaljevanju *SSKJ*) opredeljuje e-knjigo oz. elektronsko knjigo kot knjigo v elektronski obliki, namenjeno zlasti za branje na e-bralniku ali drugih elektronskih napravah. Kot sopomenko e-knjigi najdemo tudi pojem digitalna knjiga (prim. [24]). Tukaj najdemo še nekoliko obširnejšo opredelitev, saj gre za enciklopedičen članek, in sicer da je to knjižna publikacija, izdana v digitalni obliki. Lahko je izdana samostojno ali kot različica tiskane knjige. Namesto v fizični obliki do nje dostopamo s pomočjo računalniške naprave in se izpisuje na zaslonu (za primerjavo glej [6]).

E-knjiga je torej prvenstveno namenjena branju (in posledično v šolski praksi bralnemu razumevanju).

2.2 Opredelitev zvočne knjige

V *SSKJ* ne najdemo zadetka pod iztočnico "zvočna", ko želimo najti definicijo zvočne knjige, prav tako ne pod iztočnico "knjiga". Ponujena nam je razlaga pod iztočnico "avdioknjiga" in je v *SSKJ* opredeljena kot "obsežnejše literarno besedilo, ki je posneto na nosilec zvoka, navadno na CD-ploščo". Nadalje jo najdemo še pod iztočnico "zvočnica", ki jo *SSKJ* opredeljuje kot:

(1) "zvočni posnetek zlasti literarnega besedila, ki ga navadno berejo profesionalni bralci, igralci" oz. kot
(2) "knjig[o] za otroke, ki omogoča zaznavanje predstavljene vsebine (tudi) s sluhom".

Iz slovarskega sestavka izvemo še, da je pojem "zvočnica" nastal iz "zvočne knjige" po zgledu angleškega izraza "audio book" in da se zanj uporabljata še sinonimna pojma "avdioknjiga" in "zvočna knjiga".[5]

Zvočna knjiga/zvočnica je torej knjiga, namenjena poslušanju (posledično v šolski praksi imenovanemu slušnemu razumevanju).

2.3 Kaj pa (e-)bralnik?

E-bralnik (pogosto tudi elektronski papir ali e-papir) je naprava, zelo podobna tabličnemu računalniku, namenjena branju e-knjig. Zanj je značilen zaslon e-ink oz. zaslon s črnilom. "Zaslon s črnilom je vrsta zaslonske tehnologije, ki natančno posnema videz knjige. E-ink zaslon je tudi zelo varčen in manj obremenjuje oči." [10] (več o tem tudi [11])

3 APLIKACIJE, NAMENJENE BRANJU E-KNJIG

V nadaljevanju navajamo pregled aplikacij, namenjenih branju e-knjig. Pri tem se osredotočamo na e-knjige v

[3] Za lažje razumevanje posebnosti e-branja (tudi digitalnega branja, kakor se pogosto imenuje v slovenistični stroki, primer [2]), na kratko po S. Pečjak [19] povzemamo nekaj značilnosti generacij, ki so v času nastajanja prispevka vključene v sistem formalnega izobraževanja. Gre za dve generaciji, in sicer za (1) generacijo Z (rojeni v letih 1995–2010), imenovano tudi digitalni pionirji, in (2) generacijo alfa (rojeni po letu 2010), ki jo imenujejo tudi digitalni domorodci. »Za obe generaciji je značilno, da sta v svojem življenju doživeli največ družbenih sprememb od vseh generacij pred njima, najbolj pa ju je zaznamovala digitalizacija življenj, tj. povsod navzoča prisotnost tehnologije« (62) Nadalje avtorica povzema rezultate raziskav, ki so pokazale, da „digitalne" generacije nimajo odpora do branja z zaslona, a lažje razumejo slišano/prebrano in prikličejo bistvo prebranega, če poslušajo oz. preberejo na papirju kot v e-obliki.

[4] Na podlagi nove informacije si širimo besedni zaklad in s kognitivnimi procesi gradimo znanje [1] (po Kovač in van der Well 2018).

[5] Za več glej [12].

slovenskem jeziku, saj želimo osvetliti priložnosti in ovire pri njihovi uporabi pri pouku slovenščine [6] (kot prvega oz. maternega jezika):

(1) KOBI je aplikacija, namenjena začetnemu branju, tj. učenju in treningu branja (bralne tehnike). Uporaba aplikacije je brezplačna. Ker je namenjena učenju branja in je torej primerna za prvo triletje osnovne šole, je podrobneje ne bomo obravnavali.
(2) Biblos, spletna platforma, je prva slovenska e-knjižnica (in e-knjigarna), nastala leta 2013 pod okriljem Beletrine, zavoda za za založniško dejavnost, in s sodelovanjem mreže slovenskih knjižnic ter inštitutom IZUM, skrbnikom sistema COBISS [13]. Prvenstveno je bila namenjena izposoji e-knjig, kasneje tudi njihovemu nakupu. Za uporabnike, člane splošnih knjižnic, je bila izposoja brezplačna. S 1. 6. 2024 jo je za člane splošnih knjižnic nadomestila platforma COBISS Ela (več o njej v nadaljevanju). Beletrina ima od takrat naprej novo platformo, Beletrina Digital, ki ob plačilu naročnine nudi izposojo in nakup e-knjig, zvočnih knjig, filmov, podkastov in prispevkov.
(3) sBiblos je Beletrinina spletna platforma, namenjena izposoji knjig za učence zadnjega triletja osnovne šole in srednješolce. Uporaba je zanje brezplačna, prijava je mogoča z AAI računom.
(4) Mladinska knjiga PLUS je aplikacija založbe Mladinska knjiga, ki ob plačilu izbranega paketa nudi različne digitalne vsebine (e-knjige, zvočnice, animirane pravljice in podkaste ter drugo, glede na izbran paket).
(5) COBISS Ela je platforma, ki nudi članom splošnih knjižnic ob namestitvi ustrezne programske opreme izposojo e-knjig.

3.1 Za šolsko prakso uporabne aplikacije

Pregled aplikacij za e-branje, ki so uporabne v šolski praksi, bomo naredili na podlagi temeljnih ciljev pouka književnosti, ki jih opredeljuje učni načrt za osnovno šolo v zadnjem triletju (7.–9. razred) in učni načrt za gimnazijo.[7] Kot podlago smo vzeli še gradnike bralne pismenosti projekta OBJEM [8], ki se nanašajo na branje in bralno motivacijo.

3.1.1 Cilji pouka slovenščine (kot prvega oz. maternega jezika)

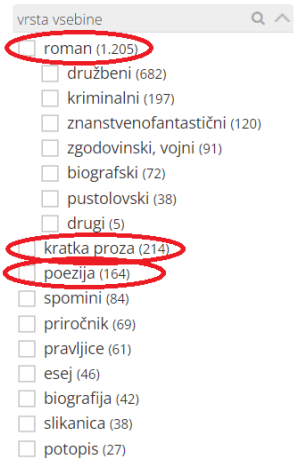
Naj na kratko zaradi lažjega razumevanja in za argumentacijo izbora povzamemo temeljne cilje pouka slovenščine, ki se nanašajo (tudi) na (motivacijo za) branje.

Učenci in dijaki pri pouku slovenščine razvijajo sporazumevalno zmožnost v slovenskem (knjižnem) jeziku, torej zmožnost kritičnega sprejemanja (in tvorjenja) besedil različnih vrst. Branje (zlasti v okviru pouka književnosti) prepoznavajo kot užitek, prijetno doživetje in intelektualni izziv. "Pri razvijanju sporazumevalne zmožnosti ob dejavnem stiku z neumetnostnimi in umetnostnimi besedili z uporabo digitalne tehnologije varno, ustvarjalno in kritično pridobivajo ter uporabljajo podatke/informacije." [21] (7) V gimnaziji razvijajo zmožnost literarnega branja kot specifično podvrsto sporazumevalne zmožnosti ter se usposabljajo za branje in interpretacijo literarnih besedil [22] (7).

Eden od gradnikov bralne pismenosti je motiviranost za branje, ki zajema interes za branje, pozitiven odnos do branja različnih vrst besedil (za različne namene, in sicer branje za znanje in branje leposlovja oz. razvojanje bralne kulture) ter izbiranje tiskanih in drugih informacijskih virov glede na namen branja v povezavi z uporabo različnih lokacij bralnih virov. Drug (za naš prispevek relevanten) gradnik je še tekoče branje, ki med drugim zajema tehniko branja (in njeno prilagajanje zahtevam besedila).

3.1.2 Zbirka e-knjig v slovenščini

Razpoložljiva baza e-knjig v slovenskem jeziku zajema zlasti literarna/umetnostna besedila, kot je razvidno s Slike 1[8] in ki jih obravnavamo pri pouku književnosti. Ker gre za branje literarnih besedil, to vrsto branja v slovenistični stroke imenujemo literarno branje[9] (prim. [5, 3]).



Slika 1: Tipologija e-knjig v COBISS Eli (zajem zaslona)

Tudi baza e-knjig, ki so brezplačno na voljo za učence in dijake v platformi sBiblos zajema literarna besedila, kot je razvidno s Slike 2.

Slika 2: Tipologija e-knjig v sBiblosu (zajem zaslona)

[6] Osredotočili se bomo na pouk slovenščine od 6. do 9. razreda osnovne šole in pouk slovenščine v srednješolskem izobraževanju.
[7] Na ostale programe srednješolskega izobraževanja se nismo posebej osredotočali, saj gre v večini za nadaljevanje in manjšo nadgradnjo osnovnošolskih ciljev.
[8] Podatke sicer navajamo za platformo COBISS Ela, vendar podobno velja tudi za Biblos v začetku leta 2017 [13]: razmerje gre v prid leposlovja, in sicer je predstavljajo 71 % vseh razpoložljivih e-knjig, strokovna literatura pa 29 %.
[9] V stroki pojmujemo literarno branje kot najbolj kompleksno branje, ki nudi največ možnosti oblikovanja vsestranskega bralca [5, 3].

E-knjige v slovenskem jeziku najdemo tudi na slovenskem Wikiviru [23] (in drugih spletnih mestih), kjer so digitalizirana dela slovenskih avtorjev različnih obdobij slovenske književnosti (prim. [14, 25]). Ker gre za postavitev literranih besedil na splet, do katerih ne dostopamo preko aplikacije, jih v našem prispevku ne bomo podrobneje obravnavali.

3.2 Možnost uporabe izbranih aplikacij pri pouku

Pri predstavitvi možnosti uporabe aplikacij za branje e-knjig smo se odločili za vključitev tistih, ki nudijo brezplačno uporabo za učence in dijake, saj na ta način omogočimo vsem učencem enake možnosti dostopa. To sta dve, in sicer COBISS Ela in sBiblos.

3.2.1 COBISS Ela

Platforma COBISS Ela na spletni strani [7] nudi pregledna navodila, katere naprave in aplikacije za branje podpirajo izposojo in branje e-knjig. Kot prednost platforme gre izpostaviti, da lahko e-knjige beremo na mobilnih napravah, ki temeljijo na Androidu in tudi na sistemu iOS. Zraven je navedeno tudi ime aplikacije, ki si jo je potrebno namestiti. Navodilom so dodani tudi e-vodiči za posamezne korake.

E-knjige lahko beremo tudi na osebnih računalnikih ter bralnikih e-knjig in bralnikih inkBOOK. Preprost je tudi način iskanja želene e-knjige, saj je brskalnik enak iskalniku tiskanih knjig v knjižnicah. To je zagotovo velika prednost, saj ni potrebnega "novega učenja" iskanja želene e-knjige.

V bazi e-knjig najdemo večino sodobnih slovenskih mladinskih romanov, ki najbolj motivirajo mlade bralce, saj jih nagovarjajo z njim aktualnimi vsebinami/temami. E-knjigo si lahko izposodimo na dveh različnih napravah, na voljo pa nam je 21 dni od dneva izposoje. Naenkrat si lahko uporabnik izposodi 5 e-knjig. To je lahko uporabno za učence, saj lahko e-knjige berejo na dveh različnih napravah, na eni npr. v šoli in na eni doma. Prav tako lahko hkrati berejo več različnih knjig, jih med seboj primerjajo (iščejo podobnosti in razlike, analizirajo posamezne motive ipd.).

3.2.2 sBiblos

Beletrinin sBiblos prav tako deluje na mobilnih napravah z operacijskima sistemoma Android in iOS. Na spletni strani [9] so podrobna navodila, kako po korakih namestiti potrebne aplikacije za dostop do e-knjig. Zelo uporabni so tudi e-vodiči in slikovno gradivo, ki pomaga pri nameščanju in uporabi bralnika. E-knjige lahko uporabniki berejo na osebnih računalnikih, mobilnih napravah in e-bralnikih.

Do storitev sBiblos lahko učenci dostopajo z AAI uporabniškimi podatki, v kolikor ima šola urejen dostop do storitve Moja Knjižnica in podpisano pogodbo o obdelavi osebnih podatkov z IZUM-om.

V zbirki e-knjig najdemo večino literarnih del, ki se obravnavajo v šoli in tudi novejša dela z učencem in dijakom privlačnimi temami. Tudi sBiblosovi zbirki pedstavljajo navečji del literarnega opusa romani in kratka proza. Učenci in dijaki si lahko naenkrat izposodijo 3 e-knjige, na mesec 10 e-knjig, vsaka knjiga pa jim je na voljo 30 dni od dneva izposoje. V primerjavi s COBISS Elo je čas izposoje e-knjig uporabnikom prijaznejši, je pa na voljo manj hkrati izposojenih knjig.

3.2.3 Čemu v šolsko prakso vključiti e-knjige?

Nanizali bomo zgolj nekaj argumentov, zakaj v šolsko prakso (občasno) vključiti e-knjige.

Prvič se nam zdi takšen način zelo pragmatičen, saj potrebujemo malo opreme, zadostuje že kakšen (pametni) telefon ali tablični računalnik in lahko manjša skupina (predlagamo do 4) učencev/dijakov bere skupaj eno e-knjigo. Na ta način pokrijemo tako sodelovalno učenje, razvijanje digitalnih kompetenc učencev in še hkrati jih motiviramo za branje ter pogovarjanje o prebranem (izmenjavo mnenj, različnih interpretacij prebranega, razjasnjevanje manj jasnih mest ipd.). Na ta način lahko pokrijemo tudi skupno daljše branje izbranih literarnih del po delih z učencem zanimivo/privlačno tematiko.

Podoben način dela lahko uporabimo tudi za (obvezno) domače branje, ki nemalokrat učencev ne pritegne in se ga izogibajo ali pa površno preberejo (pogosto zgolj obnove na spletu). Digitalno tehnologijo lahko v tem primeru uporabimo tudi za refleksijo o prebranem in analizo prebranega, in sicer v obliki e-dnevnika, lastne e-knjige, e-diagrama ali e-table. Ob tem je potrebno učencem le še dati nekaj usmeritev/navodil, kako se lotiti dela.

Vključevanje e-knjig v šolsko prakso pa se vidimo kot koristno tudi za možnost večjega poudarka na lastni izbiri literarnega dela v obliki e-knjige za branje, saj lahko učenec zlahka dostopa do druge e-knjige, če ga tematika ene ne pritegne. To zagotovo deluje zelo motivacijsko pri današnjih generacijah, ki so vešče dela z digitalnimi viri.

SKLEP

Digitalizacija v šolstvu je pogosto videna kot nekaj negativnega, vendar je potrebno pristopiti v smeri iskanja priložnosti in pozitivnih vidikov. Šole in učiteljev računalniki (in naraščajoča uporaba umetne ingteligence) ne bodo mogli nadomestiti, lahko pa učitelji tehnologijo izkoristimo sebi in namenom pouka v prid. Glede na to, da so naši učenci in dijaki "digitalin pionirji" in "digitalin domorodci", je potrebno didaktične pristope prilagajati njim in značilnostim njihovega učenja. S tem vsekakor ne mislimo na popolno opustitev "tradicionalnih" pristopov in načinov dela, ampak tehnologijo izkoristiti za motivacijo tistih področij/dejavnosti, ki jih zaznavamo kot šibkejše oz. manj učinkovite.

V prispevku smo v skladu s tem namenom želeli prikazati, kako en segment pri pouku slovenščine, tj. motivacija za branje (morda tudi domače ali vsaj skupno dolgo branje v razredu) skušati razvijati skladno z značilnostmi šolajočih generacij, da bo čim učinkoviteje in da bodo uspeli uresničiti (vsaj del) ciljev pouka.

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Umetnointeligenčna pismenost in šolske knjižnice

Artificial Inteligence Literacy and School Libraries

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POVZETEK

V prispevku je podana razlaga termina umetnointeligenčna pismenost, predstavljen je vidik uporabnosti umetne inteligence v šolskih knjižnicah doma in po svetu.

Ob nastanku ter hitrem razvoju umetne inteligence je pomembno, da se tudi v šolskih knjižnicah o tej temi govori, se uči ter uporablja pravilno in etično. Šolske knjižnice imajo tudi izobraževalno vlogo na tem področju, saj so že do sedaj skrbele za ustrezne vire in literaturo ter izobraževanje svojih uporabnikov.

Zelo hitro je z izobraževanji na področju nove pismenosti pričela tudi Narodna in univerzitetna knjižnica, ki je pripravila izobraževanja ter soorganizirala konference na temo umetne inteligence.

KLJUČNE BESEDE

Umetna inteligenca, knjižnice, šolske knjižnice, umetnointeligenčna pismenost, Narodna in univerzitetna knjižnica

ABSTRACT

The paper explains the term AI literacy, and presents an aspect of the use of AI in school libraries at home and abroad.

With the emergence and rapid development of AI, it is important that it is also discussed, taught and used in school libraries in a correct and ethical way. School libraries also have an educational role to play in this area, as they have already been providing relevant resources and literature and educating their users.

The National and University Library has been very quick to take up the new literacy education agenda, providing training and co-organising conferences on artificial intelligence.

KEYWORDS

Artificial Intelligence, libraries, school libraries, Artificial Intelligence Literacy, National and University Library

1 UVOD

Razvoj digitalne tehnologije je spodbudil globalizacijo in modernizacijo življenja ter ustvarja vedno bolj medsebojno povezan svet. V letih po epidemiji (2020) so se pojavile mnoge prosto dostopne oblike umetne inteligence (dalje UI), ki se pospešeno razvijajo ter razširjajo in prodirajo v vse sisteme ter dele družbe, hkrati pa je poskočila tudi uporaba različnih orodij, ki so narejena s pomočjo UI. Izjema niso niti knjižnice, šole in šolske knjižnice.

Šolski knjižničarji doma in po svetu se vse bolj izobražujejo na to temo ter uporabljajo različna orodja in pripravljajo navodila, smernice in načrte za izobraževanje svojih uporabnikov (različnih deležnikov).

Narodna in univerzitetna knjižnica (dalje NUK) je nacionalna knjižnica Republike Slovenije, katere temeljno poslanstvo je zbiranje in varovanje ter zagotavljanje uporabe nacionalne zbirke knjižničnega gradiva, strokovna podpora knjižnicam pri izvajanju javne službe in nacionalnemu bibliografskemu sistemu ter vključevanje v mednarodne knjižnične povezave [1]. Skladno z zakonodajo izvaja knjižnično dejavnost kot javno službo [2] in skrbi za dediščino ter sodeluje v nacionalnem vzajemnem bibliografskem sistemu, opravlja pa tudi druge dejavnosti in naloge.

Med drugim je za knjižničarsko stroko izjemno pomembna izobraževalna dejavnost, za katero v NUK skrbi Oddelek za izobraževanje, razvoj in svetovanje. Izobraževalne vsebine so razdeljene po različnih sklopih, med katerimi so vključene tudi vsebine o umetni inteligenci in posameznih aplikacijah. Stalno izobraževanje je za vsakega posameznika nepogrešljivo ter pomembno, česar se NUK zaveda in temu vsako leto posveča veliko pozornosti. [3]

V NUK smo izvajali izobraževanja (Uporaba orodij umetne inteligence v knjižnicah) ter soorganizirali konference na temo umetne inteligence (Artificial Intelligence and the Future of Digital Preservation), katerih so se udeležili tudi šolski knjižničarji.

2 ŠOLSKE KNJIŽNICE IN UMETNA INTELIGENCA

Šolsko knjižnico v Sloveniji opredeljuje Zakon o organizaciji in financiranju vzgoje in izobraževanja (2007), v 68. členu je zapisano, da ima šola knjižnico, v kateri se zbira, strokovno obdeluje, hrani, predstavlja in izposoja knjižnično gradivo ter ki opravlja informacijsko-dokumentacijsko delo kot sestavino vzgojno-izobraževalnega dela v šoli. Del naše šolske knjižnice je tudi učbeniški sklad. [4]

Šolske knjižnice že dolgo predstavljajo vir informacij in znanja za svoje deležnike (učence, dijake, učitelje in profesorje). Poleg ustaljenih knjižničnih storitev (izposoja knjig, dostop do strokovne literature in organizacija različnih dejavnosti), šolski knjižničarji spodbujajo razvoj kritičnega mišljenja in

informacijskih spretnosti. Z nenehnim napredkom tehnologije in digitalizacije se vloga šolskih knjižnic hitro spreminja in prilagaja novim izzivom ter potrebam. Z razvojem ter prisotnostjo UI orodji se je potrebno prilagoditi tudi tem novostim.

Eden od najpomembnejših tehnoloških trendov, ki že danes vpliva na šolske knjižnice (predvsem v ZDA), je UI, saj tudi že spreminja način, kako se zbira, obdeluje in uporablja informacije. V šolskih knjižnicah po ZDA se UI uporablja za izboljšanje iskalnih algoritmov, personalizacijo priporočilnih seznamov gradiv, avtomatizacijo administrativnih nalog in celo za pomoč pri učenju, kar so različni avtorji opisali v svojih prispevkih (An AI Toolbox for Librarians; ChatGPT and Generative Artificial Intelligence in drugi). Napredni sistemi UI omogočajo učencem lažji dostop do informacij in prilagojene učne izkušnje, hkrati pa šolskim knjižničarjem omogočajo učinkovitejše delo, tudi upravljanje knjižničnih virov. Mnogo prispevkov je dostopnih tudi na portalu Knjižničarske novice, kjer se za lažje iskanje uporabljajo ključniki: #umetnainteligenca, #umetnointeligenčnapismenost, in #digitalnapismenost.

Izobraževanje o umetni inteligenci v šolskih knjižnicah ne samo da pripravi učence na tehnološko prihodnost, ampak tudi spodbuja inovacije, povečuje različne pismenosti (digitalno, bralno, medijsko …) in zagotavlja, da bodo mladi opremljeni z znanji in veščinami, potrebnimi za uspeh v sodobni družbi. Ob vsem tem pa je potrebno razmisliti tudi o umetnointeligenčni pismenosti ter kritičnem mišljenju.

2.1 Umetnointeligenčna pismenost

Terminološka sekcija Inštituta za slovenski jezik Frana Ramovša - Znanstvenoraziskovalni center Slovenske akademije znanosti in umetnosti je predlagala, da se za prevod Artificial Intelligence Literacy uporabi pridevnik umetnointeligenčni, ki je jezikovno sistemsko ustrezen in je že del terminov, kot so npr. umetnointeligenčni sistem, umetnointeligenčna slikovna analitika. S pridevnikom v levem prilastku (umetnointeligenčni) ustrezno določimo samostalniško jedro (pismenost). Tako govorimo o umetnointeligenčni pismenosti. [5]

V današnjem hitro razvijajočem se digitalnem svetu postaja umetnointeligenčna pismenost ključnega pomena za vse starosti, tudi za mlade. Razumevanje in uporaba UI omogoča mladim, da postanejo kompetentni uporabniki sodobnih tehnologij, kar jim odpira vrata do številnih priložnosti v izobraževanju in kasnejšem poklicnem življenju.

Šolske knjižnice lahko in v prihodnje morajo igrati ključno vlogo pri poučevanju in spodbujanju umetnointeligenčne pismenosti. Knjižničarji in učitelji lahko skupaj ustvarjajo pedagoške ure in dejavnosti, kjer učenci spoznavajo osnove umetne inteligence, njeno delovanje in praktične aplikacije. Tako se učenci naučijo kritičnega razmišljanja, reševanja problemov in etičnih vprašanj, povezanih z uporabo UI.

3 PRIMERI UPORABE UMETNE INTELIGENCE V ŠOLSKIH KNJIŽNICAH

Da bi uporabniki sami uporabljali UI, jo morajo najprej razumeti in postati vešči na tem področju. Umetnointeligenčna pismenost obsega poznavanje, razumevanje, uporabo in vrednotenje umetne inteligence ter upoštevanje etičnih vprašanj. Osebe, ki so umetnointeligenčno pismene, razumejo temeljne koncepte UI, kot so strojno učenje, obdelava naravnega jezika in nevronske mreže. Da bi svoje deležnike uporabnike opremili s potrebnimi veščinami za krmarjenje po tem zapletenem področju, morajo knjižnice prednostno razvijati vire za usposabljanje, ki posameznikom omogočajo natančno preverjanje informacij v zvezi z aplikacijami UI. [6]

Šolske knjižnice, poleg osnovnih knjižničnih dejavnosti, izvajajo tudi različne učne oblike (medpredmetne povezave, pouk knjižnično-informacijskega znanja, interesne dejavnosti, izbirne predmete in mnoge druge dejavnosti), ki so predpisane, ter tako lahko svojim uporabnikom ponudijo še tisto nekaj več. [7]

Šolske knjižnice, kot središča znanja in informacij, so idealne ustanove za spodbujanje učenja o UI. V ZDA je bilo veliko primerov predstavljenih na različnih konferencah, seminarjih in drugih dogodkih. Več zanimivih primerov je bilo omenjenih na spletni konferenci Teaching and Learning with AI, kjer so predavatelji med drugim izpostavili ter predstavili primere dobih praks. Spregovorili so o primerih uporabe UI: kako so ustvarili tutorja s pomočjo UI, klepetalnega robota za pomoč v knjižnici ter se učili uporabljati različne programe. [8]

Šolski knjižničarji v ZDA uporabljajo UI za pripravo različnih navodil, plakatov, oznak za knjižnično gradivo, za izdelavo bralnih seznamov, pisanje zgodb, izdelavo nalog in različnih didaktičnih iger ter še mnogo drugega. Med drugim uporabljajo aplikacije kot so: Canva, Claude, Gemini, Bard, Midjourney, Dall-E, Copilot, Perplexity, Ideogram in druge.

Ameriške šolske knjižničarke so mnogo svojih primerov opisale tudi v spletnem podkastu Leading from the Library, kjer so omenile klepetalne robote, pomen podatkov in virov ter upoštevanje avtorskih pravic. [9]

Precej primerov uporabe UI so uredniki zbrali v publikaciji z naslovom 101 creative ideas to use AI in education, A crowdsourced collection, kjer ponujajo zbrane zamisli za prenos v prakso ob kritičnih in ustvarjalnih možnostih ter omejitvami uporabe UI pri učenju, poučevanju, podpori učencem pri učenju in drugih dejavnostih. [10]

V Sloveniji so šolske knjižnice začele s pospešeno rabo aplikacij in dela prek spleta v letu, ko je cel svet spremenila pandemija. Kot so to zapisale posamezne avtorice v svojih prispevkih z naslovi: Virtualna šolska knjižnica OŠ Komenda Moste med poukom na daljavo (2020), Delo na daljavo v naši šolski knjižnici (2020), Šolska knjižnica kot popestritev pouka na daljavo (2021), Šolska knjižnica na daljavo (2021), Šolska knjižnica in učenje na daljavo (2021), so šolske knjižnice pogumneje začele uporabljati digitalne poti in gradiva, a še ne posameznih orodji UI. To je prišlo z leti, ko nekateri šolski knjižničarji uporabljajo in učijo uporabo UI ter poudarjajo pomen umentointeligenčne pismenosti. V šolskem letu 2023/2024 je kar nekaj slovenskih šolskih knjižničarjev začelo z uporabo in učenjem pomena UI. Prispevke v uredništvu še pričakujemo in bodo objavljeni na portalu Knjižničarske novice.

Če omenimo le nekatere, je bila med zanimivejšimi idejami spletna soba pobega, ki so jo pripravili v eni izmed osnovnošolskih knjižnic, kjer so se morali ujetniki vsakič znova rešiti iz druge umetno generirane situacije (potrebno je bilo poznavanje določenih pravljic). Ravno tako je potrebno izpostaviti tudi šolsko knjižnico, ki je za učence pripravila lov za knjižnim zakladom s pomočjo ChatGPT, slikovno gradivo pa je

bilo ustvarjeno z ustreznimi pozivi v aplikaciji Canva (slika 1) in Copilot.

Poudariti je potrebno tudi, da so se v šolskih knjižnicah lotili tudi priprave navodil, kako pravilno navajati vire (v besedilu in v virih), ki so ustvarjeni s pomočjo UI.

Slika 1: S pomočjo aplikacije Canva ustvarjen primer napotkov, kaj nudi šolska knjižnica svojim uporabnikom

4 ZAKLJUČEK

V današnji dobi digitalizacije in hitrega tehnološkega napredka postaja umetnointeligenčna pismenost zelo pomembna. Pri poučevanju o temi naj bi imeli tudi šolski knjižničarji vlogo, saj delujejo kot most med tradicionalnim učenjem in sodobnimi tehnologijami. Šolski knjižničarji naj bi bili ključni pri spodbujanju radovednosti in kritičnega mišljenja med uporabniki. Z organiziranjem dejavnosti in pouka o osnovah umetne inteligence, ob sodelovanju strokovnih sodelavcev, bi učencem omogočili uvid v delovanje UI, kje se uporablja in kakšne so njene prednosti ter nevarnosti.

Poleg tega šolski knjižničarji zagotavljajo dostop do različnih virov, ki učencem omogočajo poglobljeno raziskovanje umetne inteligence. Knjižničarji skrbno izbirajo knjige, članke, e-knjige in druga izobraževalna gradiva, ki so relevantni in aktualni. S tem učencem omogočajo, da pridobijo celovito razumevanje področja in ostanejo na tekočem z najnovejšimi trendi in razvojem v svetu UI.

Šolski knjižničarji naj v bodoče tudi sodelujejo z učitelji pri integraciji umetnointeligenčne pismenosti v učni načrt. S skupnim načrtovanjem učnih enot in projektov, ki vključujejo uporabo UI orodij, knjižničarji pomagajo učencem pridobiti praktične izkušnje in veščine, ki jim bodo koristile v prihodnosti.

Poleg tega knjižničarji spodbujajo etično razmišljanje in ozaveščanje o odgovorni uporabi umetne inteligence. Organizirajo razprave in debate, kjer učenci razmišljajo o etičnih vprašanjih, povezanih z UI, kot so zasebnost, pristranskost in vpliv na življenje. Tako učence pripravljajo na kritično ocenjevanje in premišljeno uporabo tehnologij v vsakdanjem življenju.

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E-igrifikacija kot metoda dela z učenci s posebnimi potrebami v osnovni šoli

E-gamification as a Method of Working with Students with Special Needs in Primary School

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POVZETEK

Igrifikacija kot metoda dela v osnovnošolskem izobraževanju, zlasti za delo z učenci s posebnimi potrebami, ima že stalno prakso. Z uvedbo iger podobnih elementov, kot so točke in nagrade, želijo učitelji pomagati učencem z motnja pozornosti s hiperaktivnostjo (ADHD), avtizmom in drugimi učnimi izzivi, da ostanejo osredotočeni in motivirani dlje, kot bi bili drugače. Z dobo digitalizacije se je tudi področje igrifikacije razširilo in ponudilo številna nova digitalna orodja, ki jih bomo raziskali v nadaljevanju.

Dotaknili se bomo tudi pomislekov glede uporabe igrifikacije in se vprašali kaj je naš končni cilj v izobraževanju – ali samo želimo, da so učenci v danem trenutku aktivni ali si prizadevamo pri učencih spodbujati notranjo motivacijo in veselje do znanja? Poleg tega niso zanemarljive raziskave, ki ugotavljajo, da se pozornost učencev zaradi uporabe digitalnih medijev skrajšuje [1]. Kako najti pravo ravnovesje?

KLJUČNE BESEDE

Igrifikacija, osnovana šola, učenci s posebnimi potrebami, digitalizacija

ABSTRACT

Gamification as a method of work in primary school education, especially for work with students with special needs, already has a permanent practice. By introducing game-like elements like points and rewards, teachers aim to help students with ADHD, autism and other learning challenges to stay focused and motivated longer than they would otherwise. With the era of digitalization, the field of gamification has also expanded and offered many new digital tools, which we will explore in the article.

We also have some concerns regarding the use of gamification especially regarding our ultimate goal in education - do we just want students to be active at a given moment or do we strive to encourage their internal motivation and joy of knowledge? In addition, researches show that the attention span of students is shortened true the years due to the usage of digital media [1]. How to find a perfect balance?

KEYWORDS

Gamification, primary school, students with special needs, digitalization

1 UPORABA IKT V SLOVENSKEM ŠOLSTVU

Slovenski šolski sistem je že dlje časa podvržen kritikam, da je staromoden, neprilagodljiv in da nujno potrebuje spremembe. Kot odgovor je bila ustanovljena delovna skupina za pripravo prenovljenega Nacionalnega programa vzgoje in izobraževanja 2023 – 2033. Eden izmed pomembnih strateških ciljev in ukrepov je tudi razvoj digitalnih kompetenc tako učiteljev kot učencev [2].

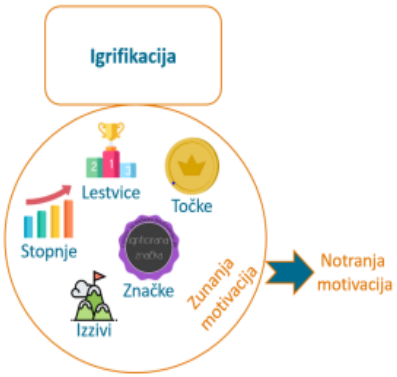
Med digitalne kompetence spada tudi uporaba IKT tehnologij kot metod in strategij učenja. Na podlagi raziskave Pedagoškega inštituta [3] slovenske šole zaostajajo pri uporabi IKT tehnologij za poučevanje v osnovnih in srednjih šolah. Eden izmed pomembnih razlogov za to navajajo, da je sama uporaba v veliki meri vezana na lastno zanimanje in motivacijo posameznih učiteljev, saj je bilo v preteklosti izobraževanj vezanega na uporabo IKT tehnologij za učitelje relativno malo. To ugotovitev lahko potrdim tudi sama, saj je angažiranost za vpeljevanje t. i. novosti v šolsko delo v veliki meri odvisno od angažiranosti tako vodstva kot strokovnih delavcev. Vlada RS je že leta 2021 sprejela in potrdila Nacionalni program spodbujanja razvoja in uporabe tudi umetne inteligence v Republiki Sloveniji do leta 2025 [4], vendar konkretnih rezultatov v šolstvu še ni zaznati.

Z desetletnimi izkušnjami z delom kot izvajalka dodatne strokovne pomoči učencem s posebnimi potrebami sem se tudi sama lotevala iskanja možnosti v informacijski tehnologiji, predvsem na področju igrifikacijskih vsebin za učence s posebnimi potrebami – kar v nadaljevanju poimenujem kot e-igrifikacija.

2 IGRIFIKACIJA

Pojem igrifikacije (angl. gamification), kot ga poznamo danes, je leta 2002 uvedel Nick Pelling. Izraz igrifikacija se je sicer začel pogosteje pojavljati šele v drugi polovici leta 2010 [4]. Pri

igrifikaciji gre za uporabo pristopov, elementov in načinov razmišljanja, ki se uporabljajo pri igranju iger, vendar so le-ti uporabljeni izven iger, npr. sistem, ki beleži število oddanih nalog in ki nagrajuje dosežke z virtualnimi nagradami, kot so pokali, zvezdice (Slika 1). Pomemben dejavnik doseganja določenih ciljev predstavlja motivacija. Ko posameznik uspešno reši zastavljeno nalogo oz. problem, doživi uspeh, kar v posamezniku sproži motivacijo. Ko imajo posamezniki priložnost spopasti se z individualiziranimi učnimi izzivi, so pripravljeni vložiti več energije v nalogo, poleg tega pa so tudi bolj dovzetni za povratne informacije. Vključitev igrifikacije se kaže v uporabi kvizov, odzivov, sodelovanj v skupinah in drugih učnih aktivnostih [6].



Slika 1: Prikaz delitve v igro usmerjenega poučevanja [6]

V zadnjih letih je e-igrifikacija vedno bolj prisotna v osnovnošolskem izobraževanju kot nov pristop za spodbujanje in motiviranje učencev in posledično izboljševanje učnih rezultatov. Obljuba o spreminjanju učenja v bolj privlačno in zabavno izkušnjo se zdi idealna predvsem za učence s posebnimi potrebami, ki težje sledijo bolj tradicionalnim metodam učenja ali imajo drugačen tempo osvajanja znanja.

S pomočjo igrifikacije lahko povečamo motivacijo, aktivnost in zavzetost udeležencev za učni proces, spodbujamo sodelovanje, omogočamo sprotno povratno informacijo, vključujemo spremembe, omogočamo varno učno okolje za udeležence, ki imajo težave pri deljenju mnenj ter omogočamo sprotne nagrade za opravljeno delo (Slika 2). Če pri tem uporabljamo še IKT-tehnologijo, je uporaba navadno bolj preprosta tako za učitelja, kot tudi bolj zanimiva za učenca.

Slika 2: Prednosti vključevanja igrifikacije v učenje [6]

3 VKLJUČEVANJE E-IGRIFIKACIJE PRI DELU Z UČENCI S POSEBNIMI POTREBAMI

Po konceptu dela z učenci z učnimi težavami v osnovni šoli mora šola učencem ustrezno prilagoditi metode in oblike dela, da so primerne za posamezno skupino učencev. E-igrifikacija le to relativno preprosto omogoča, hkrati pa omogoča lažje uresničevanje temeljnih načel pomoči učencem kot so načelo interdisciplinarnosti, odkrivanje močnih področij, načelo akcije in samozagovorništva, predvsem pa načelo opravljanja optimalnih izzivov [7].

V poglavju bomo pregledali glavne značilnosti uporabe e-igrifikacije pri učencih s posebnimi potrebami.

Aktivnost in zavzetost

Ena izmed največjih prednosti uporabe igrifikacije je njena zmožnost povečanja motivacije učencev. S preoblikovanjem vsakdanjih nalog v interaktivne in tekmovalne dejavnosti lahko naredi učenje bolj privlačno. Dr. Karl Kapp, znani strokovnjak za izobraževalno igrifikacijo, trdi, da le-ta posega v osnovne človeške želje po dosežkih, statusu in tekmovanju, zaradi česar je močno orodje za motivacijo [8]. Za osnovnošolce, ki jih pogosto vodijo takojšnje nagrade in povratne informacije, lahko uporaba točk, značk in lestvic zagotovi občutek uspeha in jih spodbudi, da bolj aktivno sodelujejo v učnem procesu.

Vključevanje sprememb

Ena najpomembnejših prednosti igrifikacije v inkluzivnem izobraževanju je zmožnost individualizacije in prilagajanja učenja vsakemu posamezniku. Tradicionalna učilnica s svojimi metodami dela in določenim tempom dela je lahko izziv za učence s posebnimi potrebami, ki imajo pogosto težave z osredotočenostjo in organizacijo. E-igrifikacija omogoča bolj prilagodljivo učno izkušnjo, kjer lahko učenci delajo s svojim tempom in se ukvarjajo z materiali na načine, ki ustrezajo njihovim individualnim potrebam kot tudi različnim učnim stilom. Nekaterim učencem bodo morda koristili vizualni pripomočki, medtem ko se bo drugim zdelo bolj učinkovito avditivni ali kinestetični stil učenja.

Dr. Thomas E. Brown, klinični psiholog poudarja, da učencem z ADHD prilagojena učna okolja zelo koristijo, saj jim omogočajo, da se lažje osredotočajo na svoje prednosti in interese [9]. Izobraževalne aplikacije in spletne platforme lahko ponudijo prilagodljive učne načrte, kjer je vsebina prilagojena vsakemu učencu posebej. E-igrificirane učne aplikacije lahko naredijo lekcije bolj privlačne in s tem pomagajo ohraniti osredotočenost in motivacijo dlje, kot brez njih.

Varno učno okolje

Pomemben aspekt e-igrifikacije na inkluzivno izobraževanje je tudi izboljšanje dostopnosti. Učenci s telesnimi oviranostmi, senzoričnimi okvarami ali učnimi težavami lahko tako uporabljajo tehnologijo, ki jim omogoča učinkovitejše sodelovanje z izobraževalno vsebino kot tudi sodelovanje v skupini. Orodja, kot so bralniki zaslona, programska oprema za pretvorbo govora v besedilo in predvsem aplikacije, ki spodbujajo sodelovanje, omogočajo učencem s telesnimi okvarami ali socialnimi zadržki lažji dostop do izobraževalnih vsebin kot tudi sodelovanja in deljenja svojih mnenj z ostalimi v skupini.

Po mnenju dr. Davida Rosa, soustanovitelja organizacije CAST (Center for Applied Special Technology) in vodilnega strokovnjaka za oblikovanje univerzalnega pristopa k učenju (Universal design for learning- UDL) pravi, da tehnologija lahko služi kot most za učence s posebnimi potrebami, saj jim omogoča sodelovanje v izobraževalnih dejavnostih, ki bi sicer bile za njih težje dostopne [10].

Sodelovanje in povratna informacija

Uporaba e-igrifikacije ima lahko pomembno vlogo tudi pri omogočanju sodelovanja in komunikacije med učenci, učitelji in starši. Oblikovanje igrificiranih vsebin na spletnih učnih platformah, forumih za razprave in uporaba različnih orodij za sodelovanje, udeležencem omogočajo skupno delo pri projektih, ne glede na njihovo lokacijo ali sposobnosti. To je še posebej pomembno v inkluzivnih učilnicah, kjer lahko učenci preko zabavnih vsebin na različne načine pristopajo k učenju in deljenju svojih znanj, mnenj.

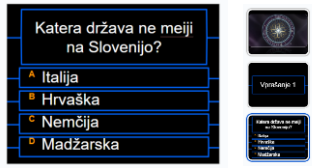
Druga pomembne prednost e-igrifikacije je možnost hitre povratne informacije o uspešnosti učenja. Povratna informacija je eden od dejavnikov, ki najbolj vplivajo na učenčevo učenje. Poglavitni cilj vzgojno-izobraževalnega procesa je namreč pomoč pri identifikaciji stopnje osvojenega znanja v primerjavi s končnim ciljem (»Kako mi gre?« sorazmerno z »Kam grem?«) in ukrepanje v smislu predlogov nadaljnjih korakov (»Kam naprej?«) [11]. Digitalizirane vsebine pa to omogočajo zelo natančno in sprotno, kar daje povratni informaciji največjo učinkovitost in težo še posebno, če so le-te vezane tudi na pridobivanje morebitnih nagrad (zvezdice, značke, pokali, napredovanje …).

4 PREDLOGI ORODIJ ZA OBLIKOVANJE E-IGER ZA UČENCE S POSEBNIMI POTREBAMI

Pregled orodij za pomoč pri oblikovanju e-igrificiranih vsebin pri učenju glede na posebne potrebe učencev.

Orodja za pripravo prezentacij

Igrificirane vsebine se lahko oblikujejo tudi v orodjih za pripravo prezentacij kot npr. Microsoft Powepoint (Slika 3) in so primerne za vse vrste učencev.



Slika 3: Primer kviza v orodju Powepoint

Kobi - https://kobiapp.si/

Slovenska aplikacija, ki je namenjena branju, predvsem za učence z bralno-napisovalnimi težavami, težavami s pozornostjo ali težavami z razumevanjem prebranega (Slika 4). Prednost je nalaganje vsebin preko fotografiranja gradiva. Podprt je tudi s strani Ministrstva za šolstvo.

Slika 4: Aplikacija Kobi [12]

Kahoot – https://kahoot.com/

Kahoot je norveška spletna učna platforma, ki temelji na učenju preko iger. Vsebuje učne igre, znane tudi kot "kahoots"(Slika 5), ki so uporabniško ustvarjeni kvizi z več možnimi odgovori, do katerih se lahko dostopa preko spletnega brskalnika ali aplikacije [13]. Primerna je predvsem za spodbujanje motivacije, učence s težavami s pozornostjo in za boljše vključevanje učencev s težavami na socialnem področju, saj učenci lahko sodelujejo preko pametni telefonov ali tablic.

Slika 5: Primer kviza v orodju Kahoot [13]

CŠOD Misija - mobilna aplikacija za učenje na prostem

Mobilni vodič CŠOD Misija (Slika 6) je inovativen didaktičen pristop, ki nadgrajuje samostojno doživljajsko učenje z doživetjem zunaj učilnice. Poleg tega, da spodbuja uporabnike k učenju na terenu, upošteva tudi najnovejša pedagoška spoznanja koncepta igrifikacije, ki pedagoškemu procesu dodaja elemente iger in motivira uporabnike k doseganju boljših učnih rezultatov. Gibanje spodbuja pomnjenje in razmišljanje, kar je tudi ena od prednosti orodja [14]. Primerna je predvsem za učence s težavami na področju motivacije, koncentracije in za učence z večjo potrebo po gibanju. Primerna je tudi za spodbujanje skupinskega dela.

Slika 6: Aplikacija CSOD Misija [14]

Baamboozle - https://www.baamboozle.com/

Baamboozle je učna platforma, ki temelji na igrah in se uporablja predvsem za oblikovanje učnih kvizov (Slika 7). Glavna prednost je možnost igranja v skupinah prav tako pa omejuje tekmovalnost preko vključevanja naključnih dogodkov, kot je npr. menjava točk skupin, zmanjšanje točk za 20 in podobno. Primerna je predvsem za učence s težavami s pozornostjo, učence, ki potrebujejo več-senzorno učenje in učence s težavami na socialnem področju.

Slika 7: Primer vprašanja Baamboozle kviza[15]

Educaplay - https://www.educaplay.com/

Educaplay je platforma za oblikovanje e-igrificiranih vsebin. S pomočjo že pripravljenih predlog se lahko enostavno oblikuje različne individualizirane izobraževalne igre kot so križanke, igre dialogov, igre narekovanja, igre izpolnjevanja praznih mest, kvize, igre ujemanja, igre spomina in podobno (Slika 8). Primerna je predvsem za učence s težavami s pozornostjo, učence, ki potrebujejo več senzorno učenje, večjo slikovno podporo in učence, ki se učijo s svojim tempom učenja.

Slika 8: Primeri aktivnosti na platformi Educaplay[16]

Scratch - https://scratch.mit.edu/

Scratch je orodje, ki je prvotno namenjen učenju programiranja za otroke. Zaradi enostavnega vmesnika pa je primerno tudi za oblikovanje različnih igrificiranih vsebin. Omogoča ustvarjanje digitalne zgodbe, različne igre in animacije. Scratch je ustvarjen, razvit in vzdrževan pri Združenju Scratch, neprofitni organizaciji in je v celoti brezplačen. Primeren je za oblikovanje vseh vrst vsebin predvsem za učence, ki potrebujejo jasna in v naprej znana in strukturirana pravila igre.

Slika 9: Primer igre v orodju Scratch[17]

5 POMISLEKI

Nevarnost razpršene pozornosti

Medtem ko je IKT tehnologija lahko močno orodje za učenje, predstavlja tudi veliko tveganje za večanje razpršene pozornosti, zlasti za učence z ADHD. Prav naprave, ki se uporabljajo za podporo učenju – računalniki, tablice in pametni telefoni – lahko nudijo tudi dostop do iger, družbenih medijev in drugih motenj, ki lahko iztirijo učenčevo osredotočenost. Dr. Edward Hallowell, psihiater in strokovnjak za ADHD, opozarja, da je ista tehnologija, ki pomaga učencem z ADHD, lahko tudi vir motenj, če je ne uporabljajo previdno [18]. Pri učencih z ADHD, ki se že borijo z ohranjanjem pozornosti, je lahko velika skušnjava, da bi zamenjali naloge ali se vključili v neizobraževalne dejavnosti. Zaradi tega je potrebno, da učitelji izvajajo nadzor nad uporabo zaslonov, lahko tudi uporabo aplikacij, ki blokirajo druga spletna mesta med učenjem, ali določanje jasnih pravil o uporabi naprave.

Zmanjševanje razvoja kompetenc

Pretirano zanašanja na IKT tehnologijo lahko privede do zmanjšanja sposobnosti kritičnega mišljenja in reševanja problemov. Čeprav e-igrificirano učenje lahko podpira učenje, ne sme nadomestiti temeljnih veščin, ki jih morajo učenci razviti, kot so bralno razumevanje, matematične spretnosti in neodvisno in kritično razmišljanje. Za učence s posebnimi potrebami obstaja še večje tveganje, da bi jim zanašanje na tehnologijo za organizacijo in upravljanje nalog preprečilo, da bi sami kasneje razvili te bistvene spretnosti.

Pedagoška psihologinja dr. Larry Rosen trdi, da pretirano zanašanje na tehnologijo lahko ovira razvoj pomembnih kognitivnih veščin, zlasti pri učencih z ADHD, ki lahko postanejo preveč odvisni od digitalnih pripomočkov [19]. Raziskave na slovenskih mladostnikih tudi kažejo, da se pri tistih, ki so bolj zgodaj začeli igrati računalniške igrice, kažejo slabši rezultati pri samoregulativnem učenju. Izpostavljajo tudi pomembno ugotovitev, da so negativne povezave med rabo interneta za zabavo in samoregulativnim učenjem pri učencih s posebnimi potrebami močnejše [20].

Za učitelje je pomembno, da najdejo ravnotežje med uporabo e-igrificiranih vsebin kot orodja za učenje in spodbujanjem učencev v omejeni meri, da ne ovirajo razvoja lastne kognitivne strategije za učenje.

Neenakopraven dostop in poznavanje tehnologij

Dostop do tehnologij ni enak za vse učence in ta digitalni razkorak lahko še poveča obstoječe neenakosti v izobraževanju. Učenci nimajo enakega dostopa do naprav ali internetnih povezav, ki so potrebne, da bi v celoti izkoristili uporabo e-orodij v izobraževanju. To je lahko še posebej problematično za učence s posebnimi potrebami, ki se morda bolj zanašajo na tehnologijo za podporo pri učenju. Dr. Mimi Ito, strokovnjakinja za digitalno učenje, poudarja, da t. i. digitalni razkorak ustvarja velike izzive za inkluzivno izobraževanje, zlasti za učence s posebnimi potrebami, ki potrebujejo dostop do specializirane tehnologije [21]. Brez dostopa do potrebnih orodij se lahko določeni učenci znajdejo v slabšem položaju v primerjavi s svojimi vrstniki, zaradi česar jim je težje uspeti v vse bolj digitalnem učnem okolju.

Izzivi pri izvajanju in usposabljanju učiteljev

Učinkovita uporaba vseh vrst IKT tehnologij v inkluzivnem izobraževanju zahteva, da so učitelji dobro usposobljeni tako za samo tehnologijo kot za strategije za podporo učencem s posebnimi potrebami. Vendar pa mnogi učitelji poročajo, da se počutijo premalo pripravljeni za integracijo tehnologij v svoje poučevanje, zlasti ko gre za njeno uporabo pri poučevanju učencev s posebnimi potrebami.

Na podlagi raziskave Pedagoškega inštituta [3] tudi slovenski učitelji poročajo, da bi za uspešno vključevanje IKT tehnologij v poučevanju potrebovali več izobraževalnih vsebin.

6 RAZPRAVA

Uporaba igrificiranih vsebin kot didaktični pripomoček pri učenju učencev s posebnimi potrebami je lahko učinkovit pripomoček za spodbujanje motivacije, pozornosti in tudi kot krepitev pozitivnega vedenja. Medtem ko e-igrifikacija ponuja dragocena orodja za obravnavo nekaterih edinstvenih izzivov, s katerimi se soočajo otroci s posebnimi potrebami, je nujno najti ravnovesje. Poraja se namreč velika skrb, da tovrsten način učenja vse preveč poudarja pomen zunanjih nagrad, spodkopava notranjo motivacijo in dolgoročne izobraževalne cilje. Poleg tega večja osredotočenost na tekmovanje in zunanje nagrade zmanjšuje vrednost učenja zaradi njega samega, kar bi lahko vodilo k površnemu razumevanju znanja namesto k poglobljenemu učenju [22].

Strokovni delavci morajo igrifikacijo uporabljati premišljeno, selektivno in jasno ciljno usmerjeno s sprotnimi evalvacijami glede učinkovitosti in primernosti uporabe. Končni cilj bi moral biti spodbujanje motivacijo do učenja, ki presega takojšnje zadovoljstvo, ki ga ponujajo igrificirane naloge, in učence pripravi ne le na pomen rezultatov, ampak tudi na razvoj notranje motivacije in spretnosti kritičnega mišljenja, potrebnih za vseživljenjsko učenje.

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Malo po nemško z IKT

A Little German with ICT

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POVZETEK

Senekova misel, da se ne učimo za šolo, marveč za življenje, še kako drži. V šolah danes ni predmeta na urniku, kjer se ne bi pri pouku posluževali IKT, bodisi zaradi dodatnih razlag, demonstracije, popestritve pouka ali pa samo kot prikaz tega, da smo tudi učitelji v koraku s časom razvoja vseh vrst tehnologij, pa čeprav so v realnosti naši koraki pogosto krajši kot tisti naših učencev. Navsezadnje je to tudi naša dolžnost, da se tudi mi naučimo in spremljamo novosti, ki so nam na razpolago, zanimivo pa je tudi, da nas naši učenci v znanju uporabe IKT marsikje že prekašajo, kar pa je za nas lahko tudi pozitivna izkušnja, saj se iz tega tudi sami lahko veliko naučimo. Za življenje.

KLJUČNE BESEDE

Učenje za življenje, v koraku s časom, pozitivne izkušnje

ABSTRACT

Seneca's idea that we don't learn for school, but for life, is still true. In schools today, there is no subject on the schedule where ICT is not used in lessons, either for additional explanations, demonstrations, to enrich lessons, or just to show that teachers are also keeping up with the times of development of all kinds of technologies, even though in in reality, our steps are shorter than those of our students. After all, it is also our duty to learn and follow the innovations that are available to us, and it is also interesting that our students already surpass us in the knowledge of using ICT in many places, which can also be a positive experience for us, because we can learn a lot about this ourselves. For life.

KEYWORDS

Learning for life, keeping up with the times, positive experience

1 FERTIG…LOS!

V učnem načrtu za nemščino kot prvi tuji jezik v osnovni šoli je uporaba IKT vključena v razvijanje digitalne pismenosti. Učenci pri pouku nemščine kritično uporabljajo informacijsko-komunikacijsko tehnologijo za pridobivanje, vrednotenje in shranjevanje informacij, za njihovo tvorjenje, predstavitev in izmenjavo ter za sporazumevanje in sodelovanje v mrežah na svetovnem spletu. Učenci razvijajo zmožnosti uporabe informacijsko-komunikacijske tehnologije tako, da:

- spoznajo in uporabljajo elektronske in spletne slovarje,
- pridobivajo podatke s spleta (spletne strani, video portali, družbena omrežja) in uporabljajo brskalnike in iskalnike v nemščini,
- jo uporabljajo za komuniciranje v nemščini in sodelovanje na daljavo (npr. s pomočjo e-pošte, e-telefona, spletnega socialnega omrežja, klepetalnice, video konference, bloga, foruma ipd.),
- pridobivajo gradivo o državah, v katerih govorijo nemško, in o Sloveniji iz tujih virov,
- izdelajo in objavljajo svoje izdelke in sporočila, • predstavljajo svoje izdelke v nemščini (grafično, slikovno, pisno, zvočno, večpredstavno),
- se vključujejo v mednarodne mrežne projekte in šolska partnerstva. Uporabo IKT lahko vključimo tudi v razvijanje sporazumevalne zmožnosti v nemščini.

Pouk drugega tujega jezika nemščine kot neobveznega izbirnega predmeta v drugi triadi ter kot obveznega izbirnega predmeta v tretji triadi na šoli poteka pred poukom ali po pouku. Večinoma se za drugi tuj jezik odločajo tisti učenci, ki imajo željo po učenju novega jezika, tisti, ki vedo, da bodo ta jezik imeli kot obvezni jezik v srednji šoli ter tudi tisti učenci, čigar starši jih na nek način usmerijo k učenju dodatnega jezika, saj vedo, da jim bo v življenju to znanje prišlo prav. Na žalost pa so v skupine nemščine vpisani tudi učenci, ki jih starši na nek način »prislijo« k učenju, morda zaradi tega, ker si želijo, da bi njihov otrok znal čim več jezikov ali pa zato, ker sami nikoli niso imeli možnost učiti dodatnega tujega jezika. Toko so v vsaki skupini učenci z različni predznanji in interesi, kar pomeni, da je potrebno med poukom izvajati učno diferenciacijo in to sploh ne bi smelo predstavljati nikakršne težave – prav nasprotno! Učitelju uspešno izpeljati strukturirano ter kvalitetno učno uro v mešani učni skupini je res neke vrste izziv, a vendar je potrebno ta izziv pogledati iz Takšnega zornega kota, da se tudi učitelj sam kaj nauči in pozitivne izkušnje nadgrajuje, negativne pa vzame kot nekaj, kar je možno vedno izboljšati. Torej »Fertig…los!« (Pripravljeni, pozor, zdaj!, op.a.) Ena izmed stvari, ki učitelju pri tem ogromno pomagajo, pa je prav uporaba IKT.

Kljub vse večji težnji in potrebi po uporabi IKT pri pouku, je potrebno pri izvedbi učne ureimeti tudi neko zmernost, saj prepogosta uporaba pogosto zasenči prvotni cilj pouka, torej pridobivanje in utrjevanje znanja, ob prekomerni uporabi IKT pa so učenci na koncu pogosto preveč pod vplivov nekih animacij,

distraktorjev in kasneje nekako ne znajo potem izluščiti bistva učne snovi. Še vedno je pri pouku smiselno vpeljati tudi druge učne metode in pripomočke, predvsem ob razlagi zapletenejših nemških slovničnih struktur, ko mora biti učenčev fokus usmerjen v razumevanje in logično povezovanje že pridobljene z novo osvojeno učno snovjo. Popoldanske ure drugega tujega jezika znajo biti za učence včasih naporne, koncentracija jim pade hitreje kot pri rednem pouku, misli pa jim uhajajo na igrišče ter k počitku doma. Kot učitelj je potrebno najti prav pristop, da se pritegne pozornost učencev, hkrati pa imeti v mislih tudi to, da se v teh urah fizične prisotnosti pri pouku učenci že samo s poslušanjem naučijo največ. In prišlo je leto 2020. Pred zaprtjem šol se je učence pogosto nagovarjalo o tem, kako je lepo popoldne preživeti ob športu, druženju s prijatelji, sprehodih v naravi in ne ob celovečernem buljenju v ekrane računalnikov, tablic ali mobilnih telefonov. Kar naenkrat pa se je začelo drugačno leto – leto izzivov, tako za učence, kot tudi za nas učitelje, vodstvo šole in starše. Pa vendarle se je to leto v smislu pridobivanja znanja IKT na koncu izkazalo kot zelo produktivno.

2 WIR, DEUTSCH UND IKT

Postopoma se je po epidemiji pri vseh predmetih začelo več uporabljati IKT, sploh na začetku, ko je bil pouk deloma še na daljavo. Tudi pri nemščini so učenci najprej morali osvojiti znanje uporabe ZOOM-a in okolja TEAMS- ter spletnih učilnic. Popoldanski čas učiteljev je bil namenjen iskanju novih idej z vključitvijo IKT, veliko primerov dobre prakse pa smo si učitelji nemščine izmenjali na študijskih srečanjih v okviru Zavoda za zaposlovanje ter na večernih »online« srečanjih v lastni organizaciji, kjer smo imeli na razpolago čas za predstavitev novih idej, predlogov za pouk ter seveda pogovoru ter refleksiji. Vse aktualno in v okviru zmožnosti smo učitelji postopoma prenesli tudi na pouk predmeta, ki ga poučujemo na svojem delovnem mestu. To se ni zgodilo kar čez noč, saj smo se morali učitelji najprej sami spopasti s programi, aplikacijami ter spletnimi mesti, ki ponujajo pri poučevanju nekaj več, predvsem pa imeti v mislih, da je ponujeno primerno starosti in znanju učencev.

2.1 E-učbeniki

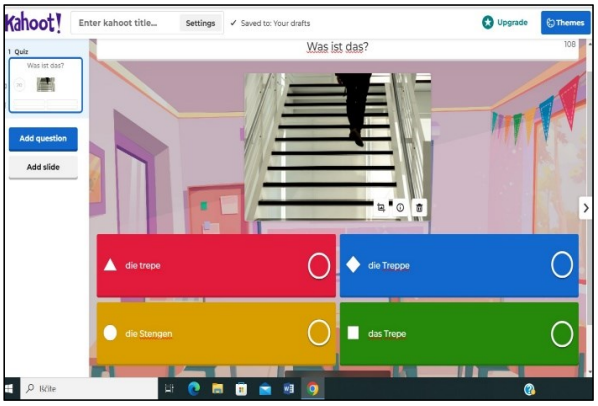
Kot dodatek klasičnemu učbeniku so nam na voljo tudi e-učbeniki (sliki 1 in 2), ki so nastali v sodelovanju profesorjev nemščine z namenom, da ponujajo dodatne vaje različnih vrst in različnih stopenj težavnosti, dodatna besedila za branje in vaje ob branju ter vaje za slušno razumevanje. Odlična izbira so predvsem zato, ker imajo na spletu do njih dostop vsi, tako da lahko učenci tudi sami doma samostojno delajo z njihovo pomočjo ter si tudi sami pregledajo rešene vaje s pomočjo rešitev.

2.2 Kahoot!

Ta aplikacija je pri nemščini zelo popularna, saj se jo učenci zelo hitro naučijo uporabljati. Večinoma se ga poslužujejo ob koncu učnega sklopa za utrditev učne snovi, pogosto pa učence kar presenetim z nenapovedanim kvizom za dvig adrenalina (sliki 3 in 4). Z učenci je potrebno vzpostaviti zaupanje v njihovo uporabo mobilnih telefonov, zato so jih po predhodnem dogovoru z njimi in vodstvom šole tudi lahko uporabljali pri teh kvizih. Pomembno pri sestavi vprašanj za kvize je bilo to, da se ob zabavi pri reševanju utrjuje tako besedišče, izgovorjava ter pravopis. Največkrat je bilo učencem med ponujenimi možnostmi ponujen tudi zapis, ki je enak izgovorjavi, kjer so učenci morali dvakrat premisliti, ali se beseda dejansko tako napiše, kot se izgovori.

Slika 1: Posnetek zaslona spletne strani E-učbeniki za nemščino

Slika 2: Posnetek zaslona vaje v E-učbenikih

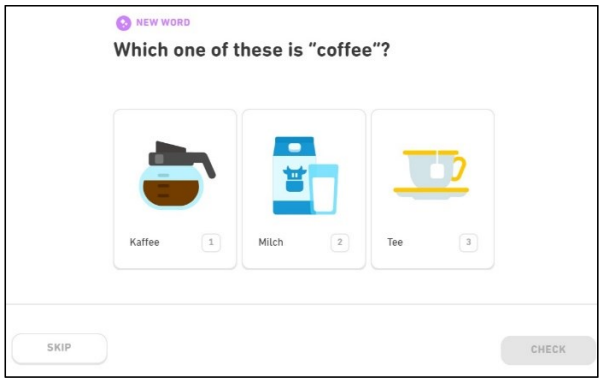


Slika 3: Primer vprašanja pri Kahoot kvizu

Slika 4: Reševanje Kahoot kviza pri pouku nemščine

2.3 Duolingo

Ker imamo v šoli dobro opremljeno računalniško učilnico, večkrat izkoristimo priložnost za pouk v njej, hkrati pa imajo učenci možnost samostojnega dela z računalnikom pod nadzorom. Na šoli pa imamo tudi petnajst tabličnih računalnikov, ki jih lahko uporabljamo po dogovoru tudi v matičnih učilnicah, kar je seveda zelo praktično. Priljubljena aplikacija za učenje jezika je seveda zelo znan Duolingo (slika 5), ki omogoča učenje več jezikov, pri nemščini pa izvajamo tudi medpredmetno povezovanje, zato je Duolingo odlična pomoč pri primerjavi besedišča več jezikov. Ker je tudi vizualno zelo privlačno oblikovan, služi hkrati tudi kot dodatna motivacija.

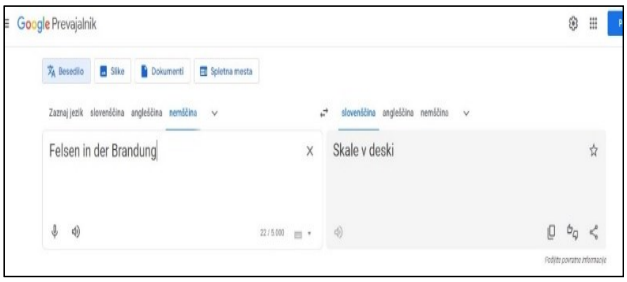


Slika 5: Primer vprašanja v aplikaciji Duolingo

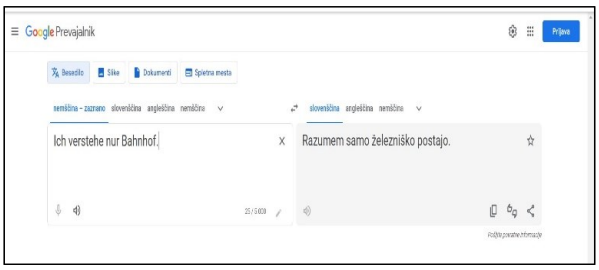
2.4 Google vs. PONS

Učenci se pri prevodih, še posebno daljših povedi z več slovničnimi strukturami, pogosto zadovoljijo s hitro rešitvijo – Googlovim prevajalnikom. Na pogoste napake v prevodu, nesmiselne besedne zveze ter na splošno izraze brez pravega pomena je učence potrebno opozoriti večkrat. Še vedno opažam, da se ga učenci prevečkrat poslužujejo, sploh takrat, ko je treba nekaj narediti čez noč.

Na slikah 6 in 7 sta prikazana primera, ko Google Prevajalnik ne prevede pravilno in pogosto se zgodi, da so ti prevodi nesmiselni. Največ napak je še vedno pri prevodih frazemov ali pregovorov, posameznih besednih zvez, ki jih v slovenščini uporabljamo v drugačnem pomenu oz. z drugačnimi izrazi.

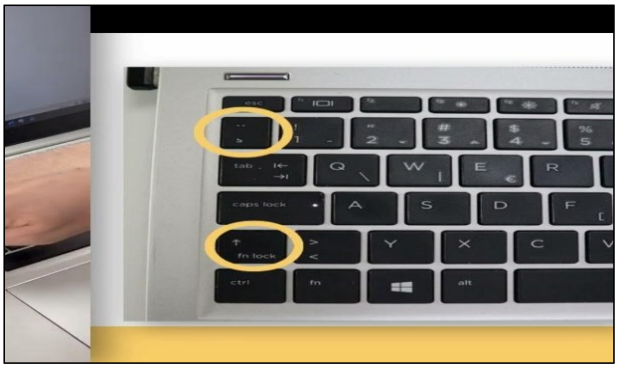


Slika 6: Primer nesmiselnega prevoda v Google Prevajalniku

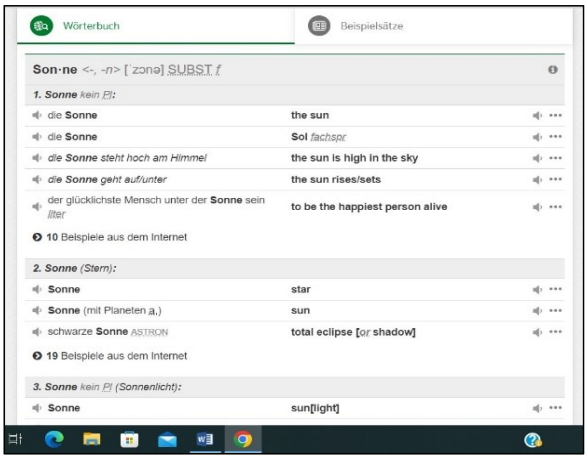


Slika 7: Primer napačnega prevoda v Google Prevajalniku

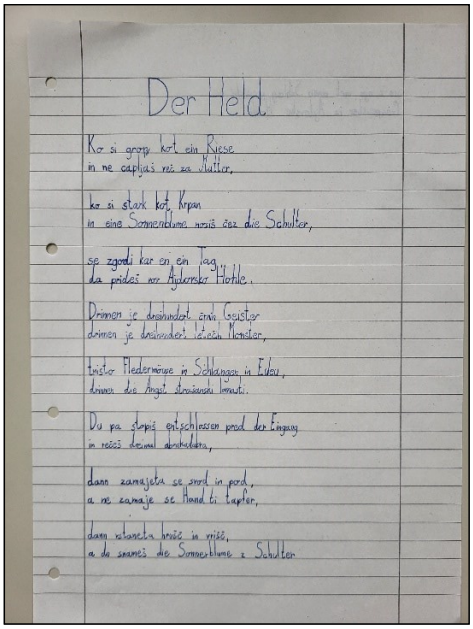
Učencem je vedno na voljo brezplačni PONS slovar, trenutno zelo kvaliteten in pregleden slovar v elektronski obliki, ki zadostuje potrebam osnovnih in srednjih šol. Uporaba ni težka, največ težav imajo učenci predvsem s kraticami ali okrajšavami, zato se jim uporabo tega e-slovarja pojasni večkrat, za pomoč pa imajo tudi zapiske v zvezku, kaj posamezni znaki predstavljajo. Ker je pogosto uporaba e-slovarja PONS časovno zamudna, se učenci premalo odločajo za samostojno delo z njegovo uporabo. Pri nemščini imajo nekatere črke tudi preglase, zato se morajo učenci naučiti tudi uporabe določenih simbolov na tipkovnici (slike 8, 9 in 10).



Slika 8: Tipke za pomoč pri zapisovanju preglasov



Slika 9: Primer prevoda s slovarjem PONS



Slika 10: Primer delnega prevoda pesmi s pomočjo PONS slovarja

2.5 Selbstgemacht (Narejeno samostojno)

Eden izmed ciljev uporabe IKT pri nemščini je torej spodbujanje uporabe IKT naprav, ki jih imajo učenci v šoli na razpolago v namene učenja jezika, hkrati pa tudi uporaba novih ponujenih možnosti na spletu. S tem postanejo učenci vedno bolj samostojni pri učenju in odločni v smislu, da se sami (tudi doma) lotijo reševanja nalog brez učiteljeve pomoči. Učenci s tem, ko naredijo nalogo sami (torej »selbstgemacht«), čutijo zadovoljstvo, tudi ponosni so nase, naloga učitelja pa je, da učencem poda kvalitetno povratno informacijo ter seveda pohvalo za trud, ki ga je posamezen učenec vložil v delo.

Poleg že omenjenih možnosti, se učenci poslužujejo tudi naslednjih spletnih orodij oziroma spletnih virov:

- Padlet,
- Simple Mind,
- Movie Maker,
- www.iVerbs.de
- Termania,
- PowerPoint,
- http://www.wdrmaus.de,
- https://www.liveworksheets.com,
- https://www.youtube.com
- https://interaktivne-vaje.si

Izzivi pri nemščini so bili s pomočjo IKT poleg dejavnosti pri pouku še naslednji:

- prevodi v sklopu tematskih dni (januar 2024),
- nastop v nemščini na Slomškovem tednu kulture (marec 2024) (slika 11),
- organizacija ogledov na ekskurziji v Avstrijo z nadarjenimi učenci, ki obiskujejo izbirni predmet nemščina (april 2024)
- sodelovanje na projektu Spodbujajmo prijateljstvo (učenci so posneli kratke filme o prijateljstvu, maj 2024),
- dopisovanje s šolo v Nemčiji preko elektronske pošte (maj 2024),
- organizacija poti in ogledov na ekskurziji v Celovec (junij 2024) (slika 12).

Slika 11: Nastop učencev nemščine na Slomškovem tednu kulture

Slika 12: Izlet v Celovec v samoorganizaciji učencev

3 ZAKLJUČEK

Z vsakimi generacijami mlajših učiteljev se v pouk vključuje več IKT. Prav je tako, na nas ostalih pa je, da se prilagajamo novim smernicam v digitalnem svetu ter jih na pozitiven način izkoristimo otrokom in nam v prid. Posebna zahvala gre ravnateljici OŠ Antona Martina Slomška Vrhnika ge. Sonji Strgar za spodbudo, navdih, omogočanje uporabe IKT in priložnost za naše vseživljensko učenje.

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Understanding Factors Affecting Artificial Intelligence Literacy among Higher Education Students

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ABSTRACT

In an era dominated by technological advancements, understanding how Artificial Intelligence influences the digital literacy skills of the younger generation is crucial for educational and social development. The study aims to examine the effects of sociodemographic characteristics, digital literacy and patterns of using artificial intelligence tools on artificial intelligence literacy. This study aspires to provide additional insights for educators and artificial intelligence developers, while providing awareness of implementing artificial intelligence technologies to empower youth to navigate the digital landscape with proficiency, responsibility, and ethical discernment. We employed an online survey questionnaire among higher education students in Spain. The results revealed that individuals with higher self-reported artificial intelligence literacy showed increased engagement with artificial intelligence tools in leisure and exam preparation. However, concluding about whether using these tools improves artificial intelligence literacy requires further investigation.

KEYWORDS

Artificial Intelligence, higher education, artificial intelligence literacy, frequency of usage

1 INTRODUCTION

Over the past few years, various studies have been conducted in parallel with the ongoing development of Artificial Intelligence (AI) (Xia et al., 2023). As this is a recent subject of study, numerous aspects remain to be measured regarding these emerging technologies. The existing literature studies often overlook digital literacy as a crucial factor in AI literacy. In our study, we thus sought to examine how users' demographic characteristics and habits of using contemporary technologies affect AI literacy in university students.

2 THEORETICAL FRAMEWORK

AI is a field of Computer Science that focuses on creating intelligent systems inspired by human intelligence. The diverse applications of AI encompass a range of sectors, including medicine, manufacturing, and, notably, education. Thus, it is not just education being transformed; AI is transforming the entire education sector. Gradually, intelligent systems are revolutionizing educational institutions at every level, including primary and higher education, as well as adult and professional learning. These systems aim to enhance human learning experiences and facilitate the achievement of learning goals (Koravuna et al., 2020). Artificial Intelligence has also been referred to as the ability of a digital machine to carry out tasks commonly associated with intelligent beings. Its related technologies are categorized into various branches, such as Computer Vision, Speech, Machine Learning, Big Data, and Natural Language Processing (Chiu, 2021; Chiu et al., 2022; Xia et al., 2022, as cited in Xia et al., 2023). For this study, we will address AI in a broad sense, as a field of Computer Science that solves different kinds of problems inspired by human intelligence, and that may employ different technologies, such as Neural Networks and Machine Learning, as the main ones. In 1956, AI was defined as “the science and engineering of creating intelligent machines” (McCarthy, 2007, as cited in Su et al., 2023). The primary purpose of these intelligent machines is to solve different kinds of problems via Natural Language Processing, Neural Networks, and Machine Learning (Mondal, 2020, as cited in Su et al., 2023).

In its initial conception, "literacy" referred to the capability to articulate oneself and communicate through written language. Recently, the concept of literacy has been extended to delineate skill sets across diverse disciplines, each possessing the capacity to facilitate expression, communication, and access to knowledge. One example encompasses digital literacy. **AI literacy** is a set of competencies that enable individuals to evaluate AI technologies critically, communicate and collaborate effectively with AI, and use AI as a tool online, at home, and in the workplace. AI literacy is clearly related to other, previously defined literacies in related fields. These relationships manifest themselves in several ways; for instance, digital literacy is a prerequisite for AI literacy, as individuals need to understand how to use computers to make further use of AI (Long et al., 2020). In addition to simply adopting the role of AI tool end users, AI literacy is a set of competencies that enables people to evaluate, communicate, and collaborate effectively with AI critically (Druga et al., 2021, as cited in Su et al., 2023). For this study, we will address AI literacy as the knowledge and

understanding of concepts related to Artificial Intelligence, and the practical ability to use it to obtain specific desired goals.

3 METHODOLOGY

A quantitative research approach was adopted in this study. An online survey questionnaire was employed for data collection. Four research questions led our research:

- RQ1: What is the effect of sociodemographic characteristics (age, gender, and level of studies) on AI literacy?
- RQ2: What is the effect of digital literacy on AI literacy?
- RQ3: What is the effect of the level of interest in AI on AI literacy?
- RQ4: What is the effect of the frequency of using AI tools on AI literacy?

3.1 Measures and the measuring instrument

The measuring instrument was composed of three parts. The first part was dedicated to demographic questions, the second to questions regarding digital literacy, and the third to questions regarding AI.

Prior to developing the measuring instrument, we prepared a list of variables as follows:

- Variables related to sociodemographic characteristics (age, gender, level of studies)
- Digital literacy
- Interest in AI
- AI literacy
- Frequency of using AI tools (during free time, homework, exam preparation).

We used closed-ended questions with clear answer choices for each category. For age, we provided ranges focusing on younger generations (less than 18 years,18–25 years, 26–30 years, >31 years or more). We measured gender in 3 categories (male, female, and other). We followed the international ISCED standards (UNESCO Institute for Statistics, 2011) to measure the level of studies, allowing for comparisons across regions. Digital literacy and interest in AI were self-reported through seven statements with 5-point Likert-type answer options ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

AI literacy was measured according to Williams et al (2023) through the indicators as follows. Technical AI knowledge where students had an opportunity to express whether they can define AI, identify AI systems daily, and articulate what makes them AI. The students also reported to what extent they had a practical understanding of how AI algorithms (pertaining to each curriculum) function, and what is the humans' role in creating AI systems.

Ability to think critically about the implications of AI allowed students to report whether they can think critically about the potential benefits or harms of AI systems and their impact on stakeholders. The students had also possibilities to report to what extent they can reflect on and discuss ethical issues (e.g., fairness, privacy, and responsible design) as they relate to AI.

Ability to apply AI knowledge allowed the students to report to what extent they can employ their AI knowledge and skills appropriately to topics they care about personally. They also had an opportunity to report whether they can leverage skills like ethical thinking, creativity, empathy, and idea synthesis as they create AI artefacts.

The frequency of using AI tools was measured with Likert-type answer options, ranging from never to always (Never; Rarely, <11 times a year; Occasionally, 1-3 times a month; Frequently, 2-6 times a week; Always, >1 a day).

3.2 Sample

Our study focused on university students aged between 18 and 25 years, aiming mainly at undergraduate and Master's students (N=28).

Most respondents, constituting a significant 78.6% of the surveyed group, fell within the age bracket of 19 to 25, representing a dominant age group in our study. The remaining 21.4% of respondents consisted of individuals aged 26 to 31. Regarding gender, 46.4% of the participants were identified as female and 53.6% as male.

About the maximum level of studies achieved by the participants, the largest representation came from individuals with a Bachelor's degree, constituting 28.6% of the participants. Following closely, 28.6% of the respondents had completed upper secondary education. Additionally, 21.4% of our sample hold a Master's degree. There were also 21.4% of the participants who came from post-secondary non-tertiary education and college or vocational training.

3.3 Procedure

The data were collected online, mainly among students of the University of Maribor of which some were Erasmus students. Likewise, they had different backgrounds from different countries; this research may have also reached students from other universities, especially Spanish universities, and other types of study centers, such as vocational training students.

The online questionnaire was held from 9th January 2024 until 12th January 2024, and it was distributed by WhatsApp links to different chats and groups following a convenience sampling method.

4 RESULTS

4.1 RQ1: Effect of the sociodemographic characteristics on AI literacy

To find an answer to the first research question, we analyzed the effects of gender, age, and level of studies on AI literacy (see Table 1). Accordingly, we used a Mann-Whitney U Test. The results revealed a statistically significant difference between males and females ($U = 30$, $p = .002$, $Z = -3.14$). Specifically, the males had a higher mean rank (19.00) than females (9.31), suggesting that they scored higher on AI literacy measures on average. The results revealed no statistically significant difference in AI literacy between the 18–25 and 26–30 age groups ($p > .05$). Likewise, the p-value for level of studies ($p = 0.32$) indicated that there was no significant difference in AI literacy between people with pre-university studies and those with higher studies.

Table 1: Sociodemographic characteristics

Variable	Value	N	Mean Ranks
Gender	Male	15	19
	Female	13	9.31
Age	18-25 years	22	14.27
	26-30 years	6	15.33
Level of studies	Pre-university studies	8	12.06
	Higher studies	20	15.48

4.2 RQ2: Effect of digital literacy on AI Literacy

Analyzing the collected results, most of the participants (85.8%, *n*=24) had self-reported a high level of digital literacy (see Table 2).

Table 2: AI literacy according to the digital literacy

Variable	Value	N	Mean Ranks
Digital literacy	Low level	4	9.75
	High level	24	15.29

Following the Mann-Whitney U Test, the results did not reveal a statistically significant difference between students with low and high levels of digital literacy ($U = 29$, $p = .207$, $Z = -1.261$). Specifically, the students with high digital literacy had a higher mean rank (15.29) than those with low digital literacy (9.75), suggesting that they scored higher on AI literacy measures on average. However, this difference was not statistically significant ($p > .05$), indicating that other factors might be influencing AI literacy that are not related directly to the levels of digital literacy assessed in this study.

The results suggest that participants exhibited relatively high levels of both digital and artificial literacy. The mean digital literacy score of 1.86 out of a maximum of 2 indicates a strong grasp of digital technologies. However, the mean artificial literacy score of 21.54 appears notably high considering the maximum possible value of 30 (see Table 3).

Table 3: digital literacy and artificial literacy

Variable	Mean	Standard Deviation	Min. value	Max. value
Digital literacy	4.50	0.84	2	5
Artificial literacy	21.54	4.53	13.00	30.00

4.3 RQ3: Effect of the level of AI interest on AI literacy

The descriptive data revealed an interest in AI among respondents, with 78.6% expressing a strong interest. Meanwhile, 21.5% of respondents expressed disinterest.

A Mann-Whitney U test was conducted to compare AI literacy between students with high and low interest in AI. The results indicated a statistically significant difference between the two groups ($U = 26$, $p = .024$, $Z = -2.26$). The students with a high interest in AI had a higher mean rank (16.32) than those with a low interest in AI (7.83), suggesting they scored higher on AI literacy measures on average (see Table 4).

Table 4: AI literacy according to AI interest

Variable	Value	N	Mean Ranks
AI interest	Low interest	6	7.83
	High interest	22	16.32

4.4 RQ4: Effect of the frequency of using AI tools on AI literacy

A Mann-Whitney U test was conducted, to investigate the relationship between the frequency of using AI tools during free time or for exam preparation and participants' AI literacy levels. The participants were categorized into two groups based on their reported usage: "at least once a week" and "less than once a week."

Regarding the frequency of use of AI during free time, the results revealed a statistically significant difference between both groups ($U = 53$, $p = .04$, $Z = -2.07$). Individuals who reported using AI tools at least once a week had a higher mean rank (17.92) compared to those who used them less often (11.53), suggesting higher AI literacy on average (see Table 5).

Table 5: AI literacy according to the frequency of using AI tools during free time

Frequency	N	Mean Ranks
Less than once a week	15	11.53
At least once a week	13	17.92

Regarding the frequency of use of AI for exam preparation, the results revealed a statistically significant difference between the groups ($U = 38$, $p = .031$, $Z = -2.16$). The results revealed a higher mean rank in the group that reported the highest frequency of using AI tools for exam preparation (19.75), compared to those who used them less often (12.40), suggesting higher AI literacy on average (see Table 6).

Table 6: AI literacy according to the frequency of using AI tools for exam preparation

Frequency	N	Mean Ranks
Less than once a week	20	12.40
At least once a week	8	19.75

5 CONCLUSIONS

This study aimed to examine the relationship between various factors and AI literacy among higher education students. Specifically, it explored the impact of demographic factors, digital literacy, interest in AI, and frequency of AI usage.

After assessing the sociodemographic variables pertinent to RQ1, the results revealed a statistically significant difference between males and females in AI literacy, suggesting that male

participants scored higher in AI literacy than women. According to Long and Magerko (2020), diversity in the Computer Science workforce, including AI, remains a significant issue. In 2018, 80% of AI Professors and 71% of applicants for AI-related jobs were men. This lack of diversity can influence the target users of developed systems, a critical concern in AI, where biased algorithms can harm marginalized groups disproportionately. The specific field of study of the students was not assessed in this study, which could influence the results significantly, especially if there was a concentration of Computer Science students. It is essential to incorporate this variable in future research to obtain more accurate results.

While our findings do not show a significant gap in AI literacy between the age groups analyzed, or between pre-university and university students, however, other studies suggest that low socioeconomic status (SES) children perform on average worse on AI abilities and AI literacy education than children with higher SES backgrounds (Druga et al., 2019).

Digital literacy was examined to address RQ2. Our results did not show a significant correlation between digital literacy and AI literacy. However, it is worth noting that most participants expressed a high level of confidence in their abilities in both areas. Given that participants self-reported their AI literacy, there is a likelihood of overestimation bias due to the Dunning-Kruger effect. Consistent with this, other research indicates that children often overvalue the capabilities of AI agents, possibly reflecting a limited understanding of underlying AI technologies (Long and Magerko, 2020). To enhance the reliability and validity of the data, future research should consider utilizing a combination of measurement techniques, to obtain a more accurate and objective measurement of the participants' actual AI knowledge and genuine understanding.

Our findings indicate that students with a higher interest in AI (RQ3) and those who frequently use AI tools (RQ4), especially for exam preparation, may possess a higher level of AI literacy. Regarding homework, the AI literacy levels was not statistically significant as a factor in relation to the frequency of use of Artificial Intelligence as an assistant with homework. Drawing conclusions about whether using AI tools improves literacy or individuals with higher literacy simply use them more requires further investigation.

Our results are also limited by the small sample size. Further research is needed to confirm causality (between digital literacy, interest in AI, frequency of use and AI literacy), and consider another factor as the area of knowledge of the participants in which they are specialized.

AI can be a powerful educational tool, offering more personalized learning experiences and improved accessibility. Some studies support the importance of the inclusivity of chatbots to facilitate the learning process, but AI tools also present ethical dilemmas, such as biased results and an uncritical use of information (Kožuh et al., 2023).

This research shows a small insight into the relationship of young students with these new technologies. For further research, it is also suggested that the uses and gratifications of these technologies be explored in more depth, exploring which type of AI is the most used by the population and students.

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Pogovorno programerstvo: pot do boljšega razumevanja izotopov

Conversational Programming: A Better Understanding of Isotopes

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POVZETEK

V članku je opisujemo primer medpredmetne povezave kemije in informatike, pri čemer razvijamo temeljna znanja obeh predmetov. Pri tem izpostavimo dejstvo, da je zelo pomembno, da se kemik zna pogovarjati z informatikom. Predstavljena je izvedba učnih ur v 1. letniku gimnazijskega programa. Dijaki so z izdelovanjem programa, s katerim so narisali submikroskopsko predstavitev izotopske sestave elementa, bolje spoznali funkcije s parametri, tabele in uporabo modula. Z izdelavo lastne slike se jim je izboljšal uvid v zgradbo snovi.

KJUČNE BESEDE

algoritmično razmišljanje, MINT, medpredmetno povezovanje

ABSTRACT

The article describes an example of interdisciplinary integration between chemistry and computer science, where fundamental knowledge of both subjects is developed. It highlights the importance of a chemist being able to communicate with a computer scientist. The implementation of lessons in the first year of the gymnasium program is presented. By creating a program that draws a submicroscopic representation of an element's isotopic composition, students gained a better understanding of functions with parameters, tables, and module usage. Creating their own image also improved their insight into the structure of matter..

KEYWORDS

Computational thinking, STEM, multi-disciplinary teaching

1 UVOD

Učitelji informatike na gimnazijah pogosto iščemo konkretnega primere iz vsakdanjega življenja ali vsaj iz vsebine nekega drugega gimnazijskega predmeta, kjer si lahko pomagamo z znanji računalništva in informatike. Ker vstopamo v vedno bolj razvijajočo se digitalno družbo, je za šole postalo nujno, da se prilagodijo in opremijo prihodnje generacije s potrebnimi znanji in spretnostmi. [2] V projektu NAPOJ MINUT se povezujemo učitelji računalništva in informatike (RIN) z ostalimi (pretežno) naravoslovnimi predmeti, torej MINUT - M(atematika) I(nformatika) N(aravoslovje) U(metnost) T(ehnologija) predmete.

V okviru projekta:

- Se redno sestajamo na spletnih (ZOOM) sestankih in izmenjujemo izkušnje
- Razvijamo gradiva, kjer se prepletata RIN in še en predmet
- Se srečujemo na delavnicah
- Sodelujemo na konferencah: NAK, STEAMColab, DigiDakta, VIVID
- Obiskujemo kolege iz drugih držav, ki poučujejo na podoben način

V sklopu projekta je nastalo že več kot 10 obravnav tem, določene pa so še v razvoju. Za več informacij o projektu se lahko obrnete na napoj@404.si

1.1 Povezovanje predmetov informatika in kemija

Dijaki si težko predstavljajo submikroskopsko zgradbo snovi, pri tem jim lahko pomagajo grafični prikazi. Predvidevali smo, da bo vizualizacija še učinkovitejša, če si prikaze dijaki ustvarijo sami s pomočjo želvje grafike. Pri tem uporabijo podatke, ki so dostopni na spletu.

S povezovanjem teh dveh predmetov želimo pri dijakih utrditi znanje obeh predmetov in v dijakih povzročiti vsaj majhen premik v zavedanju, da bodo v poklicu, ki si ga bodo izbrali, pa naj bo kakršen koli, potrebovali sposobnost, da informatiku razložijo kakšen program potrebujejo za rešitev nekega , recimo kemijskega problema. Za čim bolj učinkovito razlago potrebujejo tudi nekaj temeljnega znanja informatike.

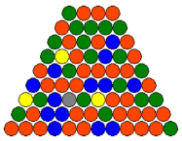
Druga želja pri povezovanju je, da bi dijaki videli, da je znanje enega predmeta uporabno in potrebno tudi pri drugem.

1.1.1 Ideja projekta

Dijaki že na osnovni šoli spoznajo izotope, na gimnaziji pa to še nadgradijo z računanjem relativne atomske mase elementov s pomočjo relativnih atomskih mas posameznih izotopov in njihove pojavnosti v naravi. Izkaže se, da ima veliko dijakov težave s submikroskopsko predstavo izotopske sestave, zato jim pri tem lahko pomaga grafičen prikaz za vsak element posebej, ki ga lahko s pomočjo želvje grafike naredijo sami.

Pri poučevanju informatike na gimnaziji želimo dijakom omogočiti pridobivanje temeljnih znanj računalništva in

informatike. Zato jih učim programiranja, pri čemer je primer risanja grafične predstavitve odličen za utrjevanje številnih konceptov programiranja. Naloga vključuje uporabo funkcij s parametri, tabel in modula random.



Slika 1: Zn

2 O PROJEKTU

2.1 Operativni učni cilji

V sklopu projekta smo zastavili naslednje učne cilje.
Dijaki bodo:

- sposobni razviti algoritem v psevdo kodi,
- sposobni razmišljati o potrebnih iteracijah zanke in ustrezno prilagoditi algoritem,
- sposobni zapisat funkcijo v programskem jeziku,
- sposobni zapisat tabelo in elemente z uporabo modula random naključno premešat,
- spoznali osnovne ukaze grafične knjižnice,
- znali bodo pojasniti, kako se izotopi istega elementa razlikujejo glede na atomsko maso, kljub enakim kemijskim lastnostim,
- znali bodo interpretirati grafični prikaz izotopske sestave elementov.

2.2 Načrtovanje projekta

Pred samo izvedbo projekta medpredmetnega sodelovanja je pomembno, da se učitelji uskladimo, kakšno mora biti predznanje dijakov pri vseh sodelujočih predmetih. S tem določimo tudi časovne okvire v katerih lahko izvedemo projekt. Pogosto se pokaže, da so potrebne manjše prilagoditve v programih posameznih predmetov, kot tudi morebitno spremembo operativnih učnih ciljev projekta.

Pri pouku kemije so se dijaki naučili, da niso vsi atomi istega elementa enaki oziroma, da ima večina elementov vsaj dva ali več izotopov. V okviru pouka informatike smo najprej obravnavali temeljne koncepte programiranja, vključno z zaporedjem ukazov, uporabo spremenljivk in zankami. Nadaljevali smo z osnovami želvje grafike in funkcijo za izris kroga.

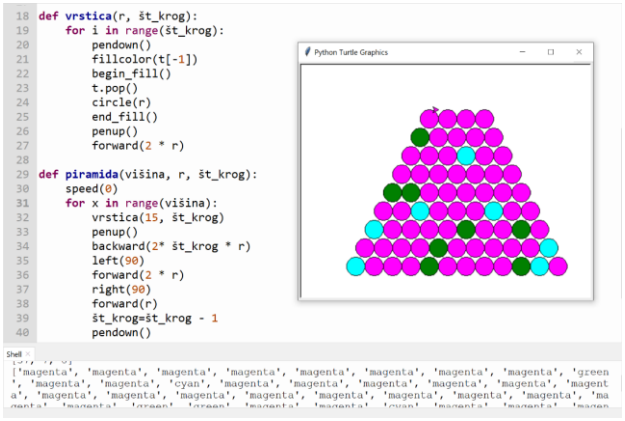
2.3 Izvedba

Skupaj smo zasnovali algoritem za izris prve vrstice krogcev brez barv. V naslednji učni uri so dijaki v parih ta algoritem implementirali v programskem jeziku Python. Nekateri naprednejši dijaki so program razširili na več vrstic, vendar sprva nihče ni uporabil funkcij. Funkcijo smo definirali v kasnejši fazi in jo uporabili za izris celotne slike, pri čemer so dijaki spoznali uporabnost funkcij in pomen smiselne uporabe parametrov.

V nadaljevanju smo se posvetili barvanju krogcev, kar je zahtevalo definiranje tabel in postopek za izračun deleža izotopov v ustrezno število krogcev.

Dijaki so na ustrezni spletni strani pridobili podatke o izotopski sestavi izbranega elementa [1], ki so jih nato vključili v program. Vsak par dijakov je izbral svoje barvne sheme in, glede na pridobljene podatke, zapisali zanko, ki je generirala tabelo z ustreznim številom barv. Za naključno premešanje barv so uporabili funkcijo shuffle iz modula random.

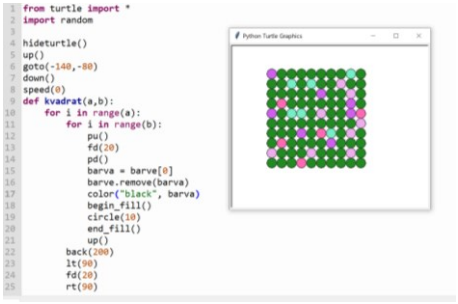
Na slikah 2 in 3 sta primera izdelkov dveh dijakov. Večina dijakov se je odločila za izris v obliki piramide, nekateri pa so izbrali drugačne geometrijske oblike, na primer kvadrat.



```
def vrstica(r, št_krog):
    for i in range(št_krog):
        pendown()
        fillcolor(t[-1])
        begin_fill()
        t.pop()
        circle(r)
        end_fill()
        penup()
        forward(2 * r)

def piramida(višina, r, št_krog):
    speed(0)
    for x in range(višina):
        vrstica(15, št_krog)
        penup()
        backward(2* št_krog * r)
        left(90)
        forward(2 * r)
        right(90)
        forward(r)
        št_krog=št_krog - 1
        pendown()
```

Slika 2: primer kode programa (Mg)



```
from turtle import *
import random

hideturtle()
up()
goto(-140,-80)
down()
speed(0)
def kvadrat(a,b):
    for i in range(a):
        for i in range(b):
            pu()
            fd(20)
            pd()
            barva = barve[0]
            barve.remove(barva)
            color("black", barva)
            begin_fill()
            circle(10)
            end_fill()
            up()
        back(200)
        lt(90)
        fd(20)
        rt(90)
```

Slika 3: primer izdelka (Ti)

Za izvedbo projekta pri kemiji ni bilo potrebnih dodatnih ur, saj je bila vsebina že vključena v redni učni načrt. Prav tako so bile aktivnosti pri informatiki v skladu z učnim programom. Celoten projekt je obsegal približno 5 učnih ur, vendar niso bile izvedene v neprekinjenem zaporedju, saj smo vmes potrebovali dodatne vaje za utrjevanje osnov funkcij in tabel. Projekt je bil uspešno izveden v dveh različnih razredih.

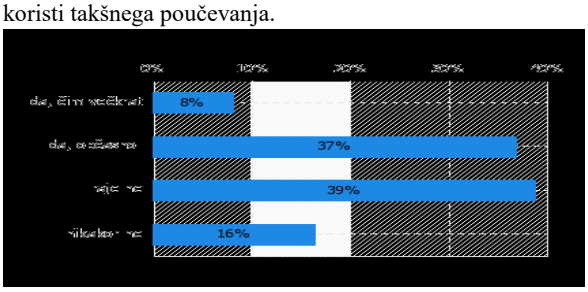
Pri utrjevanju tabel in funkcij smo uporabljali pripravljene naloge iz projekta Tomo [3]. Dodali smo tudi nekaj novih nalog, ki smo jih potrebovali med projektom.

3 REFLEKSIJA

Med izvajanjem aktivnosti se je pokazalo, da dijaki zelo dobro sledijo procesu izdelave algoritma, kadar ga razvijamo skupaj. V drugem razredu sem preizkusila drugačen pristop: z dijaki smo sprva ustno načrtovali izris ene vrstice krogcev, nato pa so dijaki v parih samostojno zapisali algoritem. V naslednji učni uri smo zapise algoritmov zamenjali med pari, tako da je vsak par dobil algoritem od sošolcev, njihova naloga pa je bila, da ta algoritem implementirajo v programskem jeziku Python. Izkušnja je pokazala, da je bila ta naloga za mnoge dijake

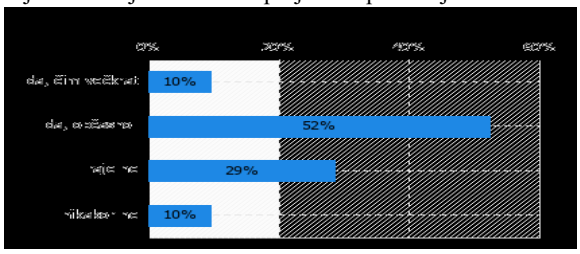
pretežka. Nekateri so zapisali svojo različico algoritma, medtem ko so bili drugi zmedeni in niso uspeli sestaviti niti svojega niti sošolčevega algoritma. Na koncu ure smo zato skupaj zapisali eno izmed možnih rešitev.

Po izvedbi aktivnosti smo se temeljito posvetili analizi anket, ki so jih dijaki izpolnili pred in po aktivnosti. Rezultati predhodnih anket so pokazali precejšen skepticizem in nezainteresiranost dijakov glede povezovanja različnih predmetov, kar je izpostavilo izziv pri vzpostavljanju pozitivnega odnosa do interdisciplinarnega pristopa. Dijaki so sprva izražali dvome o smiselnosti in uporabnosti tovrstnega načina dela. To je potrdilo naše prepričanje o potrebnosti dodatnih prizadevanjih za izboljšanje njihovega dojemanja koristi takšnega poučevanja.



Slika 4: Bi rad(a), da se tak pristop k snovi, ki ga boste izvedli (prepletanje "druge" snovi in računalništva) še večkrat izvaja

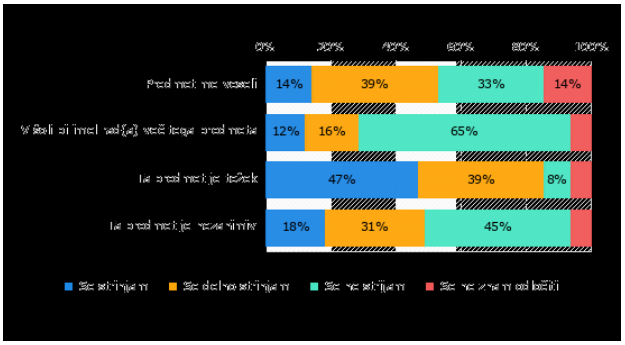
Kljub temu so povratne informacije po izvedeni aktivnosti pokazale premik v razmišljanju dijakov, saj so nekateri prepoznali vrednost v povezovanju različnih disciplin in izrazili večje zanimanje za tovrstne projekte v prihodnje.



Slika 5: Bi rad(a), da se tak pristop k snovi, ki ste ga izvedli (prepletanje "druge" snovi in računalništva) še večkrat izvaja?

Dijaki so ocenili, da je uporaba računalništva pri kemiji zapletena in težka, pri čemer so navedli, da je tak pristop nerazumljiv, nesmiseln in včasih celo nemogoč. Le 10 od 51 dijakov je izrazilo pričakovanja, da bodo pridobili novo znanje, poglobljeno razumevanje obeh predmetov in da bo delo tudi zabavno. Po izvedbi projekta se je mnenje, da je računalništvo zahtevno, še okrepilo, kar je bilo v nasprotju z našimi začetnimi predvidevanji. Po premisleku pa smo ugotovili, da je to pričakovano, saj so dijaki poleg osnov programiranja, s katerimi so se srečali pred projektom, morali obvladati tudi naprednejše koncepte, kot so tabele in funkcije.

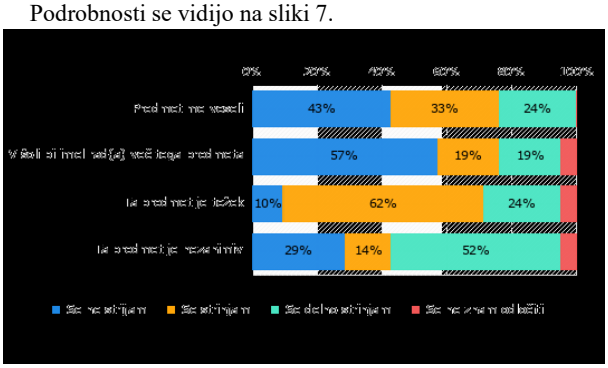
Pokazalo se je, da se je odnos dijakov do kemije po izvedbi aktivnosti pozitivno spremenil. Medtem ko so bili odgovori pred aktivnostjo, prikazani na sliki 6, bolj zadržani in negativni, so rezultati po aktivnosti, prikazani na sliki 7, pokazali izboljšanje. Dijaki so kemijo dojemali kot bolj zanimivo in dostopno, kar kaže na uspešnost medpredmetnega pristopa pri izboljšanju njihovega dojemanja predmeta.



Slika 6: Oceni svoj odnos do predmeta, kjer boste uporabili računalništvo (kemija, fizika ...)

Po aktivnosti je sicer odgovarjalo malo manj dijakov, vendar jim je predmet bolj zanimiv, manj težak ipd.

Podrobnosti se vidijo na sliki 7.



Slika 7: Oceni svoj odnos do predmeta, kjer ste uporabili računalništvo (kemija, fizika ...)

Z veseljem opažamo, da so odgovori dijakov na vprašanja o pridobljenih izkušnjah iz te aktivnosti v večini primerov spodbudni, čeprav je na to vprašanje odgovorilo le 15 dijakov. Le dva dijaka sta izrazila negativno mnenje, navajajoč, da jim je tovrstna aktivnost povzročala več zmede in stresa. Nasprotno pa je 12 dijakov prepoznalo več prednosti, kot so: pridobitev dodatnega znanja, globlje razumevanje snovi, nov pristop k reševanju problemov in bolj zanimiv pouk. Posebej zanimiv je bil komentar enega izmed dijakov, ki je predlagal, da bi bilo koristno prilagoditi zahtevnost programov glede na predznanje dijakov, saj je to med njimi precej različno.

4 ZAKLJUČEK

Medpredmetno povezovanje kemije in informatike se je izkazalo kot koristna strategija za poglabljanje razumevanja tako kemijskih kot tudi računalniških konceptov. Z aktivnostmi, kjer so dijaki ustvarjali grafične predstavitve izotopske sestave elementov, smo uspeli doseči več ciljev. Ne samo, da so dijaki poglobili svoje razumevanje kemije in informatike, temveč so se tudi spoprijeli z izzivom uporabe programiranja kot orodja za reševanje kemijskih problemov.

Rezultati ankete so pokazali, da kljub začetnemu skepticizmu, ki so ga dijaki izražali pred izvedbo projekta, večina po izvedbi

ceni prednosti takega integriranega pristopa. Pozitiven premik v odnosu dijakov do kemije in informatike nakazuje na pomembnost nadaljevanja in razvijanja podobnih projektov, pri čemer je ključno prilagajanje zahtevnosti nalog glede na različno predznanje dijakov.

Kljub izzivom, kot je občutek povečane težavnosti informatike, je medpredmetno povezovanje smiselno, saj izboljša njihovo razumevanje učnih vsebin, kar je tudi eden izmed dolgoročnih ciljev projekta NAPOJ MINUT.

Pomemben poudarek projekta ostaja na sposobnosti dijakov, da s pomočjo temeljnih znanj informatike in naravoslovja prepoznajo uporabnost enega predmeta pri drugem, kar je bistveno za njihovo prihodnjo poklicno pot, kjer bodo morali znati komunicirati z različnimi strokovnjaki, vključno z informatiki. Med načrtovanjem in izvedbo projekta je bilo potrebno veliko pogovorov med učiteljem informatike in učiteljem kemije, da sva se pravilno razumeli. Zadnjo uro pouka v tem projektu sva bili pri pouku informatike prisotni obe učiteljici, da smo zadevo zaključili z obeh zornih kotov. Nadaljnje raziskave in izboljšave pri medpredmetnem povezovanju lahko še naprej prispevajo k boljšemu izobraževalnemu procesu in pripravijo dijake na izzive digitalne dobe.

Vse navedeno poudarja potrebo po poglobljenem in kontinuiranem razvoju medpredmetnih povezav, ki dijake ne le učijo vsebin, ampak tudi razvijajo pomembne veščine, kot so algoritmično razmišljanje, kritično mišljenje in interdisciplinarno sodelovanje.

VIRI

[1] Atomic Weights and Isotopic Compositions for All Element (avgust, 2024) DOI: https://physics.nist.gov/cgi-bin/Compositions/stand_alone.pl?ele=&all=all

[2] Bridging the Gap: Infusing Natural Science Classes with Computer Science Concepts and Skills - na koncu Springer proceedings (doi:10.1007/978-3-031-44900-0)

[3] M. Pretnar, „Spletna storitev za poučevanje programiranja,“ v Vzgoja in izobraževanje v informacijski družbi – VIVID 2014 , Kranj: Fakulteta za organizacijske vede, 2014

Z umetno inteligenco nad domače branje

Artificial Intelligence on Top of Home Reading

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POVZETEK

V prispevku je predstavljen primer iz prakse, in sicer obravnava domačega branja pri pouku slovenščine s pomočjo umetne inteligence. Cilj dejavnosti je, poleg predpisanih ciljev učnega načrta, razvijati tudi različne spretnosti in sposobnosti pri učencih, npr. komunikacijske, informacijske in raziskovalne, hkrati pa vzpostavljati pozitivno izkušnjo z literaturo in s tem pri učencih vzbujati zanimanje za branje. S sodobnim pristopom ter približevanjem zanimanjem in trendom mladih lahko učitelji pouk književnosti naredijo učencem privlačen. Učenci so za rabo različnih tehnologij v zasebni rabi, tako za komunikacijo kot zabavo, zelo motivirani. Vse te nove tehnologije imajo lahko tudi v šoli veliko moč, če so kakovostno osmišljene in povezane s cilji in vsebinami učenja.

KLJUČNE BESEDE

Keywords in the language of the paper separated by commas

ABSTRACT

This article presents a practical example of integrating artificial intelligence into Slovenian language classes to support home reading assignments. In addition to the prescribed curriculum objectives, the aim of this activity is to develop various skills and abilities in students, such as communication, information literacy, and research skills. Furthermore, it seeks to establish a positive experience with literature, thus fostering an interest in reading among students. By adopting a modern approach that aligns with the interests and trends of young people, teachers can make literature lessons more appealing. Students are highly motivated to use different technologies in their private lives for both communication and entertainment. When thoughtfully integrated and aligned with learning objectives and content, these new technologies can also hold great potential in the classroom.

KEYWORDS

Slovenian language, literature, home reading, artificial inteligence, Chat GPT

1 UVOD

V sodobnem izobraževalnem okolju se učitelji nenehno soočamo z izzivom motiviranja učencev za branje. V kontekstu poučevanja slovenščine se pojavlja vprašanje, kako lahko izkoristimo potencial umetne inteligence (UI) za izboljšanje učne izkušnje. Umetna inteligenca je namreč že močno prisotna v življenju učencev, zato je ključno, da prepoznamo njen potencial za ustvarjalno in učinkovito poučevanje. V članku je predstavljen primer iz prakse, in sicer uporaba umetne inteligence in digitalnih platform za spodbujanje aktivnega branja in povečanje literarne ter digitalne pismenosti med učenci. Obravnavali bomo primer praktične uporabe teh tehnologij in njihov potencial za izboljšanje učne izkušnje pri pouku.

2 RABA UI PRI SLOVENŠČINI

Marija Žveglič v svojem raziskovanju rabe IKT pri pouku slovenščine ugotavlja, da so učenci v prostem času zelo motivirani za rabo različnih tehnologij, tako na ravni komunikacije kot tudi zabave; zastavlja pa se vprašanje, ali zmoremo njihovo zasebno navdušenost na šolskem polju kakovostno osmisliti ter povezati s cilji in z vsebinami učenja oz., ali smo glede na dejstvo, da je tehnološki razvoj v velikem zagonu, pripravljeni premisliti in prevrednotiti obstoječo pedagoško prakso v luči ustvarjalne in učinkovite rabe novih tehnologij [1]. Kot poudarja učni načrt za slovenščino (2019), se razvijanje digitalne zmožnosti povezuje z razvijanjem sporazumevalne zmožnosti v slovenskem jeziku. Poleg spletnih učnih okolij, kot so forum, klepetalnica, uporaba anket ali drugih odzivnih sistemov za razne oblike preverjanja, videokonferenca za sodelovalno učenje itd., učni načrt omenja tudi uporabo družabnih omrežij, ob čemer naj učitelj učence tudi ozavešča o odgovornem poseganju v splet in o odgovorni rabi informacijske tehnologije ter jih uči, kako lahko sami prispevajo za splet [2].

Uvajanje umetne inteligence v izobraževanje je prineslo številne spremembe in priložnosti za izboljšanje izobraževalnega procesa. Z umetno inteligenco lahko razvijemo bolj prilagojene in personalizirane učne dejavnosti, ki ustrezajo individualnim potrebam učencev [4]. Kljub hitremu vdoru umetne inteligence v naše učilnice, priložnosti, ki jih bo le-ta ustvarila za naše šole, daleč presegajo tveganja, ki jih te tehnologije prinašajo. Prilagajanje šolstva UI je velik izziv, vendar lahko z ustrezno znanjem in veščinami učitelji pristopijo k temu novemu obdobju pripravljeni, da se osredotočijo na to, kar najbolje delajo: poučevanje naših učencev. Kljub temu pa moramo, tako kot pri vsakem hitrem razvoju, skrbno premisliti, kako, kdaj in zakaj prilagajamo našo prakso in pedagogiko v odzivu na umetno inteligenco. V mnogih primerih namreč lahko umetna inteligenca izboljša naše obstoječe prakse in nam tako pomaga učinkoviteje doseči naše izobraževalne cilje [3].

V začetku poletja 2024 je Ministrstvo za šolstvo RS objavilo predlog nacionalnega programa vzgoje in izobraževanja 2023-2033. Nacionalni program digitalni pismenosti namenja nekaj pozornosti, vendar pri tem vsebine umetne inteligence umešča predvsem v srednje šole [5]. Ker pa se otroci z njo srečajo že dosti prej, vsaj z razvpitim Chatom GPT, bo dobrodošel razmislek, kako jim predstaviti delček teh vsebin tudi že v osnovni šoli. Primer takšne aktivnosti podajamo v nadaljevanju.

Domače branje je sestavni del pouka slovenščine, ki ga številni učenci dojemajo kot nepotrebno breme. Kljub velikim prizadevanjem učiteljev, da bi literaturo približali učencem in jih navdušili za branje, se pogosto zgodi, da učenci ne izpolnijo pričakovanj. Namesto da bi se poglobili v knjige in jih prebirali z zanimanjem, se mnogi odločijo za prepisovanje obnov, kar vodi do slabih rezultatov na testih preverjanja znanja in občutka neuspeha tako pri učitelju kot pri učencih. Učitelji se pogosto soočamo z izzivom, kako učence motivirati za branje, da bi dosegli boljše razumevanje literature in bogatejšo izkušnjo branja.

Pomanjkanje motivacije za branje med učenci je velik izziv, zato je še toliko bolj pomembno, da se učitelji slovenščine trudimo domače branje narediti čim bolj privlačno. Veliko truda in energije je potrebno, da učencem poleg obveznih kanonskih del ponudimo tudi literarna dela, ki so jim po vsebini bližja in zanimivejša, ter jih obogatimo z dejavnostmi, ki jih naredijo privlačnejše in je tako obravnava literarnih del čim bolj raznolika in inovativna. V razredu uporabljamo različne metode in pristope, ki vključujejo interaktivne dejavnosti, diskusije, igranje vlog in kreativno pisanje. Pri obravnavi knjig pogosto posegamo tudi po sodobnih orodjih in tehnologijah, kar omogoča bolj dinamično in zanimivo učno izkušnjo. Na primer, uporabljamo digitalne platforme za skupinsko delo, spletne kvize za preverjanje znanja in multimedijske vire za poglobljeno razumevanje konteksta literarnih del.

S takim pristopom želimo učencem približati literaturo na način, ki je zanje bolj dostopen in zanimiv. Verjamemo, da je ključ do uspeha v prilagodljivosti in inovativnosti pri poučevanju, saj lahko s tem pripomoremo, da bodo učenci razvili ljubezen do branja in literarne kulture. Na ta način dosežemo, da domače branje postane manj obremenjujoče in prijetnejše doživetje za vsakega učenca, kar bo dolgoročno prispevalo k njihovemu celostnemu razvoju in izobraževanju.

3 PRIMER IZ PRAKSE

3.1 Domače branje malo drugače

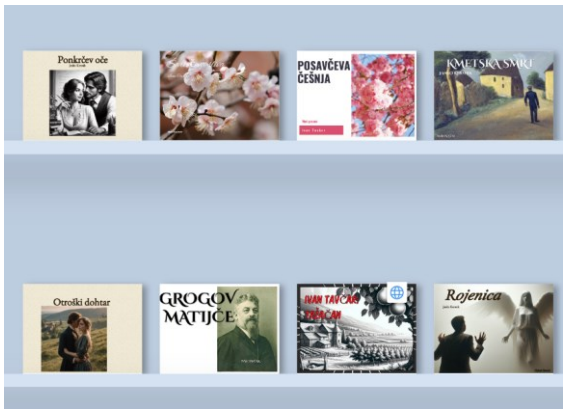
Med deli, ki se jih učenci za domače branje lotijo z manj navdušenja, sta deli iz obdobja slovenskega realizma, zbirki slik Med gorami Ivana Tavčarja ter Kmetske slike Janka Kersnika. Ker gre za starejša literarna dela, jim pri branju dela težave že sam jezik, prav tako pa jim zgodbe niso blizu zaradi povsem drugačnega izkušenjskega sveta. V iskanju možnosti, kako spodbuditi učence k aktivnemu branju in sodelovanju, smo se osredotočili na inovativen pristop s pomočjo umetne inteligence.

3.2 Potek dejavnosti

Chat GPT je napreden jezikovni model, ki omogoča generiranje koherentnih in informativnih besedil. Uporabili smo ga kot orodje za pomoč učencem pri oblikovanju obnov prebranih zgodb. Učenci so najprej prebrali knjigo in nato s pomočjo Chat GPT ustvarili obnove posameznih zgodb. Predhodno branje izhodiščnih besedil je bilo pri tem pomembna osnova, saj so učenci le ob natančnem poznavanju vsebine lahko kritično presojali rezultate, ki so jih dobili z uporabo UI. Med samo dejavnostjo v računalniški učilnici so bili zato razdeljeni v manjše skupine, da so lahko med sabo primerjali razumevanje vsebine knjige in dobljenih rezultatov. Vsaka skupina je imela nalogo v Chat GPT kopirati celotno zgodbo posameznih enot izbrane knjige (obe književni deli sta v celoti objavljeni na platformi Wikivir) ter od Chata zahtevati njeno obnovo. Dobljeni rezultati so se od skupine do skupine precej razlikovali, nekatere obnove so bile precej dobre, druge bistveno manj, kar nam je služilo tudi kot iztočnica za pogovor o napakah in pasteh uporabe Chat GPT. Ta pristop je učencem omogočil, da so se osredotočili na ključne elemente zgodbe in razvijali svoje sposobnosti analize in sinteze informacij. Po ustvarjanju obnov so učenci nato svoje delo predstavili s pomočjo spletne platforme Book Creator, ki omogoča enostavno oblikovanje digitalnih knjig. Aplikacija omogoča učiteljem in učencem, da na preprost način ustvarjajo in delijo interaktivne knjige. Deluje na različnih napravah, vključno s tablicami, prenosnimi računalniki in mobilnimi telefoni. Uporabniki lahko v svoje knjige vključijo različne multimedijske vsebine, kot so besedilo, slike, video posnetki, zvok in risbe.

Platforma podpira vlečenje in spuščanje, kar olajša urejanje strani in dodajanje vsebin. Ena od pomembnih funkcij je možnost sodelovanja, kar pomeni, da lahko več učencev hkrati dela na isti knjigi, kar spodbuja timsko delo. Book Creator ponuja tudi številne predloge, ki uporabnikom pomagajo začeti ustvarjanje knjig (slika 1). Učitelji lahko nadzorujejo in upravljajo delo svojih učencev, dodeljujejo naloge ter ocenjujejo njihovo delo neposredno na platformi. Platforma podpira tudi izvoz knjig v formate PDF in ePub, kar omogoča enostavno deljenje in tiskanje. Brezplačna različica omogoča osnovno uporabo platforme z določenimi omejitvami, medtem ko plačljive različice ponujajo dodatne funkcionalnosti in zmogljivosti.

Vsak učenec je s pomočjo omenjenega programa oblikoval svojo digitalno knjigo, ki je vključevala obnovo zgodbe in ilustracije. Pri tem smo šli še korak dlje, saj smo slike ustvarjali s pomočjo programa Microsoft Copilot Designer (prej Bing Image Creator). Gre za orodje, ki uporablja umetno inteligenco za ustvarjanje slik na podlagi besedilnih opisov. Temelji na tehnologiji DALL-E, ki jo je razvilo podjetje OpenAI. Designer je brezplačno dostopen, vendar je potrebna prijava z Microsoftovim računom. Ustvarjanje slik je učencem omogočilo, da so vizualno predstavili svoje razumevanje zgodb. V program so vnesli opis slike, ki so jo želeli ustvariti. Opis je lahko vključeval podrobnosti o predmetih, okoljih, barvah in slogih. Za dejavnost je bilo potrebno nekoliko več časa, kot smo načrtovali, saj so učenci potrebovali veliko pomoči pri ustvarjanju kvalitetnih ukazov za generiranje slik. Nekaj dela, predvsem uvodno seznanjanje z obema aplikacijama, smo zato opravili skupaj, v računalniški učilnici, učenci pa so svoje izdelke nato dokončali doma. Ob zaključni uri smo si nato skupaj ogledali predstavitve izdelkov ter si v pogovoru izmenjali mnenja ter vtise o izvedeni dejavnosti in uporabljenih AI pripomočkih.



Slika 1: »Knjižnica« v programu Book Creator

4 Zaključek

Uporaba umetne inteligence v okvirih programov Chat GPT, Book Creator in Copilot Designer je učencem omogočila, da so se na kreativen in interaktiven način poglobili v literarno delo ter hkrati razvijali veščine digitalne pismenosti in kreativnega izražanja. Tak pristop spodbuja aktivno učenje in povečuje motivacijo učencev za sodelovanje pri domačem branju, saj jim omogoča, da literaturo doživijo na sodoben in zanimiv način. Dodano didaktično vrednost opisane dejavnosti vidimo predvsem v drugačnem pristopu, ustvarjanje je bilo učencem zabavno, saj se jim je pri tem utrnilo ogromno idej, hkrati pa smo ure pouka izkoristili tudi za osveščanje ter pogovor o etičnih vidikih in pasteh uporabe umetne inteligence pri šolskem delu.

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Uporaba orodja OneNote pri delu z učencem z več motnjami: študija primera

Using OneNote to Work with a Student with Multiple Disabilities: Case Study

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POVZETEK

Učenci s posebnimi potrebami se v šolskem prostoru pogosto srečujejo z ovirami, zato potrebujejo prilagoditve časa, prostora, pripomočkov, načina poučevanja in učenja ter preverjanja in ocenjevanja znanja. Še posebno pozornost moramo temu namenjati pri delu z učenci z več motnjami. V prispevku predstavljamo primer uporabe digitalnega zvezka znotraj orodja OneNote pri poučevanju učenca z več motnjami v razredu, pri urah dodatne strokovne pomoči in doma. OneNote omogoča hkratno sodelovanje strokovnih delavcev ter ponuja učinkovita orodja za učenčevo lažje spremljanje pouka ter šolsko delo.

KLJUČNE BESEDE

OneNote, digitalni zvezek, posebne potrebe, učenec z več motnjami

ABSTRACT

Students with special needs often encounter obstacles in the school environment, so they need adaptations of time, space, learning aids, teaching and learning methods, and knowledge assesment. We have to pay special attention to this when working with students with multiple disabilities. In this paper, we present an example of the use of a digital notebook within the OneNote tool when teaching a student with multiple disabilities in the classroom, during additional professional help, and at home. OneNote enables the simultaneous collaboration of professionals and offers effective tools for the student's easier following of lessons and school work.

KEYWORDS

OneNote, digital notebook, special needs, student with multiple disabilities

1 UVOD

Učenci s posebnimi potrebami so raznolika skupina otrok in mladostnikov, pri katerih je pogosto prepletanje različnih težav, ki jih ovirajo pri doseganju optimalnih rezultatov v šolskem okolju. Eno izmed pomembnih načel za vzgojo in izobraževanje učencev s posebnimi potrebami je tudi zagotavljanje ustreznih pogojev, ki so osnova za uspešno učenje otrok s posebnimi potrebami in omogočajo njihov optimalen razvoj, kot to izpostavljata Navodila za izobraževalne programe s prilagojenim izvajanjem in dodatno strokovno pomočjo za devetletno osnovno šolo ter Zakon o usmerjanju otrok s posebnimi potrebami [1, 2]. Pri poučevanju učencev z več motnjami je pomembno, da učni proces prilagodimo vsakemu posamezniku, njegovim težavam ter močnim področjem. Z upoštevanjem načel personalizacije in diferenciacije učno snov učencu posredujemo na način, ki mu ustreza [3]. Eden izmed načinov je tudi uporaba informacijsko-komunikacijske tehnologije. Ta si vedno bolj vtira pot v šolo in v pouk. Učitelji so v zadnjih letih bolje seznanjeni z različnimi aplikacijami in računalniškimi orodji ter jih uporabljajo pri svojem delu. Premisliti pa je potrebno še, kako ta orodja narediti bolj dostopna za učence z različnimi posebnimi potrebami in kakšne možnosti ponujajo, da se lahko tudi ti enakovredno vključujejo v pouk.

V prispevku bomo predstavili poučevanje učenca z več motnjami, ki pri pouku uporablja računalnik in digitalni zvezek, znotraj orodja OneNote.

2 PREDSTAVITEV UČENCA TER UVEDBA RAČUNALNIKA

Učenec zaradi kombinacije gibalne oviranosti, okvare vidne funkcije ter govorno-jezikovnih motenj izkazuje težave na področju:

- motorike, grafomotorike, koordinacije oko-roka: učenčeva pisava je slabše čitljiva, pri zapisu je počasnejši, potrebuje veliko prostora, težje prikliče oblikovanost posameznih črk, za pisanje potrebuje veliko energije, njegova drža je pri tem pogosto neustrezna;
- vidnega zaznavanja: več časa potrebuje za osredotočanje pogleda na detajle, vidno polje je zoženo, več napora vlaga v branje, težje preklaplja pogled med zapisom na šolski tabli ter zapisom v zvezku ali učbeniku;
- pozornosti: pozornost zmore osredotočati na eno opravilo, zato velikokrat težje sledi učiteljevi razlagi;
- govora in jezika: več časa potrebuje za priklic besed, prisotna so mašila, upočasnjeno je jezikovno procesiranje.

Učenčeva močna področja predstavljajo splošna razgledanost, matematične spretnosti, ima bogat besedni zaklad in dobro razvito slušno pozornost in pomnjenje. Učenec z ustreznimi prilagoditvami dosega dobre učne rezultate. Z odločbo o usmeritvi mu pripada spremljevalec za nudenje fizične pomoči.

V četrtem razredu smo pričeli z uvajanjem računalnika v učenčevo delo. Pri poučevanju in delu z učenci z gibalno oviranostjo se računalnik pogosto omenja kot pripomoček, ki omogoča samostojnejše funkcioniranje, uspešnejše učenje in enakovredno vključevanje v izobraževalne programe [1, 4].

Učencu smo z uporabo računalnika želeli olajšati izdelovanje zapiskov, saj se pri uporabi tipkovnice izognemo priklicu oblike črke in motorični izvedbi zapisa. Posledično smo želeli vplivati na učenčevo držo za mizo, ki je bila pogosto pretirano sključena. S projeciranjem vizualnega gradiva, ki ga je pripravil učitelj, na računalniški zaslon, smo se izognili preklapljanju pogleda med tablo in delovno površino. Z vnaprej pripravljenimi zapiski, ki so bili naloženi v učenčev digitalni zvezek, je učenec pozornost lahko namenil učiteljevi razlagi, praktičnim prikazom ipd. namesto zapisovanju. Z uporabo bralnika je učenec daljša besedila poslušal namesto bral. Spoznaval je elektronske delovne zvezke, ki jih je izpolnjeval s pomočjo urejevalnika PDF dokumentov in s tem lažje povečeval vizualna gradiva ter imel dovolj prostora za zapis na za to predvidena mesta.

Učenec je z računalnik najprej začel delati v individualni situaciji, v okviru ur dodatne strokovne pomoči ob vodenju specialnega in rehabilitacijskega pedagoga, kjer je vodeno reševal šolske naloge s pomočjo računalniških orodij. Kasneje smo uvedli računalnik pri pouku v razredu. Pri učencu je bil prisoten strah, da bo zaradi tega v razredu izstopal, zato smo uvedli še dodaten, razredni računalnik, pri katerem so se ostali učenci izmenjevali pri posameznih urah pouka in na njem opravljali načrtovane aktivnosti.

V naslednjem šolskem letu se je zaradi večje kompleksnosti posredovanih vsebin pokazala potreba po uporabi digitalnih delovnih zvezkov in zvezka za zapiske. Odločili smo se za uporabo storitev Microsoft 365, ki jih je šola pred tem uporabljala. V ustvarjanje primernega digitalnega okolja so se vključili vsi strokovni delavci, ki so delali z učencem, in njegov spremljevalec.

3 OneNote

OneNote je digitalni zvezek znotraj različnih storitev Microsoft 365, ki samodejno shranjuje ustvarjene zapise tekom našega dela. Njegova prednost je, da z njim lahko kreiramo več različnih zvezkov, ki jim dodajamo poljubne strani in odseke, znotraj katerih se lahko hitro in preprosto orientiramo, vanje pa lahko poleg zapiskov vnašamo tudi druge vsebine. Omogoča skupno rabo in sodelovanje z drugimi uporabniki, dostopen je s katere koli naprave in se povezuje tudi z ostalimi storitvami Microsoft 365. Mogoče ga je uporabljati tako v spletni kot v namizni različici [5].

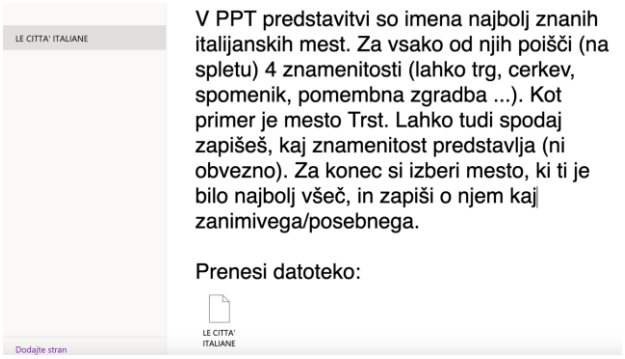
Za učenca smo ustvarili digitalni zvezek in znotraj tega dodali posamezne odseke za posamezen predmet, pri posameznem predmetu pa smo dodajali strani glede na obravnavano vsebino (slika 1). Zvezek je bil shranjen v oblaku OneDrive poleg ostalih datotek, kot so delovni zvezki ali učni listi, in je bil za učenca tako hitro dostopen.

Slika 1: Odseki in strani v digitalnem zvezku

Z načinom uporabe in dodajanjem vsebin smo pred začetkom pouka seznanili strokovne delavce, ki so učenca poučevali. Digitalni zvezek in naložene vsebine smo predstavili tudi staršem in podali usmeritve za uporabo, da so učencu nudili oporo pri domačem delu in učenju. Učenec je možnosti OneNote preizkusil pri individualnih urah dodatne strokovne pomoči, v razredu pa jih je uporabljal ob pomoči spremljevalca.

Učitelji so pred učno uro v zvezek dodajali povzetke snovi, večpredstavnostne vsebine, kot so slike, videoposnetki, zvočni posnetki (slika 2), učne liste, navodila za delo v času učenčeve daljše odsotnosti (slika 3) in druge vsebine. Manjkajočo snov je dopolnjeval učenec sam ob podpori spremljevalca, saj sta lahko zaradi skupne rabe, zapiske na strani soustvarjala hkrati.

Slika 2: Nalaganje večpredstavnostnih vsebin



Slika 3: Učiteljeva navodila za delo v času učenčeve daljše odsotnosti

Učenec je orodje OneNote hitro usvojil, poznal je njegove najpomembnejše funkcije, dodajal je posamezne strani v ustrezne odseke in jih naslovil. Prenašal je naložene datoteke na računalnik za izpolnjevanje teh, uporabljal potopni bralnik, ki se ga je posluževal predvsem pri branju daljših besedil ter pri učenju angleščine za namene poslušanja izgovorjave ter razumevanja pomena besed. Potopni bralnik se je izkazal kot najučinkovitejše orodje za zagotavljanje dostopnosti vsebin

3.1 Orodja za zagotavljanje dostopnosti

Potopni bralnik je orodje, ki ga je učenec poleg ustvarjanja zapiskov najpogosteje uporabljal. V poštev je prišel predvsem pri daljših besedilih. Bralnik poleg poslušanja besedila omogoča tudi prilagajanje velikosti pisave, razmika med vrsticami in besedami, barve ozadja itd. za lažje sledenje besedilu. Poleg poslušanja besedil pa je potopni bralnik uporabljal pri učenju angleščine (slika 4). Z njegovo pomočjo je preveril pomen posamezne besede, besedo je slišal ter s pomočjo trenerja za branje (»Reading Coach«) utrjeval izgovorjavo.

Slika 4: Pomoč potopnega bralnika pri razumevanju besed v angleščini

Ker učenec uporabe tipkovnice še ni avtomatiziral, je občasno posamezna besedila (predvsem v individualni situaciji ali doma) tvoril s pomočjo orodja narek (»Dictate«), ki je učenčev govor pretvoril v zapisano besedilo. Najbolje se je to obneslo pri tvorjenju odgovorov na vprašanja npr. o prebranem besedilu. Pri tem je učenec moral biti pozoren, da je imel odgovor v mislih v celoti oblikovan, preden ga je izgovoril in posnel, saj je za to zaradi slabšega priklica besed potreboval več časa. Pri tvorjenju daljših besedil se je narekovanje slabše obneslo, saj je učenec težje oblikoval misli, velikokrat se je želel med narekom popraviti in je prihajalo do manj smiselnega zapisa na ekranu.

Omogočeno je tudi vizualno prilagajanje posameznih strani z dodajanjem črtovja (pri tem vnašanje besedila ni vezano na postavitev črt ali mreže, ampak te predstavljajo zgolj ozadje), obarvanjem strani in ustvarjanjem različnih kontrastov med besedilom in ozadjem, povečevanjem pogleda, česar se je učenec posluževal v manjši meri.

3.2 Možne izboljšave pri uporabi OneNote

Zaradi svoje preprostosti in enostavnih funkcij je OneNote prijazen za uporabnika. Kljub temu pa smo se pri njegovi uporabi srečevali z nekaterimi omejitvami.

V primeru sočasnega urejanja določene strani je občasno prihajalo do težav v sinhronizaciji opravljenih sprememb med različnimi napravami, kar je velikokrat povzročilo podvajanje vsebin.

Glavni namen orodja OneNote je izdelovanje zapiskov, zato ne omogoča tolikšnih funkcij, kot jih najdemo v drugih urejevalnikih besedil, kot je npr. Word, in z njegovo pomočjo težje oblikujemo sheme ali druge grafike. Z dodatki lahko orodju dodamo nekatere funkcije, a ti niso del storitev Microsoft 365.

V zvezek naloženih PDF ali drugih dokumentov ne moremo urejati neposredno v OneNote ampak jih moramo prenesti na želeno mesto na računalniku, razen če v zvezek namesto dokumenta vstavimo povezavo do mesta v oblaku OneDrive, kamor smo datoteko predhodno naložili.

Kljub precejšnjemu napredku pri uporabi slovenščine in možnostim njene uporabe (branje, narek v slovenščini), je še vedno veliko več funkcij na voljo v angleškem jeziku (npr. slikovni slovar, prepoznavanje besednih vrst).

Kljub naštetim omejitvam, ki so se pojavile pri našem delu, pa OneNote še vedno predstavlja učinkovit način oblikovanja, organizacije in shranjevanja zapiskov na enem mestu.

4 ZAKLJUČEK

Predstavljen primer nam pokaže, kako lahko z zagotavljanjem ustreznih prilagoditev in uporabo digitalnih orodij, kot je OneNote, učencem s posebnimi potrebami olajšamo vključevanje v pouk. Uporaba orodja OneNote je olajšala sodelovanje med strokovnimi delavci, omogočila posredovanje vsebin na način, ki učencu najbolj ustreza, in s tem pripomogla k zagotavljanju vključujočega in podpornega šolskega okolja.

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Uporaba spletnega okolja MS Teams za izboljšanje učnih dosežkov mladinskega pevskega zbora

Using the MS Teams Web Environment to Improve the Learning Achievements of a Youth Choir

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POVZETEK

Učenci s sodelovanjem v pevskem zboru pridobijo veščine, ki so dragocene za njihov razvoj in ki jim nezavestno pomagajo pri oblikovanju osebnosti. Pevski zbori pogosto nastopajo na prireditvah in se morajo na ta način neprestano dokazovati. Da so nastopi kvalitetni, je potrebno ogromno število vaj in tudi nekaj samostojnega dela doma. Ker je postala informacijsko-komunikacijska tehnologija dostopnejša kot kadarkoli prej in je pomemben pripomoček v vzgojno izobraževalnem procesu, sem se pri delu z mladinskim pevskim zborom posluževal spletnega okolja MS Teams. Z omenjeno aplikacijo so pevci samostojno opravili dodatne vaje, hkrati pa so se spoznavali s sodobno tehnologijo. Takšen način dela s tehnologijo je odličen, saj je za otroke zanimiv in predstavlja dodano vrednost pri delu s pevskim zborom. Dodatno dokazuje tudi, da je potrebno v vzgojno izobraževalni proces uvajati sodobno tehnologijo, ker ima le-ta pozitivne učinke.

KLJUČNE BESEDE

Mladinski pevski zbor, MS Teams, večglasno petje

ABSTRACT

Students who participate in a choir gain skills which are valuable for their development, and which unconsciously help them form their personalities. Choirs often take part in events where they have to constantly keep proving themselves. In order to deliver quality performances, many rehearsals are needed, in addition to some independent practice at home. Seeing that today, information and communication technology is more easily accessible than ever before, and presents an indispensable tool in the educational process, I used the MS Teams software while working with the youth choir. With the help of this app, singers did additional exercises on their own, while at the same time getting familiar with modern technology. This way of working with technology is perfect because it is interesting for students and presents added value when working with the choir. It also shows that it is necessary to introduce modern technology into the educational process because of its positive effects.

KEYWORDS

Youth choir, MS Teams, polyphonic singing

1 UVOD

Pevski zbor je interesna dejavnost, katere namen je razvijati interesna področja učencev s poudarkom na kakovosti izvedbe, ki se udejanja ob aktivnostih vseh, ki so vključeni v proces [1]. Ker gre za dejavnost, ki je dostopna vsem otrokom, ne glede na posameznikovo predznanje, je še toliko bolj pomembno, da zna zborovodja s pravilnimi metodami dela učencem pomagati k pevskemu napredku. Sam sem se pri delu z mladinskim zborom posluževal spletnega okolja MS Teams, ki nam je omogočil, da so lahko otroci poslušali skladbe ob prostem času in ob njih tudi prepevali. To se je izkazalo za zelo učinkovito metodo, katera je pripomogla k razvoju tako večglasja, kot tudi razvoju zbora kot celote.

2 VEČGLASEN PEVSKI ZBOR IN NAČIN DELA

Zborovodja naj bo pevcem zgled, naj razvija svoj glas, išče nove ideje in načine doseganja ciljev, se dodatno izobražuje in se do glasu (pevca) vede odgovorno [2]. Zborovodja je odgovoren tudi za sistematsko urejene vaje, ki sledijo viziji razvoja pevskega zbora. Ker je pevski zbor interesna dejavnost, pri kateri zborovodja razvija smisel za večglasno muziciranje in pevce usposablja za skupinsko glasbeno umetniško poustvarjanje [3], mora izbrati primeren program, ki vsebuje enoglasne in večglasne skladbe. Večglasne skladbe zahtevajo več utrjevanja in poglobljenega razumevanja glasbe in si je za njih potrebno vzeti več časa. Ob tem ima zborovodja na voljo celo paleto načinov, kako pevcem pomagati pri hitrejšem osvajanju večglasnih skladb.

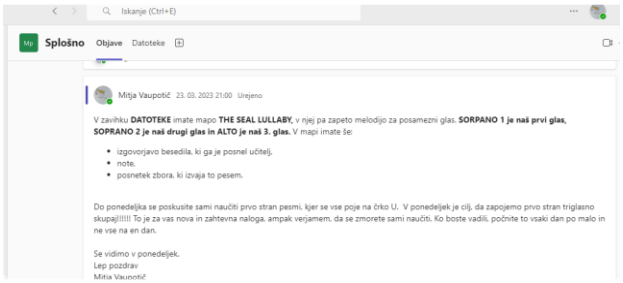
3 MS TEAMS

Microsoft Teams je aplikacija za sodelovanje, ustvarjena za hibridno delo [4]. V času šolanja na daljavo je bila omenjena aplikacija ena izmed spletnih orodij, ki so omogočale učiteljem sistematično posredovanje snovi, ki so jo otroci utrjevali v času in načinu kot jim je najbolj ustrezalo. Čeprav je šolanje na daljavo stvar preteklosti, sem za mladinski pevski zbor ohranil elemente tega načina poučevanja, vendar sem mu spremenil namen. Po novem smo MS Teamse uporabljali za dodatno

utrjevanje večglasnih skladb, ki smo jih prepevali na vajah. Osnovni način dela z mladinskim zborom na vajah sem še vedno ohranil, MS Teamsi so nam služili le kot dodatek in pripomoček na poti k izboljšanju rezultatov.

3.1 MS Teams in mladinski pevski zbor

Preden smo z učenci začeli uporabljati omenjeno spletno okolje, smo morali obnoviti znanje o uporabi Teamsov, saj so nekateri to že pozabili. Ko sem se prepričal, da delo z računalnikom in Teamsi ne predstavlja večjih ovir, sem ustvaril skupino in vključil vse člane mladinskega pevskega zbora. V objavah sem otrokom posredoval informacije o novem gradivu in navodila za samostojno delo (Slika 1).

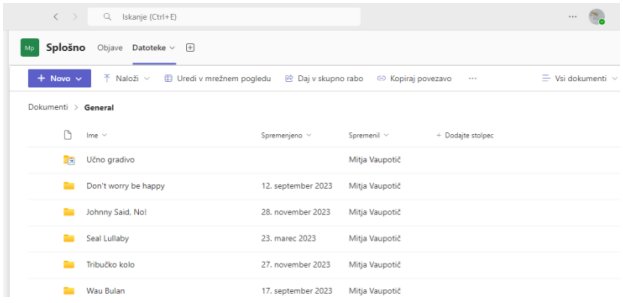


Slika 1: Objavljanje navodil

Pevci so do gradiva prosto dostopali, ob morebitnih težavah sem jim svetoval in jih pomagal odpraviti. Večjih težav z dostopom in delom z gradivom pri učencih nisem zaznal.

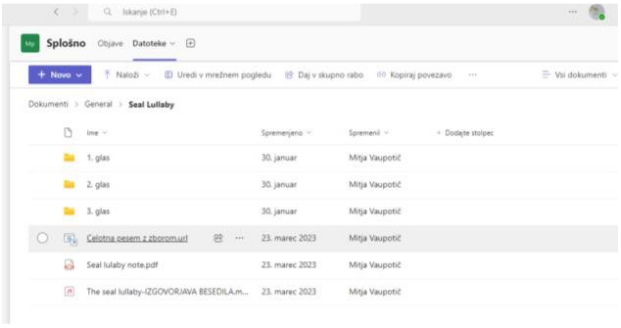
3.2 Urejanje gradiva pevskega zbora v MS Teams

Gradivo sem urejal sistematsko, kar je pevcem omogočalo lažjo orientacijo pri delu in s tem doseganje boljših rezultatov na vajah. Skladbe sem dodajal sproti, in tako je nastala cela zbirka not, do katerih so otroci imeli dostop in so jih lahko utrjevali (Slika 2).



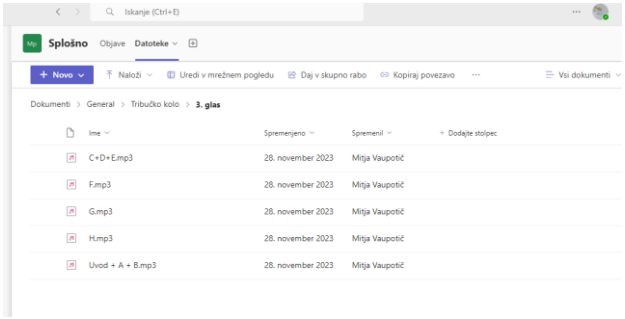
Slika 2: Delovno gradivo za pevski zbor razporejeno po mapah

Note sem v mapah razdelil po posameznih glasovih in na ta način so imeli učenci pregleden dostop do gradiva posameznih glasov. Otrokom sem posredoval gradiva v različnih formatih in oblikah, in sicer: notno gradivo v pdf formatu, posnetke celotnih skladb, posnetke posameznih glasov, ki smo jih posneli na vaji, mp3 posnetki posameznih glasov, ki so si jih lahko prenesli na svoje naprave, povezave na koreografije določenih skladb in izgovorjava besedila (Slika 3). Pri delu sem skušal biti čim bolj raznolik, da so učenci spoznavali skladbo na več različnih načinov.



Slika 3: Različni dokumenti za utrjevanje skladb

Glavni namen samostojnega dela otrok je bilo utrjevanje, zato sem posnetke posameznih glasov skladb razdelil na manjše enote, ki sem jih različno označeval (Slika 4). Da ne bi prišlo do nezaželene zmede, sem se držal pravila, da so deli skladb v notah enako označeni kot na posnetkih. Za ta način sem se odločil, ker so nekatere skladbe obsežne in jih je bolje utrjevati po posameznih delih.



Slika 4: Označevanje posnetkov skladb s posebnimi oznakami

4 ZAKLJUČEK

S pomočjo sodobne tehnologije so učenci na inovativen način utrjevali skladbe, ki smo jih spoznavali pri pevskem zboru. Pevci so zaradi samostojnega domačega dela prihajali na vajo bolje pripravljeni in smo na ta način lahko hitreje osvojili kompleksnejše skladbe. Pred pomembnimi nastopi so te skladbe ponovno poslušali doma in tako še bolj utrdili že pridobljeno znanje. Lahko trdim, da smo tudi zaradi uporabe aplikacije MS Teams, prejeli zlato priznanje z odliko na državnem in zlato priznanje na mednarodnem tekmovanju.

Ta način dela predstavlja za zborovodjo izziv, ki zahteva nekoliko več ustvarjalnosti in iznajdljivosti kot sicer, zagotovo pa pripomore k izboljšanju rezultatov. Iz tega razloga je smiselno in pravilno vnašati sodobno tehnologijo ter aplikacije kot je MS Teams v pedagoški proces.

CITIRANA DELA

[1] K. Metoda, „Interesne dejavnosti za 9-letno osnovno šolo,“ Ministrstvo za šolstvo in šport, Zavod RS za šolstvo, Ljubljana, 2008.

[2] M. Burger, „Naši zbori,“ JSKD, 5. 6. 2014. [Elektronski]. Available: https://www.nasizbori.si/zborovodja-vokalna-tehnika/. [Poskus dostopa 11. 8. 2024].

[3] P. k. k. z. g. vzgojo, „Zavod republike Slovenije z ašolstvo,“ 2003. [Elektronski]. Available: https://www.gov.si/assets/ministrstva/MVI/Dokumenti/Osnovna-sola/Ucni-nacrti/Drugi-konceptualni-dokumenti/Pevski_zbor.pdf. [Poskus dostopa 11. 8. 2024].

[4] Microsoft, „Microsoft Podpora,“ [Elektronski]. Available: https://support.microsoft.com/sl-si/office/uvod-v-microsoft-teams-b98d533f-118e-4bae-bf44-3df2470c2b12. [Poskus dostopa 11. 8. 2024].

Analiza projektnega dela za pridobitev praktičnih izkušenj in znanj študentov v delovnem okolju

Analysis of Project Work to Gain Practical Experience and Knowledge of Students in the Working Environment

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POVZETEK

Prispevek predstavlja nastanek, izvedbo in rezultate projektnega dela za pridobitev praktičnih izkušenj in znanj študentov z naslovom Uporaba umetne inteligence za prepoznavanje bazalnoceličnega karcinoma. Gledano v celoti je bil projekt uspešen, kljub temu pa so predstavljene omejitve, ki lahko vplivajo na izvedbo takih projektov. Med omejitve so navedene omejeno financiranje, vrednotenje takih projektov, omejeno število prijav iz fakultet, čas trajanja ter predpisane vrste sodelujočih študentov,

KEYWORDS / KLJUČNE BESEDE

Študentski projekt, praktične izkušnje, umetna inteligenca, Bazalnocelični karcinom

ABSTRACT

The paper presents the origin, implementation and results of the project work to gain practical experience of students entitled Use of artificial intelligence to identify basal cell carcinoma. Taken as a whole, the project was successful, however, limitations that may affect the implementation of such projects are presented. Limitations include limited funding, evaluation of such projects, limited number of applications from faculties, duration and prescribed types of participating students.

KEYWORDS

Student project, practical experience, artificial intelligence, Basal cell carcinoma

1 UVOD

Prispevek obravnava analizo izvedbe projektnega dela za pridobitev praktičnih izkušenj in znanj študentov v delovnem okolju z naslovom *Uporaba umetne inteligence za prepoznavo bazalnoceličnega karcinoma*, ki je bil del razpisa Ministrstva za izobraževanje znanost in šport v okviru Operativnega programa za izvajanje Evropske kohezijske politike v obdobju 2014 -2020 [1].

Javni razpis za izbor operacij delno financira Evropska unija, in sicer iz evropskega socialnega sklada. Razpis je bil objavljen 4.7.2022 in je obsegal izvedbo projektov v obdobju 2022-2023. Po klasifikaciji je ta projekt spadal pod izvajanje projektnih aktivnosti sodelovanja z gospodarstvom (v nadaljnjem besedilu: Sklop A V projektu so sodelovali študent Univerze v Ljubljani iz Medicinske fakultete, študent Univerze v Mariboru, Fakultete za organizacijske vede (FOV) ter 5 študentov Univerze v Mariboru, Fakultete za elektrotehniko, računalništvo in informatiko (FERI) smeri Informatika in tehnologije komuniciranja (2 študenta), Informatika in podatkovne tehnologije, Računalništvo in informacijske tehnologije ter Medijske komunikacije. Trije študenti so bili iz 1. stopnje UNI in 4 iz 2. stopnje mag. Vključena sva bila dva pedagoška mentorja iz FOV in FERI, ter dva delovna mentorja, eden iz Dermatologije Bartenjev [2], drugi iz Doma za upokojence Idrija [3]. Na projektu so sodelovali še trije koordinatorji za izvedbo projektov iz FOV in UM. Projekt je trajal od 1.2.2023 do 30.6.2023.

2 NAČRT PROJEKTA

Ideja za projekt izhaja iz lastnih potreb avtorja, ki je sam onkološki pacient z več posegi kirurške odstranitve kožnega raka - bazalno celičnega karcinoma (BCC). Sam BCC sicer ni življenjsko ogrožajoč, njegovo ne zdravljenje pa lahko pripelje do poškodb kože ali pretvorbo v druge bolj ogrožajoče vrste kožnega raka kot sta ploščato celični karcinom ter melanom, ki je najnevarnejši in lahko od razširitvijo v telo povzroči smrt. Slednje je razlog, da imamo onkološki pacienti vedno prisotno slutnjo, da se bo katero od znamenj spremenilo v kožnega raka. Običajno so dermatološki pregledi na onkologiji enkrat letno. Da bi si lahko sami diagnosticirali morebitne sumljive spremembe v vmesnem času, smo si zadali cilj narediti programsko rešitev za uporabo umetne inteligence za prepoznavo bazalnoceličnega karcinoma. Cilj je bil torej le prepoznava BCC, ker smo menili, da je slednji najlažje prepoznan tudi laikom. Osnove projekta sva s so-mentorjem iz FERI napisala v treh srečanjih. S pomočjo socialnih mrež sva našla interes v Domu upokojencev Idrija, ki so bili pripravljeni ponuditi brezplačen pregled njihovim upokojencem, hkrati pa je direktorica doma nastopala kot mentorica študentu medicine, ki je te preglede izvedel. Da bi dobili strokovne informacije o BCC smo iskali sodelavce med javnimi onkološkimi inštitucijami, a je bil odziv negativen saj je financiranje delovnih mentorjev skromno. Ponovno smo s pomočjo socialne mreže našli privatno podjetje Dermatologija

Bartenjev, ki so bili pripravljeni usposobiti študenta medicine in pomagati pri diagnostiki – potrditvi ali je študent zaznal ustrezna spremenjena kožna znamenja ali so to le starostne pege. Fotografije pacientov smo nameravali uporabiti kot test za našo mobilno rešitev, ki bi naj s pomočjo umetne inteligence na osnovi analize fotografij v odstotkih ocenila znamenje na fotografiji kot sumljivo ali nesumljivo. Kot dodaten cilj je bil razviti spletno/namizno rešitev za zdravnika, da bi lahko opažanja zapisal v bazo pacienta.

3 ANALIZA

Glavni cilj projekta je bil razviti prototipno mobilno rešitev, ki uporabniku omogoča, da sam na sebi fotografira sumljiva kožna znamenja, sistem pa s pomočjo uporabe umetne inteligence preko naučenih nevronskih mrež obdela fotografijo in oceni verjetnost, da je to BCC. Delo je potekalo v parih ali posamezno, glede na znanja študentov. Študent FOV je skrbel za koordinacijo, organiziral tedenske sestanke preko MS Teamsov in pisal zapisnike sestankov. Sestanke je vodil eden od pedagoških mentorjev, ki je tudi usmerjal in dodeljeval nadaljnje naloge glede na zastavljene cilje. Študent FOV je bil spoznan z vodenjem tima in pomenom in izzivi, ki ga takšno delo povzroča.

Prvi korak projekta je bila študija literature s področja kožnega raka in s področja umetne inteligence ter nevronskih mrež. Delovni mentor iz Dermatologije Bartenjev je v tem delu priskrbel literaturo, ki jo sam uporablja za strokovne namene in nam je predstavljala vir osnovnih podatkov, kako BCC prepoznati med ostalimi kožnimi raki in benignimi kožnimi znamenji. Ta literatura bo koristna predvsem za študenta medicine in za nas, ko bomo nadaljevali to temo v naslednjem projektu. Kot je pokazala študija strokovnih spletnih strani in pisnih objav se BCC pojavlja v različnih oblikah in v različnih stadijih [4][5][6][7][8][9][10].

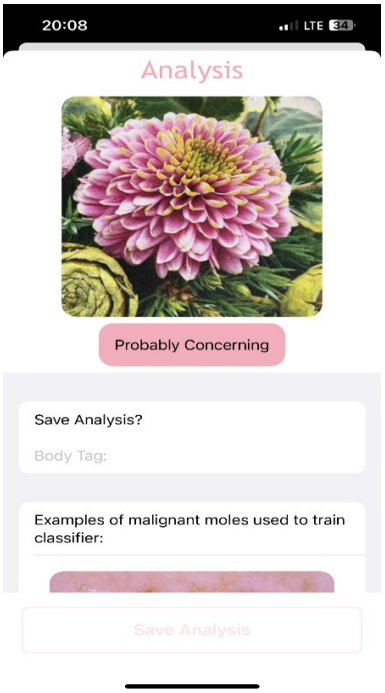
Pridobljena literatura s področja umetne inteligence in nevronskih mrež je uporabna pri več predmetih tako na FERI, kot na FOV na smeri informacijskih sistemov. Preučili smo tudi nekaj obstoječih mobilnih aplikacij za klasifikacijo kožnih znamenj in potencialne pripomočke, ki na bi olajšali zajem nekaterih dodatnih podatkov o kožnih znamenjih, ki bi izboljšale natančnost napovedovanja.

Sama izkušnja projekta z njegovimi težavami in omejitvami se lahko uporabi kot študijski primer pri predmetih na FERI in na FOV. Kot primer navajamo predmet Informacijske in komunikacijske tehnologije, ki obravnavajo superračunalnike, med drugim tudi Vego, s katero imamo sedaj praktične izkušnje. Izkazalo se je, da uporaba superračunalnika kljub dovoljenjem za uporabo sploh ni enostavna, saj je potrebno nastaviti veliko parametrov in se postaviti v čakalno vrsto, da se vaš proces požene in izvede.

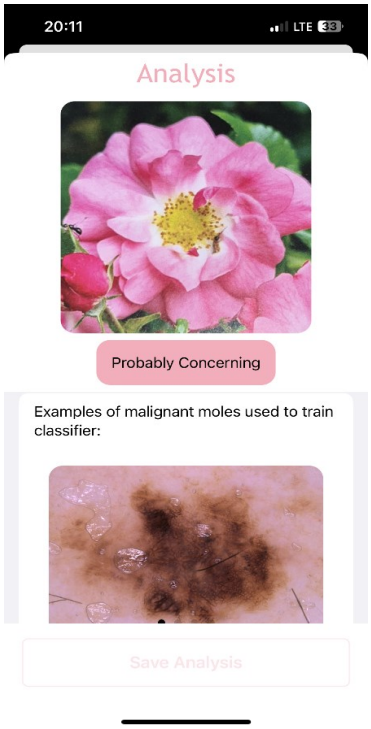
Za člane projekta in sodelavce smo izvedli izobraževanje z mikrokrediti v sistemu NVIDIA s področja umetne inteligence in uporabe nevronskih mrež za prepoznavanje objektov. To se je pokazalo kot zelo koristno in lahko prispeva k širjenju znanja tako med akademsko kot poslovno sfero. Iz pridobljene izkušnje smo ugotovili, da je zanimanje za take vrste znanj tako med študenti, kot med zaposlenimi, zato bomo tečaj periodično ponavljali za širšo javnost. Smo se pa na tečaju tudi naučili, da delo na oddaljenem namizju zahteva dobro omrežje, če tega ni, se lahko izvedba procesa na daljavo zaustavi in je potrebno vajo ponoviti. Na tečaju smo se naučili, da računalnik ne primerja slike kot celote, temveč jo razreže v dolgo vrsto bitov in iz te vrste s pomočjo algoritmov ugotavlja, kaj je na sliki. Da lahko izvede primerjavo, mora nevronska mreža skozi postopek učenja. To poteka tako, da se ji omogoči obdelava čim večjega vzorca fotografij (vsaj 10.000 slik). Večji kot je vzorec, večja je verjetnost, da bo sistem bolje deloval. Med najdenimi javno dostopnimi zbirkami slik, smo se odločili za učno množico znamenj, ki poleg samih slik in kategorije kožnega znamenja, prikazuje še nekatere druge atribute, ki bi lahko pripomogli k natančnejši klasifikaciji znamenj.

Pred izvedbo kliničnih pregledov starostnikov in za morebitno objavo v revijah višjega ranga se zahtevajo potrdila etičnih komisij. Odločili smo se, da damo vlogi na etično komisijo UL MF in na FOV. Med postopkom smo ugotovili, da je potrebno vlogo za UL MF plačati. Ker teh sredstev nismo planirali, smo oddali vlogo le na Etično komisijo FOV, ki nam je delo dovolila z izjemo, da se mora mobilna rešitev preden se da v javno uporabo, klinično preizkusiti. Iz te izkušnje sta se največ naučila študent medicine in študent FOV, ki sta vlogi pripravljala. Vsi ostali deležniki pa so bili seznanjeni s pomenom takih potrdil pri izvedbi raziskav, ki vsebujejo sodelovanje ljudi (pacientov) tudi, če se ne uporabljajo invazivni postopki.

Da bi se naučili na napakah drugih, smo analizirali obstoječe brezplačne programe, ki omogočajo fotografiranje znamenj in njihovo oceno. Med testom ene od teh rešitev smo spoznali podobno kot EurekaAlert [11], da nekateri program ne loči med posnetkom rdeče rože in dejanskim kožnim znamenjem (slika 1 in 2), zato smo se odločili za dvostopenjski sistem. Študenta FERI iz skupine za nevronske mreže sta vsak zase razvijala in testirala nevronske mreže. Prvi je preverjal, če je na sliki sploh kožno znamenje ali pa slika ni dovolj ostra (slika 5). Drugi je nato ugotavljal ali znamenje na fotografiji ustreza opisu ene od oblik BCC.



Slika 1: Prikaz napake programa Skin Check, ki ne prepozna, da je na sliki roža in ne BCC.



Slika 2: Prikaz napake programa Skin Check, ki ne prepozna, da je na sliki roža in ne BCC.

Slika 3: Prijavno okno mobilne aplikacije.

Slika 4: Prikaz sofinancerjev projekta.

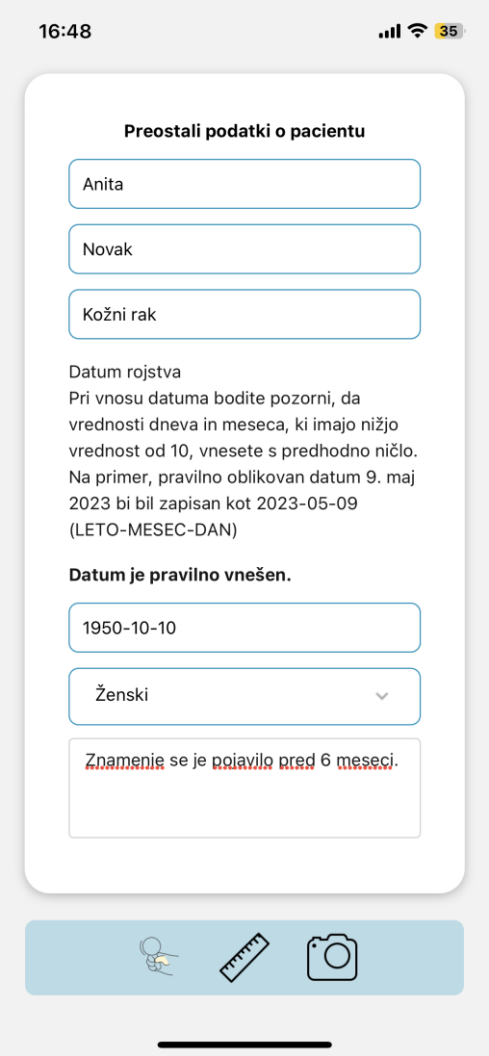
Za klasifikacijo slik smo uporabili globoke nevronske mreže. Učenje nevronskih mrež je potekalo na osebnih računalnikih v programskem jeziku Python in z uporabo programskih knjižnic za strojno učenje TensorFlow (https://www.tensorflow.org/) in Keras (https://keras.io/). TensorFlow je odprtokodna platforma za strojno učenje in simbolična matematična knjižnica, ki se uporablja za aplikacije strojnega učenja, vendar je nekoliko kompleksnejša za uporabo[12]. Keras je odprtokodna knjižnica za nevronske mreže, ki deluje na osnovi knjižnice Tensorflow. Zasnovana je tako, da jo lahko uporabnik uporablja hitro in enostavno, ter omogoča izdelavo katerega koli algoritma globokega učenja na abstrakten način [13].

Kasnejša klasifikacija slik z naučenimi nevronskimi mrežami poteka na oblačni storitvi Firebase ML (https://firebase.google.com/docs/ml). S tem je omogočeno, da se klasifikacija kožnih znamenj izvaja tudi na manj zmogljivih mobilnih napravah.

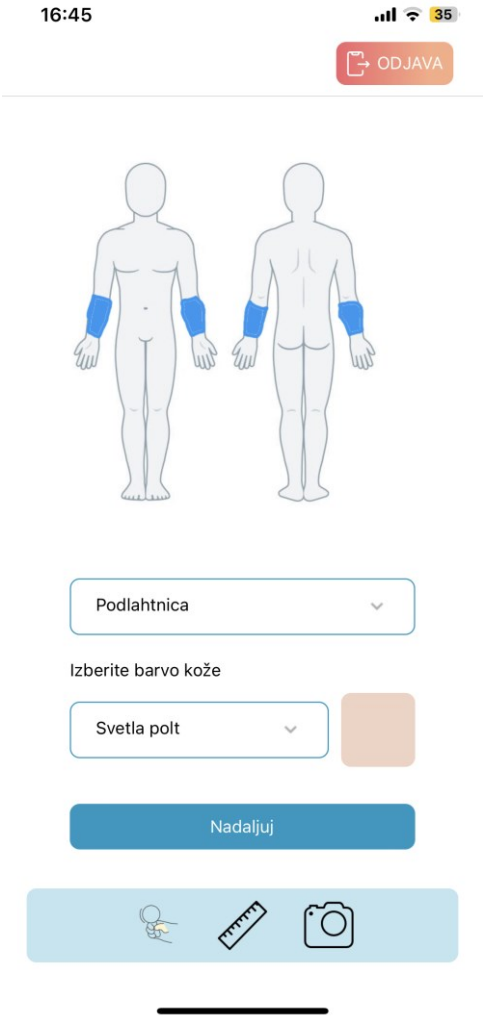
Seveda pa zaledni programi niso primerni za uporabo oseb, ki niso programerji zato smo morali izdelati uporabnikom prijazno mobilno aplikacijo. Ta del je dela drugi par študentov iz FERI zadolžen za ospredje »front end«.

Ob zagonu aplikacije se mora uporabnik najprej prijaviti (Slika 3), s čemer je zagotovljena zasebnost podatkov.

Sama slika BCC brez podatkov ni primerna za nadaljnjo uporabo zato smo program dopolnili z nekaterimi pomembnimi podatki, ki jih je potreboval študent medicine in programerja za mobilno aplikacijo (slika 5 in 6).



Slika 5: Prikaz vmesnika mobilne aplikacije, ki beleži dodatne podatke o posnetem kožnem znamenju



Slika 6: Prikaz sheme človeškega telesa, na kateri uporabnik izbere želeno lokacijo, kjer se nahaja sumljivo kožno znamenje.

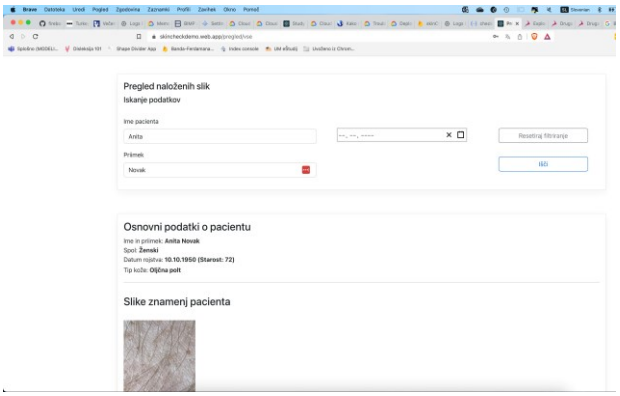
Sama rešitev deluje na mobilni platformi za Android telefone. Študenta FERI za ospredje sta pripravila navodila za namestitev in uporabo.

Da je aplikacija skladna in barvno usklajena, ima svoj logotip in ustrezno obarvana ozadja in gradnike je poskrbela študentka iz FERI na študijski smeri Medijske komunikacije. Ena od funkcionalnosti spletne aplikacije je bila tudi beleženje mesta na telesu kje se to znamenje nahaja. Tudi tukaj smo potrebovali risbo telesa (slika 8), ki jo je poiskala in prilagodila študentka zadolžena za dizajn.

Za potrebe komuniciranja med študentom medicine in delovnim mentorjem oziroma za namene naknadne obdelave fotografij sta študenta za ospredje programirala še spletno rešitev (Slika 7), ki je vezana na isto bazo podatkov in fotografij. Ta rešitev omogoča prikaz večjih fotografij kot na telefonu in tako omogoči lažjo komunikacijo in svetovanje med izvajalcem pregleda in specialistom. Slednji tako lahko na daljavo oceni ali je znamenje sumljivo in ali so potrebni dodatni postopki.

Slika 7: Prikaz prijave v spletno rešitev.

Ena od funkcionalnosti spletne rešitve je tudi, da lahko pregledamo vse slike za nazaj. Izbiro omogočajo različni pogoji(Slika 8), ki omejijo izpis na določen datum.

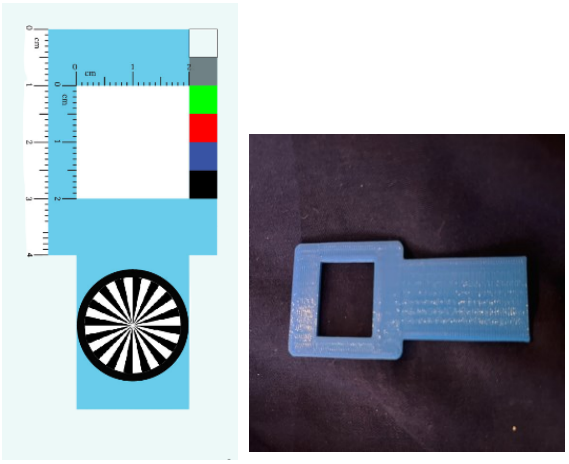


Slika 8: Prikaz možnosti izbire prikazov posnetih fotografij na spletni različici programa.

Dodatno smo želeli povečati natančnost prepoznave malignih znamenj s pomočjo pripomočka, na katerem bi namestili merila in barvne lestvice za kalibracijo slik. Študent FOV je najprej predlagal nekaj tipov vmesnikov. Zaradi enostavnosti uporabe smo se odločili za slednjega (Slika 9), ki ima odprtino 2x2 cm in že s tem omogoča umerjanje fotografija. Z dodanim merilom in barvno lestvico pa omogoča kalibracijo. Pred tiskanjem na 3D tiskalnik je potrebno v računalniškem 3D programu narisati načrt. Pri tiskanju se določijo parametri, ki opredelijo strukturo in gostoto natisnjenega materiala.

Merila so se natisnila na debelejši papir in nalepila na 3D pripomoček (Slika 9). V praksi so se spet pokazale težave, saj tiskalnik ni natisnil lestvic v pravilnih dimenzijah. Sliko smo na koncu spremenili v tako obliko, da jo je v ustrezni velikosti lahko natisnil tudi študentu iz FOV v Kranju. Pridobljeno znanje iz tega področja bo prispevalo k izkušnjam obeh udeleženih v tej dvojici, študentu FOV in študentki FERI smer Medijske komunikacije.

Za grafično podobo, logotip in dizajn je bila zadolžena študentka FERI iz smeri Medijske komunikacije. Pripravila je več verzij logotipov in barvnih shem. Skupina je na tedenskem sestanku izbrala končno verzijo logotipa in barvnih shem. Te barvne sheme je posredovala programerjema, ki sta na osnovi tega izdelala mobilno in spletno rešitev.



Slika 9: Prikaz meril in 3D natisnjenega pripomočka.

Slika 10: Prikaz logotipa in barvne lestvice mobilne rešitve v zeleni in modri barvi.

Ena od nalog študentke iz FERI smer medijske komunikacije je bila tudi, da se izdela reklamni plakat, ki smo ga uporabili za promocijo na dogodkih v prihodnosti. Sledila je še izdelava spletne ankete uporabnikov, ki se bo uporabil, ko bo rešitev na razpolago uporabnikom.

Na koncu projekta je sledilo testiranje in dopolnjevanje rešitve. Pri tem sta poleg programerjev sodelovala še študent FOV in študentka FERI smeri Medijske komunikacije ter študent medicine, ki je programerjem pripravil seznam zahtevanih meta podatkov in vsebine za spustne menije.

4 OCENA USPEŠNOSTI PROJEKTA

Sam cilj projekta je bil sicer dosežen, a se je v praksi pokazalo več omejitev, ki jih nismo pričakovali pri planu projekta..

Kot prvo se je po študiji literature izkazalo, da kljub temu, da smo kot cilj določili obravnavati le najpogostejšo obliko kožnega raka BCC, ki naj bi se najenostavneje prepoznal, smo ugotovili, da obstajajo 4 podvrste BCC, ki si niso podobne ne po obliki in ne po barvi. Zadevo smo rešili z združitvijo vzorcev po meta podatkih le na nivoju BCC in ne na podnivojih.

Kot drugo se je izkazalo, da ni bilo mogoče uporabiti superačunalnik Vega zaradi specifike poganjanja programja in dostopov do uporabniških računov. Zaradi tega smo uporabili močnejši računalnik z več grafičnimi karticami pedagoškega mentorja iz FERI in na njem izvedli učenje nevronskih mrež seveda v daljših časovnih obdobjih.

Kot tretje se je izkazalo, da je potrebno za vlogo na Etično komisijo UL MF plačati prijavnino, ki ni bila planirana v projektu. Zadevo smo rešili tako, da smo projekt prijavili na Etično komisijo FOV, kjer plačilo ni potrebno.

Potrdilo Etične komisije FOV smo dobili pod omejitvijo, da program ne sme v javno uporabo dokler ne bo klinično testiran. Zaradi časovne omejitve in malega vzorca pozitivnih primerov

bo prototip dostopen, a le raziskovalni in strokovni sferi, ne pa posameznim uporabnikom.

Predvsem smo se naučili, da ena učna baza ni dovolj, če vsebuje 10.000 enot, saj se z meta podatki vzorec razbija na podskupine s tem pa se zaželena meja 10.000 učnih enot za nevronsko mrežo ne doseže. Še posebej je pomembno, da je vzorec testnih fotografij dovolj velik, ki predstavlja testno enoto in s katerimi se lahko preveri, če sistem pravilno deluje. Vmesnik za izboljšanje rezultatov prepoznave BCC z merskimi in barvnimi kalibracijami, je bil uspešno izdelan, a zaradi časovne omejitve ni bila prilagojena nevronska mreža tako, da bi te podatke uporabila pri prepoznavi. Da bi to delovalo je potrebno posebno programiranje, ki iz fotografije pobere mere in barvne odtenke, ne upošteva pa fotografijo in vmesnik pri obdelavi posnetka.

Študent medicine je moral počakati na odobritev etične skupine preden je lahko začel z delom. Da bi povečal število pregledov je obiskal poleg planiranega doma upokojencev še Dom upokojencev Črni vrh. Kljub temu, da je pregledal 112 ljudi in se z dermatologom posvetoval o 51 fotografiranih ljudeh, od teh je bilo napotenih v nadaljnjo obravnavo 9. Tak vzorec fotografij je občutno premajhen za testiranje tako kompleksnega sistema zato nam ta del, testiranje rešitve, ostaja za naslednje projekte kjer bomo lahko pridobljeno znanje in rešitve implementirali v praksi.

5 ANALIZA DEJAVNIKOV USPEH

Kljub temu, da je bil projekt uspešno zaključen na tem mestu predstavljamo omejitve oziroma negativne dejavnike pri takih projektih.

5.1 Financiranje projekta

Vedno se vse začne pri denarju in tudi tokrat je tako. Kljub temu, da projekte sofinancira EU so to nizko proračunski projekti (do 20600€). Najprej je težko dobiti pedagoškega mentorja, ki bo pripravljen pet mesecev skrbeti za študente in partnerje za cca 1500€ bruto, 300€ bruto na mesec, torej cca. 180€ neto, 6€ na dan. S tem, da se prijava projekta ne šteje v te ure. Mi smo imeli tedenske sestanke, ki so trajali vsaj eno uro. Sam tečaj iz umetne inteligence nam je vzel en dan, kje je testiranje rešitev, iskanje literature, iskanje baz vzorčnih fotografij, svetovanje študentom, pisanje mesečni poročil in končnih poročil, kar se vsakič zavleče, ker vedno zahtevajo neka dopolnila in milijon obrazcev.

Podobno vrednost honorarja so dobili delovni mentorji. Verjetno zato ni bilo odziva iz javnih inštitucij, ker je vsak izračunal, da bo več dela kot plačila.

Plačilo študentov je druga ovira. Večina naših študentov iz smeri informatike in računalništva že honorarno programira, zato je bil odziv slab, v bistvu smo vse sprejeli, Da bi slednjim lahko plačali več ur nismo zapolnili celotno kvoto študentov(10) Za študente je bilo namenjeno 80% vseh sredstev.

5.2 Vrednotenj projekta za pedagoške mentorje

Pedagoški mentor mora za vsako habilitacijo v petih letih zbrati določeno število točk. Največ točk jim prinesejo članki iz JCR skupine. Pomembni so mednarodni projekti ali večji projekti znotraj Slovenije, med tem, ko se ti študentski projekti točkujejo zelo nizko ali celo nič.

5.3 Omejeno število možnih prijav

Kadar se razpis izvede se omeji število možnih prijav iz posamezne univerze in posledično fakultete. Ker ne obstaja način izbire, se lahko na posamezne projekte prijavi le eden iz iste fakultete neglede na to, da imajo tudi drugi izdelane ideje za nek projekt.

5.4 Predpisano število študentov različnih stopenj študija

Projekt zahteva, da se v projekte vključuje študente iz vseh stopenj študija, to pomeni, da pridejo v projekt študenti 1 letnika VS, ki niso opravili niti vseh izpitov prvega letnika in še nimajo niti teoretičnih znaj, kaj šele prakse, da bi lahko konkretno prispevali k rezultatom projekta. To se je še posebej prikazalo v našem primeru, ker je projekt kljub izvedenem tečaju iz umetne inteligence zahteval veliko predznanj s področja mobilnih in spletnih rešitev, nevronskih mrež, računalniškega vida, … Pet mesecev pa je premalo, da se nekoga iz nič priuči v strokovnjaka. Pričakuje se, da imajo študenti neka teoretična znanja in znanja programiranja, ki jih lahko nadgradijo na problemu, ki ga obravnava projekt.

5.5 Čas trajanja projekta

Med tem ko se običajni projekti izvajajo med 3-5 let ali več, so ti projekti med 3-5 mesecev. Ta čas je razmeroma kratek, ker so omejitve pri številu ur, ki jih študent lahko opravi v enem mesecu. Ta omejitev je nesmiselna, ker imajo različni člani ekipe različne dobe intenzivnosti, Na primer, analitiki in programerji imajo največ dela na začetki, testerji na koncu.

ZAHVALA

Projekt je bil financiran s strani Republike Slovenije in Evropske unije iz evropskega socialnega sklada. Projekt sta omogočili Fakulteta za organizacijske vede in Fakulteta za elektrotehniko, računalništvo in informatiko Univerze v Mariboru. Iskreno se zahvaljujemo sodelujočim iz Dermatologije Bartenjev ter Doma upokojencev Idrija in Črni Vrh.

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Nekaj izkušenj pri uporabi ChatGPT pri poučevanju študentov na FUDŠ – smer Mediji in novinarstvo

Some Experiences with the Use of ChatGPT in Teaching Students at FUDŠ – Media and Journalism Programme

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POVZETEK

Umetna inteligenca je s pojavom brezplačne platforme ChatGPT postala zelo aktualna na področju medijev, saj so strokovnjaki s področja filmske industrije in drugih umetniških poklicev zelo hitro spoznali pomen in tudi nevarnosti umetne inteligence. Zaradi trendov v stroki in zanimanja študentov smo se odločili, da pripravimo raziskavo, s katero smo želeli ugotoviti, kako lahko smiselno vključimo ChatGPT v študijski proces in to posebej v del, kjer študenti v okviru projektnega dela pripravljajo multimedijske izdelke.

Raziskava je pokazala, da študenti podpirajo uporabo umetne inteligence pri študiju in produkciji izdelkov ter da jo praktično vsi tudi uporabljajo, vendar hkrati poudarjajo potrebo po kritičnem ovrednotenju podatkov ter zavedanju omejitev tega orodja.

Raziskavo smo opravili v času od 1. 10. 2023 do 25. 12. 2023 na FUDŠ, Ljubljana, pri predmetu Vodenje in organizacija medijske produkcije, s skupino 36 študentk in študentov.

KLJUČNE BESEDE

ChatGPT, umetna inteligenca, mediji, medijska produkcija, izobraževanje, visokošolsko izobraževanje

ABSTRACT

Artificial intelligence has become highly relevant in the field of media with the advent of the free ChatGPT platform, as the significance and potential dangers of AI have been quickly recognised by experts in the film industry and other artistic professions. Due to trends in the field and the interest of students, we decided to conduct a study to determine how we can meaningfully incorporate ChatGPT into the educational process, specifically the part in which students prepare multimedia products as a segment of their project work. The study revealed that students support the use of artificial intelligence in their studies and product production, and practically all of them use it. However, they also emphasise the need for critical evaluation and awareness of the limitations of this tool.

The research was conducted from October 1, 2023, to December 25, 2023, at FUDŠ, Ljubljana, in the course Management and Organisation of Media Production, involving a group of 36 students.

KEYWORDS

ChatGPT, artificial intelligence, media, media production, higher education

1 UVOD

Umetna inteligenca je s pojavom brezplačne platforme ChatGPT v letu 2022 postala splošno dostopna in se je zelo hitro razširila tudi med mladimi in s tem tudi v izobraževalnem sistemu in ustanovah po vsem svetu. Med njimi so bile med prvimi visokošolskimi ustanovami tiste, ki se ukvarjajo z medijsko produkcijo, saj so strokovnjaki s področja filmske industrije in drugih umetniških poklicev zelo hitro spoznali pomen in tudi nevarnosti umetne inteligence ter v letu 2023 pripravili stavko, s katero so želeli čim bolj zmanjšati uporabo UI v filmski industriji oziroma predvsem preprečiti, da bi se zmanjšali honorarji in število zaposlenih [1].

Zaradi zanimanja študentov, ki večinoma delajo v praksi in so v vedno večji meri soočeni z uporabo UI, smo se odločili, da pripravimo raziskavo, s katero smo želeli ugotoviti, kako lahko ChatGPT smiselno vključimo v študijski proces in to posebej v del, kjer študenti v okviru projektnega dela pripravljajo multimedijske produkte. Želje študentov, da čim prej dobijo koristne napotke glede uporabe UI v praksi, so postavile pred nas poseben izziv, saj na tem področju ni bilo poglobljenih raziskav, večina dokumentov pa je svarila (in to počne še danes) pred uporabo UI.

UNESCO je konec leta 2023 izdal publikacijo Education in the age of artificial intelligence (okt., dec. 2023), v kateri opozarja na morebitne negativne učinke UI v izobraževanju, v kolikor to ne bo dostopno vsem učencem. Z vsako novo tehnologijo se veča digitalna revščina. Obenem se z UI lahko širi dezinformacije in sovražni govor, spletni viri pa ne upoštevajo 95 odstotkov živečih človeških jezikov. Zato je treba šole zaščititi pred škodo, ki bi jo lahko povzročila umetna inteligenca [2].

UNESCO je opozoril, da se uporaba ChatGPT v šolah uveljavlja prehitro, brez zadostnih preverjanj, pravil ali predpisov. Izobraževalni sektor je v veliki meri nepripravljen na etično in pedagoško integracijo teh hitro razvijajočih se orodij.

V publikaciji so objavljena tudi navodila za regulacijo umetne inteligence v izobraževanju (str. 8), ki jih je UNESCO objavil 7.

septembra 2023. Opozarja tudi na problem varstva podatkov in zasebnosti in nujnost izobraževanja učiteljev. Posebno težavo predstavlja dejstvo, da so trenutni modeli ChatGPT izdelani na podatkih spletnih uporabnikov, ki odražajo vrednote in prevladujoče družbene norme globalnega severa [3].

Raziskave smo se lotili s pregledom virov, pri čemer smo ugotovili, da je ChatGPT izredno interaktiven, odziven, hiter in zelo priljubljen, saj je sposoben praktično v trenutku odgovoriti na različna vprašanja z različnih področij, kar omogoča hitro pridobivanje podatkov in napotil, razjasnjevanje določenih pojmov in dilem ipd. Strokovnjaki za akademsko integriteto [5] trdijo, da namesto da bi preprečevali uporabo orodij, kot je ChatGPT, moramo kritično ovrednotiti, kako izvajamo uporabo in ocenjevanje. Klasične metode, kot so izpiti na daljavo, pisanje domačih nalog in spletni izpiti, se ponovno vrednotijo in nadomeščajo z netekstovnimi izdelki, z razvojem veščin in z multimodalnimi preizkusi, izpiti in nalogami v razredu. Multimodalni preizkusi se nanašajo na preizkuse in predstavitve, ki vključujejo več različnih modalnosti ali načinov izražanja in komunikacije. Multimodalni preizkusi združujejo več oblik izražanja, na primer besedilo, slike, zvok, video in drugo. Ti preizkusi so zasnovani tako, da študentom omogočajo uporabo različnih veščin in izraznih sredstev ter spodbujajo raznolikost pri izražanju znanja.

Uporaba umetne inteligence ima precejšen vpliv na izvedbo študijskega procesa in študente. Članek [4] prikazuje težave pri zanesljivem odkrivanju vsebine, ki jo ustvari umetna inteligenca, in vzbuja zaskrbljenost glede morebitnih lažnih obtožb proti študentom. V članku poudarjajo, da je nujno, da damo prednost etični uporabi umetne inteligence, negujemo pismenost z umetno inteligenco in razvijemo okvire, ki študentom in učiteljem omogočajo varno izkoriščanje celotnega potenciala teh tehnologij (str. 11).

Uporaba umetne inteligence (ChatGPT) pomeni za vsakega učitelja, pa tudi za študenta, velik izziv, ker so učinki zelo hitri, veliki in raznovrstni, obenem pa je še veliko nedorečenega in nepreizkušenega, kar zahteva še dodatno razmišljanje in skrbno pripravo vključevanja možnosti, ki jih omogoča UI, v poučevanje.

Z raziskavo želimo dati skromen prispevek k poznavanju in razumevanju uvajanja ChatGPT v študijski proces, obenem pa koristne predloge uporabiti pri načrtovanju predmeta v naslednjem študijskem letu in splošno tudi pri dejavnostih fakultete in njene vizije ter strategije uvajanja UI.

2 NAMEN IN CILJI RAZISKAVE

Raziskavo smo pripravili in izvedli z željo, da spoznamo, ali in kako je mogoče ChatGPT smiselno vključiti v poučevanje pri predmetu Vodenje in organizacija medijske produkcije, v 2. letniku visokošolskega strokovnega programa Mediji in novinarstvo na FUDŠ, Ljubljana. Obenem smo želeli ugotoviti, katere so prednosti in težave, ki se pri tem pojavijo, in jih primerjati z ugotovitvami raziskav iz drugih izobraževalnih sistemov.

Z raziskavo smo želeli tudi ugotoviti, kako študenti ocenjujejo vpliv uporabe ChatGPT na zanimivost in kakovost izvedbe predmeta, učno izkušnjo in ocenjevanje znanja pri predmetu.

Raziskovalno vprašanje: Kako vključitev umetne inteligence (ChatGPT) v predavanja in vaje vpliva na učno izkušnjo študentov pri predmetu Vodenje in organiziranje medijske produkcije?

Hipoteza 1: Vključitev umetne inteligence (ChatGPT) v predavanja in vaje pomeni večjo zanimivost in učinkovitost.

Hipoteza 2: Vključitev umetne inteligence (ChatGPT) v predavanja in vaje omogoča bolj učinkovit študij, ker je uporaba personalizirana

3 METODE

Uporabili smo kvalitativno raziskovalno metodo, pri kateri smo podatke dobili s pregledom in analizo virov, anketo med študenti ter pogovori in intervjuji s študenti in strokovnjaki o rezultatih raziskave. Pri anketah smo uporabili štiri tipe vprašanj – odprtega in zaprtega tipa, Likertovo lestvico in vprašanja z rangiranjem.

Študenti so se seznanili z osnovnimi principi in možnostmi uporabe UI, opravili so precej vaj, pripravili pa tudi tri projekte:

- program za izboljšanje organizacije svojega življenja je pripravil vsak študent sam;
- strokovni priročnik s področja vodenja in organizacije medijske produkcije na izbranem področju, glede na interes študentov, so pripravili študenti sami ali pa po dva ali trije skupaj, glede na željo študentov;
- 1,5-minutni film, posnet v enem kadru na določeno temo, so študenti pripravili v skupinah po 5 študentov in tako spoznavali tudi način projektnega dela v skupinah.

4 REZULTATI IN DISKUSIJA

Raziskovalno vprašanje: Kako vključitev umetne inteligence (ChatGPT) v predavanja in vaje vpliva na učno izkušnjo pri predmetu Vodenje in organiziranje medijske produkcije?

Večina študentov (86,1 %) meni, da je uporaba umetne inteligence pozitivno vplivala na jasnost razumevanja predstavljenih vsebin v predavanjih in vajah. 63,9 % študentov verjame, da je uporaba umetne inteligence naredila predmet bolj uporaben za njihovo prihodnje delo v medijski produkciji. Kar 80,5 % študentov je bilo zadovoljnih z uporabo umetne inteligence v izobraževalnem procesu, pri čemer je 44,4 % izrazilo precejšnje zadovoljstvo. Študenti najbolj cenijo večjo učinkovitost pri izvajanju nalog in razvoj analitičnih veščin, medtem ko menijo, da umetna inteligenca ne prispeva k boljšemu sodelovanju med študenti.

Najpomembnejši vidiki uporabe umetne inteligence za študente so hiter in enostaven dostop do gradiv in podatkov, 24/7 dosegljivost, interaktivnost in hitra odzivnost.

Kljub pozitivnim izkušnjam so nekateri izrazili previdnost pri zanesljivosti umetne inteligence, zlasti glede natančnosti podatkov in virov in etičnih vprašanj.

Študenti so izrazili večjo motivacijo zaradi lažjega premagovanja izzivov, vendar so hkrati opozorili na potrebo po jasnih mejah uporabe, da se prepreči zmanjšanje motivacije, ker UI prevzame delo posameznika.

Raziskava kaže, da ima uporaba umetne inteligence večinoma pozitiven vpliv na učno izkušnjo študentov, vendar je potrebna previdnost glede zanesljivosti, meja uporabe in ohranjanja motivacije in angažiranosti.

Navajamo še odgovore na dve odprti anketni vprašanji:

a.) *Kaj vidite kot največjo oviro pri uporabi umetne inteligence v svojem študiju? Od 1 (najmanjša ovira) do 5 (največja ovira).*

Študenti so pripravili prek 150 predlogov, ki smo jih tudi s pomočjo UI razvrstili v pet kategorij.

- *Nizka ovira: uporabniki prepoznajo le prednosti umetne inteligence in ne zaznavajo ovir.*
- *Srednje nizka ovira: različna dolžina odgovorov, slovnične napake, omejitve v originalnosti besedila, podobnosti besed med uporabniki in jezikovne karakteristike uporabniškega vmesnika. Dodaten čas za uporabo računalnika in omejitve pri dostopu do nekaterih spletnih strani in podatkov.*
- *Srednje visoka ovira: omejena uporaba, skrbi glede varstva podatkov in zasebnosti ter etičnih vprašanj in strahu pred nadomestitvijo ljudi z UI. Problem so tudi zastareli podatki, verjetno prekomerna raba umetne inteligence na račun zmanjšanja samostojnega razmišljanja.*
- *Visoka ovira: umetna inteligenca vedno ne ustreže zahtevam, določenih vsebin ne pojasni zadosti, spodbuja lenobo pri pripravi nalog, saj lahko prevzame reševanje vaj in pripravo gradiv, pogosto poda napačne informacije in deluje nepredvidljivo.*
- *Najvišja ovira: netočnost in nenatančnost ter zastarelost podatkov, pomanjkanje transparentnosti, etična vprašanja in odgovornosti ter v določeni meri regulativa, ki je še v pripravi.*

b.) *Katere prednosti vidite pri uporabi tradicionalnih učnih metod v primerjavi z umetno inteligenco? Od 1 (najmanj pomembno) do 5 (najbolj pomembno).*

Študenti so pripravili prek 170 predlogov, ki smo jih tudi s pomočjo UI razvrstili v pet rangiranih kategorij.

- *Najpomembnejše prednosti*

Ključne prednosti UI so: nadgradi razlago profesorja, visoka prilagodljivost, 24/7 dosegljivost, možnost sodelovanja pri nalogah in hitro dostopanje do informacij.

- *Pomembne prednosti*

Pomembne prednosti so: hitro iskanje informacij, vzpostavljanje medčloveških stikov in odnosov, spodbujanje kreativnega in kritičnega razmišljanja, personalizacija učenja ter razvoj socialnih veščin, medtem ko je umetna inteligenca manj zahtevna glede znanja in napora.

- *Srednje pomembne prednosti*

Enostavno iskanje informacij, ustvarjanje zgodb, socialna interakcija in prilagodljivost delovanja profesorja so ocenjeni kot srednje pomembni, saj lahko učenci prihranijo čas, se lažje spomnijo gradiva in se bolje prilagajajo svojim potrebam.

- *Manj pomembne prednosti*

Manj pomembne prednosti vključujejo spoznavanje učinkovitejšega učenja, razvoj praktičnih znanj, hitrejše reševanje nalog, več truda in znanja pa tudi večjo individualnost med učenci.

- *Najmanj pomembne prednosti*

Kreativnost z UI je ocenjena kot najmanj pomembna prednost v primerjavi s tradicionalnimi učnimi metodami.

Na podlagi rezultatov in diskusije lahko ocenimo ustreznosti hipotez:

Hipoteza 1 je potrjena: Vključitev umetne inteligence (ChatGPT) v predavanja in vaje pomeni večjo zanimivost in učinkovitost.

Hipoteza 2 je delno potrjena: Vključitev umetne inteligence (ChatGPT) v predavanja in vaje omogoča bolj učinkovit študij, ker je uporaba personalizirana. Še večji pozitivni učinek pa študenti namenjajo nadgradnji razlage profesorja, visoko prilagodljivost, 24/7 dosegljivost, možnost sodelovanja pri nalogah ter hitro dostopanje do informacij.

Rezultati celotne raziskave so dostopni na [6].

5 ZAKLJUČEK

V letu 2023 smo se odločili opraviti raziskavo, s katero bi ugotovili nekatere osnovne značilnosti, možnosti in tudi potencialne težave uporabe UI (konkretno ChatGPT) pri načrtovanju in izvedbi študijskega procesa. Uvodno raziskavo smo opravili pri predmetu Vodenje in organiziranje medijske produkcije v visokošolskem strokovnem programu Mediji in novinarstvo na FUDŠ, Ljubljana, pri načrtovanju in izvedbi študijskega procesa, ko smo poskusili dobiti še mnenje študentov o tem, kako je vključitev UI v poučevanje predmeta vplivala na njihovo učno izkušnjo, na zadovoljstvo s predmetom in tudi na ocene, ki so jih pridobili pri predmetu.

V raziskavi smo se pri uporabi ChatGPT osredotočili predvsem na tiste funkcije, ki so ključne za pridobivanje in obdelovanje podatkov in jih študenti tudi največ uporabljajo. UI omogoča predvsem hiter pregled in zapisan prikaz določenega obstoječega znanja, kar pomeni hiter dostop do ustrezno kakovostnega in urejenega materiala, v katerem so praviloma rešitve in predlogi, do katerih bo posameznik težje prišel sam ali pa le z dolgotrajnim iskanjem po raznih virih, ki pogosto niti niso dostopni. UI jim lahko veliko pomaga tudi pri delu kot pomoč pri brainstormingu, analizi, sintezi in vrednotenju rezultatov ipd.

Za ljudi, ki niso navajeni in preveč vešči pisanja in branja, kar je precej značilno za današnjo mladino, je tak pristop precej motivacijski, obenem pa tudi edukacijski, saj so primorani in tudi motivirani za branje in študij z UI pridobljenim gradivom, ki ga praviloma morajo še preveriti, dodelati in nadgraditi z raznimi viri, pa tudi svojimi raziskavami, razmišljanji, dognanji in predvsem s poglobljeno razpravo z mentorji ali drugimi strokovnjaki ob načrtovanju in izvedbi konkretnih nalog.

Ugotovili smo, da večina študentov meni, da je uporaba umetne inteligence pozitivno vplivala na jasnost razumevanja predstavljenih vsebin v predavanjih in da je uporaba umetne inteligence naredila predmet bolj uporaben za njihovo prihodnje delo v medijski produkciji. Študenti najbolj cenijo večjo učinkovitost pri izvajanju nalog in razvoj analitičnih veščin,

medtem ko menijo, da umetna inteligenca ne prispeva k boljšemu sodelovanju med študenti.

Za spodbudo učiteljem pri uvajanju ChatGPT v študijski proces navajamo misel študentke:

- *Z uporabo ChatGPT sem za študij in delo veliko bolj motivirana, saj vem, kje lahko dobim potrebne informacije za katerokoli vsebino. Vem, da bom s pomočjo UI naredila boljšo nalogo, zato tudi z večjim veseljem začnem z delom.*

Raziskava kaže, da ima uporaba umetne inteligence večinoma pozitiven vpliv na učno izkušnjo študentov, vendar je potrebna previdnost glede zanesljivosti, meja uporabe in ohranjanja motivacije in angažiranosti. Pri nadaljnjem uvajanju UI v izobraževanje bo treba upoštevati napredek v teoretičnih in praktičnih dognanjih in praktične izkušnje pri načrtovanju in izvedbi predmeta.

ZAHVALA

Za pomoč in zelo tvorno sodelovanje se zahvaljujemo študentom 2. letnika programa Mediji in novinarstvo (v š.l. 2023/24) na FUDŠ, Ljubljana.

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Digital Inclusion in Information Society

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Matjaž Debevc, Ines Kožuh

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PREDGOVOR

Danes, v času hitrega razvoja digitalnih tehnologij, digitalna vključenost ostaja ključen steber naše informacijske družbe. Širjenje dostopa do tehnologij in digitalnih storitev na vedno večji del prebivalstva, vključno z osebami z različnimi oblikami oviranosti, zahteva nenehno izboljševanje dostopnosti, razumljivosti in uporabnosti digitalnih rešitev. Ob naraščajoči potrebi po prilagojenih rešitvah je naš cilj zagotoviti, da vsi posamezniki – ne glede na njihove zmožnosti – lahko v celoti sodelujejo v digitalni dobi in izkoristijo njen polni potencial.

Osrednja tematika konference "Digitalna vključenost v informacijski družbi – DIGIN 2024" je, kako lahko sodelujemo za ustvarjanje digitalno dostopnega okolja, ki omogoča enakopravno vključitev vseh. Naša druga hibridna konferenca, ki se ponovno izvaja v sodelovanju z evropskim centrom virov o dostopnosti – AccessibleEU, bo združila vodilne slovenske in mednarodne raziskovalce ter strokovnjake, ki bodo predstavili svoje rešitve, spoznanja in metode za izboljšanje digitalne vključenosti. Skupaj bomo raziskali, kako lahko s podporno tehnologijo ter prilagojenimi digitalnimi pristopi premagamo ovire, s katerimi se srečujejo osebe z različnimi oblikami oviranosti, in ustvarimo digitalni svet, ki je resnično dostopen vsem.

Prispevki, zbrani v letošnjem zborniku, predstavljajo bogat vir znanja in inspiracije za vse udeležence. Preko njih bomo bolje razumeli, kako tehnologijo uporabiti za izboljšanje kakovosti življenja in omogočiti enakopravno vključevanje v digitalno okolje. Verjamemo, da bomo skupaj s tem dogodkom pomembno prispevali k bolj vključujoči in dostopni digitalni prihodnosti.

Uredniški odbor

FOREWORD

Today, in an era of rapidly advancing digital technologies, digital inclusion remains a fundamental pillar of our information society. Expanding access to digital technologies and online services to an increasingly diverse population, including persons with disabilities, requires ongoing improvements in accessibility, clarity, and usability. As the need for tailored solutions grows, our goal is to ensure that all individuals – regardless of their abilities – can fully engage with the digital world and leverage its full potential.

The central theme of the conference "Digital Inclusion in the Information Society – DIGIN 2024" is how we can collaborate to create a digitally accessible environment that enables equal participation for all. Our second hybrid conference, organized once again in cooperation with the European Resource Centre on Accessibility – AccessibleEU, will bring together leading Slovenian and international researchers and professionals to share their solutions, insights, and methods for advancing digital inclusion. Together, we will explore how supportive technologies and adapted digital approaches can help overcome the barriers faced by persons with disabilities, thereby building a digital world that is truly accessible to everyone.

The contributions compiled in this year's proceedings provide a rich source of knowledge and inspiration for all participants. Through these insights, we will gain a deeper understanding of how technology can enhance quality of life and enable equal participation in the digital environment. We believe that, through this event, we will make a significant contribution towards a more inclusive and accessible digital future.

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Exploring Digital Media Literacy: A Case Study of Elderly Deaf Users in Slovenia

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Abstract

This study explores digital media literacy and usage patterns among elderly deaf individuals in Slovenia. Interviews with two participants revealed moderate digital literacy but limited digital media literacy, particularly in critical media consumption. The participants use social media mainly for communication and information. The findings highlight a potential relationship between digital media literacy and usage frequency, underscoring the need for tailored digital literacy training for the deaf community.

Keywords

Digital media literacy, social media literacy, deaf, social media, digital media, new media, online media platforms.

1 Introduction

In the digital age digital media play a central role in daily life, shaping how individuals access, understand and create digital content. This shift presents unique challenges for D/deaf and hard of hearing (DHH) individuals in navigating the digital landscape [1, 2]. This paper explores the digital literacy and digital media literacy of DHH individuals in Slovenia, focusing on their abilities to navigate digital media and their perceptions of digital media's accessibility. The objectives were to evaluate the level of (digital) media literacy among DHH individuals in Slovenia, and examine their experience with social media and online media platforms. By examining these aspects, the study seeks to contribute to a better understanding of how DHH individuals interact with digital media. Since the study is ongoing, this paper presents only the preliminary findings from interviews with two deaf individuals.

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2 Digital media literacy

2.1 Digital Media Literacy

Digital media literacy refers to the ability to access, understand and create content using digital media [3]. These skills are essential in the information age, where rapid technological advancements demand constant adaptation and learning [4]. Digital media literacy involves not only technical skills, but also includes emotional response, consumption and cultural evaluation of media content [3, 5].

With social media becoming a key source of information for many, the importance of social media literacy increased. These platforms became a popular way of spending free time, places for socialisation and communication with others in a personal or business environment [6]. Digital media usage has also shifted from desktops to mobile devices and tablets, changing the user experience, frequency and mode of use [7, 8].

2.2 Indicators of Digital Media Literacy

Digital media literacy involves four main areas: critical consuming, critical prosuming, functional consuming and functional prosuming [9]. Critical consuming includes the ability to analyse, synthesise and evaluate media content [5]. Critical prosuming involves interactive participation and critical content creation in new media environments, such as chatrooms. The individuals' critical abilities are exhibited in their understanding of social and cultural values [10, 11]. Functional consuming refers to technical skills in using media content, such as navigating the internet and using various digital devices [9, 12]. Functional prosuming includes the technical skills needed for content production and distribution, such as creating and sharing photos and videos on social media [12].

3 DHH in the digital media

3.1 Statistics on DHH Individuals

In Slovenia there are approximately 1,500 deaf people and around 50,000 hard of hearing individuals, according to the Association of the Deaf and Hard of Hearing of Slovenia [13]. The European Union of the Deaf (EUD) reports further that around 1,850 individuals in Slovenia identify as deaf, and 1,000 of them use Slovenian Sign Language [14].

3.2 Communication Habits of DHH Individuals

Communication among DHH individuals involves primarily the use of sign language, with Slovenian Sign Language being recognised officially and protected by law [15]. The right to use sign language includes access to interpreters and information through adapted techniques, ensuring inclusion in social and professional environments [16, 17]. In addition to sign language, DHH individuals use written text and visual aids to facilitate communication, particularly in digital contexts. Video calls via platforms (e.g., Skype, Teams and Zoom) have become essential, especially during the COVID-19 pandemic, enabling real-time visual communication [18].

3.3 Habits of Using Digital Media

DHH individuals use digital media increasingly for various purposes, from social interaction, information access to entertainment. Research indicates that DHH users use social media platforms frequently to connect with their community and share experiences [19, 20]. DHH users particularly value video content with subtitles, text transcriptions or sign language for improved understanding. The shift to digital media has also seen a rise in the use of mobile applications tailored to DHH needs, such as those for real-time captioning and sign language interpretation [21, 22, 23].

3.4 Challenges in Using Digital Media

Despite many benefits, DHH individuals also encounter challenges in the digital environment. Accessibility is a common issue, as many digital platforms lack subtitles or sign language features [24, 25]. This can lead to social isolation and exclusion from mainstream digital interactions and content [26, 27]. Similar constraints arise in everyday occasions, such as public speeches, often conducted without an interpreter, and official information delivered to individuals via phone calls, posing significant barriers for DHH individuals. Another significant challenge is the lack of digital literacy training tailored to the DHH community, such as those in sign language [28].

4 Methodology

4.1 Procedure

This case study examines two DHH individuals in Slovenia, who were recruited through Associations of DHH people. The inclusion criteria were (a) Identification as a DHH individual, (b) Membership in associations of DHH people, (c) Active use of at least one social media platform, (d) Use of online media platforms, e.g., dostopno.si. We collected data using semi-structured joint interviews, providing a holistic view and direct observation of the participants` interactions [36, 37]. A sign language interpreter was present to ensure accurate communication and provide additional support and information. The interview took place at the Association of the Deaf and Hard of Hearing of the Podravje, Maribor unit, and was audio-recorded to facilitate the analysis of the interpreter's translation. The data were later transcribed and analysed according to Roblek [39].

4.2 Research Questions

The study focused on two main research questions:
(1) What is digital media literacy among elderly deaf individuals?
(2) How do elderly deaf individuals use digital media?

4.3 Participants

The interviewees were two deaf individuals residing in Slovenia, who belong to the group of elderly people aged 60 years or older. They were selected randomly from a larger sample of 12 participants, to present the preliminary results of the ongoing research study. Participant 1 (P1) is a 63 year old female with a hearing loss level of 96 dB. Her educational level is lower or vocational secondary. Participant 2 (P2) is a 60 year old female with a hearing loss level of 100 dB, and has primary school education. Both participants lost their hearing early in life and their primary language is Slovenian Sign Language.

4.4 Measuring Instrument

The measuring instrument consisted of several parts. Prior to participation, the participants were questioned on their demographic data (gender, age, education level), followed by data on their hearing loss (level of hearing loss, primary language, hearing loss history). Next, the participants were questioned on their use of digital media (social media and online media platforms). This part consisted of questions on their purpose of use, content creation, frequently encountered content and frequency of use.

The next section examined digital literacy [29, 30], digital media literacy [31, 32], and literacy about social media [33]. Lastly, the participants were also asked about their perception of the accessibility of digital media for DHH, as proposed by Maiorana-Basas & Pagliaro [34] and Kožuh & Debevc [35].

5 Results

5.1 Digital Media Literacy Among Elderly Deaf Individuals (RQ1)

Both interviewees demonstrated a satisfactory level of digital literacy. P1 uses only a phone, while P2 uses a computer and tablet, with a clear preference for the phone. Both have been using digital devices for years, learning about them informally. P1 learned to use them about 10 years ago with a partner's assistance, and P2 15 years ago with her son's help, and, later, at work. Neither expressed a desire to improve their digital literacy, believing their current skills were sufficient for their needs. Both rely on others for help when encountering difficulties (e.g., suspected money fraud), with P1 turning to her partner and P2 consulting an interpreter.

Both interviewees also follow traditional media, either television or newspapers. While critical thinking skills are a crucial part of media literacy, it is concerning that neither verified the veracity of the online content. P1 typically relies on acquaintances to check veracity, and has occasionally clicked on fake news due to its attractive content, though she did not share it. She mentioned, "I can tell when it is fake news". P2 is more suspicious of online content and fears internet scams, as

indicated by her concern about the dangers of Facebook: "There are more and more of these scams". Neither participant demonstrated an understanding of media bias and political influence on media impartiality.

Social media literacy was examined in regard to the proficiency in navigating the Facebook application. P2 showed a significantly greater proficiency, as she could navigate the main features (post, comment, share) with more ease and independence, but also caution. In contrast, P1 required more time, and showed some confusion, asking P2 for help in learning to post stories. Both participants acknowledged the positive impact of social media platforms on maintaining relationships and staying informed.

5.2 Use of Digital Media by Elderly Deaf Individuals (RQ2)

Both interviewees use social media platforms frequently, mainly in the morning. Occasionally, they access them multiple times a day. They both use Facebook, Facebook Messenger and WhatsApp, while P2 also uses Instagram and Imo. They use social media to browse content, communicate and interact with posts from other users, particularly those featuring gestures in photos or videos. One example is the travelling videos from fellow deaf individuals, which P2 finds interesting, and understands due to international gestures. Their primary reasons for using social media platforms are entertainment and staying updated with current events in their hometown. P2 also uses social media platforms for direct communication and occasional posting, such as photos and videos/stories of interesting things. Contrarily, P1 does not publish her own content.

The interviewees follow Slovenian online media portals, including rtvslo.si, dostopno.si, and 24ur.com, with P1 also using zurnal24.si. P2 also follows foreign, mainly Croatian, portals displayed in her Facebook feed. They access these portals once a day, usually in the morning, and seek mainly for information, but also entertainment. Both access online media content through social media platforms rather than direct searches. The content they typically encounter is genre-specific, including news, culture, entertainment, sports and arts. When asked about the media portal dostopno.si, a portal for people with disabilities, both expressed familiarity with it and past use, as they require the presence of an interpreter to understand the content.

The interviewees were also asked about the accessibility and adaptation of the said social media platforms and online media portals for the needs of deaf people, which they both agreed were sufficient. Nevertheless, P2 has had difficulties with verbal communication, as she finds it difficult or impossible to understand speech without gestures.

We observed that neither participant understood the importance of media impartiality. They also failed to avoid fake news, often clicking on links and reading the content (for P2 there is a possibility that she would believe the content). When asked about information, neither of them checks information from different online media sources. They do ask acquaintances about the veracity, but even they cannot know for sure if a certain piece of information is really accurate. The fact that the interviewees do not seek out media content intentionally, but only access it via social media platforms, might also contribute to their lower media literacy. This leads us to conclude that the interviewees might not think critically, and we might therefore classify their digital media literacy as lower. Their lack of understanding of it does not bother them, nor do they wish to improve their digital media literacy. We believe that they may be compelled to use social media platforms (e.g., WhatsApp, Facebook Messenger) and to follow the online media portal dostopno.si, as they cannot communicate or inform themselves otherwise, no matter how well they understand digital media.

6 Discussion

To assess the interviewees' digital media literacy, we focused on answering two Research Questions. Both participants have exhibited a moderate level of digital literacy (RQ1). Despite their age and long-term hearing loss, they adapted to using digital devices and social media platforms, learning informally through family members and work experiences. However, they lacked critical thinking skills, a key component of media literacy. Neither of the interviewees verified the accuracy of online content, indicating a gap in their digital literacy abilities. It is important to note that the primary language of both interviewees is Slovene sign language, while social media platforms and most online media portals are based on text-based communication. An exception is the online media portal dostopno.si, which the interviewees know, and use mainly because the video content has an interpreter subtitling and transcripts.

Both interviewees are active users of social media platforms and digital media platforms (RQ2). They use social media platforms frequently (e.g., Facebook, WhatsApp) and mobile apps for communication (e.g., Imo). They use it for browsing content, communication, and interacting with posts, especially those that include images and videos with gestures for better understanding. There was a notable difference in content creation habits, as one participant frequently published her own content and the other avoided such behaviour.

Following these findings, the connection between the use of digital media and digital media literacy is unclear. Although both interviewees were cautious in using social media, they exhibited different levels of proficiency. P2, who shows higher digital literacy, engages more actively and confidently with digital media, creating and sharing content regularly. She is proficient in using multiple devices and platforms, indicating a higher level of digital literacy compared to P1. In contrast, P1's lower engagement and more passive consumption of digital media reflect her more limited digital literacy. Both interviewees follow various online media portals for information and entertainment, accessing content primarily through social media platforms rather than searching for it.

Based on Lin et al`s (2013) indicators of digital media literacy, both interviewees fall into the functional category. Neither can be classified as critically consuming or critically prosuming, although P1 exhibits some skepticism towards fake news. Both possess the technical skills necessary for functional consuming, with P1 proficient in using a phone, the internet and social media platforms, and P2 is also competent with a computer and tablet. P2 additionally fits into the functional prosuming category, due to her active content creation on social media platforms. Despite initial help from family members, she now

shares photos and videos independently, underscoring her functional literacy.

Apart from the small sample size, an important limitation of this study are potential misunderstandings due to the presence of an interpreter during data collection. This may result in misinterpretations of expressions between the interviewees and the interviewer.

7 Conclusions

Our study reveals that digital media literacy is crucial in using digital media effectively. The interviewees' limited digital media literacy led to less critical and cautious use of digital media. This study identified the social media platforms and online media portals they use, as well as their reasons and ways of use. The most important reasons for using them were communication, entertainment, and information. We found that higher digital media literacy may increase their presence in the digital environment, as well as enhance their understanding of digital devices and media.

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Innovative Technological Solutions for Cities as a Response to the Challenges of Multimodal Mobility for All Citizens

Inovativne tehnološke rešitve mest kot odgovor na izzive multimodalne mobilnosti za vse prebivalce

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Abstract

Mobility is a fundamental right of all people, crucial for social participation, as recognized also by the UN Convention on the Rights of Persons with Disabilities. Despite this, persons with disabilities often face challenges when using public spaces and transport. This paper emphasizes the importance of physical accessibility, digital tools, and stakeholder collaboration to foster inclusivity. Using mixed-methods approach, including data cataloguing, field verification, surveys, and workshops, the study highlights the need for comprehensive data integration and accessible infrastructure to support independent mobility for persons with disabilities. It is important to approach and develop mobility solutions for people with disabilities. These include methodology implementation, standards, pilot testing, adaptation, and integration of the entire system in the country, and the knowledge transfer to all stakeholders.

Keywords

multimodal mobility, spatial data, persons with disabilities, public transport, accessibility

1 Introduction

Mobility is a fundamental aspect of human life, enabling individuals to navigate their environments and actively participate in society. This right to independent movement extends to everyone, regardless of personal circumstances. The United Nations Convention on the Rights of Persons with Disabilities guarantees this fundamental right to independent mobility for persons with disabilities (PwD) [1]. However, PwD often face significant barriers when navigating public spaces and utilizing public transportation.

Digital data play a crucial role in supporting efficient multimodal mobility, especially when it comes to understanding the entirety of the system, from standards to implementation. Real-time route planning apps that consider accessibility needs, designated accessible parking information, and integrated ticketing systems across various transportation modes facilitate independent mobility. The primary aim of this paper is to explore innovative technological solutions that can bridge the gap between current challenges and the vision of inclusive urban mobility.

Furthermore, this paper presents research based on key projects including, "Enabling Multimodal Mobility for Persons with Various Disabilities" [3], "Spatial Data Support for Public Passenger Transport Management – Persons with Disabilities in Public Passenger Transport" [4] and "Analysis of Conceptual Designs of Information and Technical System Support for Persons with Disabilities to Increase Social Inclusion" [4]. These projects provide insights into the current state of accessibility of public spaces and public transport infrastructure, addressing the specific experiences of PwD.

2 Methods

Understanding the travel needs of PwD is crucial for planning cities with effective public transport, accessible public spaces, and diverse options for multimodal mobility. We employed a mixed-methods approach in our research to address this topic. We developed various methodologies and object catalogues for data capture in the office. We developed methodologies for the four groups focused on in the project, such as persons with mobility impairments, persons with visual impairments, the deaf and those with hearing impairment, and the elderly. We have covered the elements related to the mobility and accessibility of the space for these people in the object catalogue. In the catalogue, elements are described as attributes with corresponding values. All elements are depicted in real-life scenarios with maps and photos, providing precise locations and real-world contexts. With the help of catalogues, we captured data in the office on a desktop computer with an Open-Source

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Geographic Information System (GIS) program tool. We used the latest orthophoto in Slovenian national coordinate system D96/TM with an accuracy of 0.25 m as the basis for captured data as background.

For this purpose, we created libraries composed of thematic characters, which we took from the object catalogues of the project. Verification of captured field data was carried out using a digital approach; with open-source mobile data capture application for Android, iOS, and macOS. Field data verification was supported by persons with mobility impairments as a participatory method. We created data capture layers that include areas for data capture, physical barriers (both permanent and temporary), routes, public facilities, parking spaces for PwD, bus stops and railway stations, as well as points of interest. Each layer contains different types of data. For example, for paths, we captured information on sidewalks, roads without sidewalks, bicycle paths, pedestrian crossings, tactile pavement elements, building edges, green spaces, fences, and stairways. Data on physical barriers includes obstacles such as steps, high curbs, hazardous objects on paths, unsuitable surfaces, traffic signs blocking sidewalks, low pegs, and movable barriers like parked cars, flower beds, advertising boards, and outdoor seating from restaurants. Temporary obstacles, such as construction sites, were also documented, including details on the duration of closures for excavation works. Additionally, we captured location data of accessible toilets for PwD, and accessibility of public transport (e.g. accessibility of bus stops and vehicles) to support route planning.

To better understand the travel habits, experiences with different modes of transport and the willingness to use the "on-call transport model among people with disabilities, we conducted a survey. The survey was conducted using the online platform - 1ka, chosen for its user-friendly interface, open-source nature, and accessibility features that cater to users with visual impairments. To ensure comprehensive data capture and increase survey participation, we employed two supplementary methods. The first method involved collecting data at social events organized by organizations for people with disabilities, allowing us to engage closely with respondents and gather opinions and information in a more informal setting. The second method involved collecting data through employment centres that cater to PwD. In both cases, respondents were given the option to complete the questionnaire either online or in person.

Finally, we conducted various workshops with persons with different types of disabilities, including those with mobility impairments, the blind and visually impaired, and the deaf and hard of hearing. These workshops were organized as focus groups, where we facilitated guided conversations through specific questions to gather as much useful information as possible. These sessions provided us with in-depth insights into how PwD navigate through different environments, how they use assistive devices, and how they prepare for travel and use public transportation. We also gained new knowledge about various technological aids and applications.

2.1 Volunteer Graphic Information for Data maintenance

For data maintenance, we used the participatory data maintenance method. We relied on similar voluntary data capture tests that have already been carried out, such as research conducted by Triglav Čekada and Radovan [6]. Participatory data maintenance is the editing and maintenance of data after the completion of data capture. Emphasis is placed on the participation of various PwD, who are often ignored in wider research or data capture. Many research projects confirm that people respond positively to changes when they are offered the opportunity to actively participate [7] in decision-making or spatial planning. The approach to data capture was based on Volunteer Geographic Information (VGI), as a new source of geospatial data. Term Volunteer Geographic Information is relatively new according to Goodchild, and it is understood as geographic data created and contributed voluntarily by individuals, often through online platforms and mobile technologies [8]. Numerous studies show that GIS, through the use of smart mobile phones, has established itself as an effective tool for ensuring participation [9][10][11][12]. This technology allows residents to actively contribute to shaping their living environment through mobile GIS applications, by capturing and sharing spatial data in real-time [13][14].

Figure 1: Demonstration of a data capture workshop.

3 Results

As highlighted in the previous chapter, we captured data for four groups of PwD included in the project. This data was then entered into the database, organized topologically, and verified for suitability in navigation applications. To visualize the captured data, we developed the Web Accessibility Viewer - a web-based GIS tool equipped with basic functionalities for displaying and defining the properties of the various layers.

Our database currently contains data for 79 municipalities, covering all groups of PwD considered in the project. The captured data includes 3,170 parking spaces designated for PwD and 5,100 physical barriers, such as dropped kerbs, inadequate ramps, unsuitable pavement surfaces, and obstructions on paths. Additionally, we have documented 1,650 accessible bus stops and 59 railway stations. In terms of public facilities, there are 4,750 identified, of which 288 have accessible toilets for PwD. For individuals with sensory impairments, 508 audible traffic signals and 921 tactile pavement elements have been captured. Furthermore, we have captured data on 712 points of interest across the municipalities.

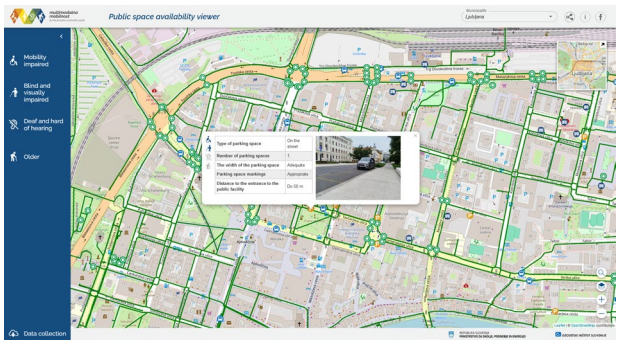

Figure 2: Web Accessibility Viewer displaying parking place from data bases.

Analysis of the survey responses highlighted current challenges in public transport, the experiences and travel habits of the respondents, as well as their actual intention to use the "on-call transport" service. A total of 921 respondents participated in the survey. The majority of respondents are from urban areas of Slovenia, more specifically Ljubljana, Maribor, Celje, Kranj, and Novo mesto.

We understand the "on-call transport" service as a service that provides transportation from the starting point to the endpoint of a journey, with both points being within the operational area of the call center. If a passenger travels outside this area, the service offers transport to the nearest accessible public transport station. This allows passengers to continue their journey using other forms of public transport, enhancing their mobility and access to a broader area. It is essential to mention that the "on-call transport" model acts as a bridge between individual transport and complements existing public transport systems.

The "on-call transport" service not only supports the independence and improves mobility of vulnerable groups but also strengthens their social inclusion and independence. Although originally designed for the transportation of PwD, the "on-call transport" service has the potential to benefit the wider community. It presents a solution that could be adapted for other vulnerable groups, such as the elderly, children, or those without private transportation in remote areas.

The majority of respondents expressed interest in using "on-call transport" if the advance notice period was 12 hours or less. A small number of respondents indicated that they would consider replacing their personal car with "on-call transport" if given the option.

Our data analysis showed that most of respondents are employed, which is probably the consequence of distributing the survey in employment centers to capture a wide range of individuals with diverse experiences and travel habits. Retirees represent the second largest group, while students and self-employed individuals constitute the smallest portion of respondents.

The analysis of field data capture, survey findings and different workshops reveals that public transport accessibility for PwD is often inadequate. Respondents cited unreliability, inaccessibility, and poor organization as some of the most significant issues, leading many to prefer using personal cars over public transport. Most stations and intercity public transport vehicles are inaccessible, as highlighted also by the Advocate of the Principle of Equality in Special Reports [15][16]. However, urban areas tend to be more accessible and the overall situation is gradually and consistently improving.

4 Discussion

As we previously established, digital data on the accessibility of public spaces and infrastructure can be captured both methodically and in a participatory way, when shared by PwD via smart mobile phones using a GIS app, thus becoming part of big data. We define big data as large-scale datasets originating from heterogeneous sources and collected in the urban environment using sensors integrated in an Internet of Things (IoT) system [17]. An IoT system combines devices such as smartphones and different sensors into a single network connected to a common server. As central elements of the IoT, sensors enable cities to collect real-time data from public transport usage and traffic flow analysis to energy consumption and weather conditions [18]. Advanced analytics tools can process and correlate this data to extract useful information to improve city planning and management decisions [19].

The importance of big data in the context of accessibility is multi-layered. These data enable the analysis and understanding of mobility patterns, use and accessibility of public spaces and infrastructure. With the help of this data, administrations or urban planning and design professionals can identify areas where improvements of accessibility are needed. Moreover, big data allows for a dynamic response to the needs of the population, as it can detect and predict changes in mobility and space use patterns. Providing accurate, real-time information on accessibility of public transport using big data improves travel planning options for PwD. This not only reduces the risk of encountering unexpected barriers, but also highlights the importance of big data in the design and planning of more accessible and inclusive public spaces. The Ljubljana Passenger Transport's Urbana mobile app is a good example of the use of big data and sensor technologies in practice, as it allows users in need of an accessible bus to order transport for a specific time and location, while the location of the bus can be monitored in real time directly through the app.

The integration of different databases which include data on accessibility and data on public passenger transport is essential for improving and enabling independent mobility of PwD. Combining data on accessible bus locations, accessible station locations, accessible sidewalks and physical barriers, and timetables allows people with different disabilities to access key information for route planning. All data are in standard format for GIS and can be converted for various application use.

To successfully implement knowledge into practice and ensure accessible public spaces, efficient public transport, and other mobility options within the context of multimodal mobility, cooperation among stakeholders at local, regional, and national levels, as well as experts in spatial planning, is essential. For digital data on accessibility of public spaces and infrastructure to be useful and effectively integrated into various systems, collaboration with urban planners, public transport operators, organizers of on-demand transport services, and representatives of PwD is necessary. This collaborative approach will help address the shortcomings and contribute to the improvement of data in the future.

5 Conclusion

In an era of rapid technological transformation, urban population growth, and ageing population, urban design faces increasing challenges to create spaces that are accessible and inclusive. The rise in the number of individuals with disabilities necessitates barrier-free access to public spaces. Over the past decade, we have witnessed a transition from traditional city concepts to the design of dynamic and adaptable urban environments. This shift is not merely physical but represents a profound change in our approach to urban design.

By centering the design process around people and leveraging innovative technological solutions, cities are becoming not only technologically advanced but also inclusive and responsive to the needs of their inhabitants. This new paradigm prioritizes accessibility and inclusiveness, ensuring that urban spaces accommodate everyone, regardless of their physical abilities. Through this approach, we are crafting cities that embody the principles of universal design, fostering environments where all individuals can thrive and participate fully in society.

The article describes the approach to the development of the entire system from methodology, standards, the use of new technologies and building a base for the purpose of mobility of persons with disabilities. It is especially worth emphasizing the involvement, sharing knowledge and collaboration between system developers and users.

In this context, technological solutions play a pivotal role in advancing multimodal mobility and enhancing urban accessibility. The integration of various transportation options such as walking, cycling, and public transit requires seamless coordination facilitated by cutting-edge technologies. Real-time data, smart infrastructure, and advanced analytics are transforming how cities manage and optimize their transportation networks.

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Note that there is a section break at the end of references to balance the columns (and this text is a part of the new section). If you have no space left at the end of your paper, you can delete it.

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The role of communication skills in the development of digital literacy competences using the "DigInGreen" model

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Abstract / Povzetek

The paper deals with the field of developing communication and digital literacy with the help of the lifelong learning model "DigInGreen" for all layers of modern society, including people with special needs. The aim of the authors is a targeted search for new solutions in the field of using digital learning and communication tools for the development of digital competences in the light of "Society 5.0". We focus on a unique way of connecting paradigms, such as: inclusive society, competences, digital, special needs, literacy and lifelong learning. We want to connect the thinking about the communicative ability, an indispensable part of which is an individual's digital literacy and point out, that the circumstances of living in a modern, but still partially exclusive society, limit the development of an individual's communicative and digital literacy, due to a demonstrated special need or disability. We believe, that the activities we carry out, are a unique example of good practice, because they connect many scientific disciplines and fields into a modern concept of competence development without excluding or conditioning the end user. We combine the paradigms of logistics, informatics, statistics, social studies, linguistics and didactics. All the above and more represent the concept of "Society 5.0", which cannot exist as a scientific construct, if it does not consider the key aspect of one's own identification - social equality and the provision of equal opportunities.

Keywords / Ključne besede

communication ability, digital literacy, competences, inclusion, special needs, lifelong learning

1 Digital literacy is an exclusive component of developed communication skills

In the last few years, we have witnessed the rapid and general progress of the digitization process everywhere, including in education, which brings many opportunities, but also challenges, especially when it comes to the inclusion of people with special needs in the educational process. In the past, the field was more related to physical and intellectual challenges, but today it is increasingly focused on emotional, behavioral, psychosocial and sensory needs and the dilemmas, associated with them. One of them being the so-called digital literacy, meaning the ability of individuals to effectively use digital technologies and the internet to find, create, evaluate and communicate information. This includes understanding and using digital tools, such as computers, smartphones, applications and social networks as well as awareness of privacy, security and ethical issues in the digital environment. Digital literacy and digital tools therefore play a key role in achieving the goal of equal opportunities for all, as they can be completed by users in different periods of time, which are different for each individual and they help themselves in solving challenges with specialized learning or work tools (letter enlargement, volume, translation into another language, font transcription). In relation to the mentioned challenges, the overall aim of this paper is to connect very different research fields with the focus to find new solutions in the field of using digital learning and communication tools for the development of digital competences in the light of "Society 5.0".

1.1 Language and communication ability

We cannot talk about the concept of digital literacy without first talking about language and the communicative ability, because the latter represents the dividing line between human and other communicative codes. Language represents our means of communication, it is a code, that humans have developed, perfected, thereby enabling communication. Language is an agreed system of signs, which means, that it is a standardized communication code and leads to the realization, that language is not just an individual property, it is a social property. With this finding, ensuring the possibility of literacy development for the individual in all its forms and variations becomes a social responsibility. The latter is implemented not only in the home environment, but also in the process of education at the primary, secondary or tertiary level and in all forms of social interaction, including models of lifelong learning. When communicating, two processes always take place; encoding, creating a message and decoding or understanding and responding, to what is communicated. At the same time, we must assume, that both the communicator and the addressee have developed communication skills. These are the knowledge and abilities of both the addressee and the communicator to create any number of texts in a wide variety of speaking positions. The ability to communicate is an important part of a person's general ability, as it enables him/her to creatively adapt to new circumstances and needs. The ability to communicate therefore defines us through expression, communication with others and our social involvement. Above all, it determines our oral and written communication, both classic and digital. We can all be creators/communicators as well as addressees, but we can only cooperate with each other with

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developed communication skills. So, we learn the means, through which we enter the communication process.

2 Accessibility for developed communication and digital skills

Universal digitization enables adaptation of learning content and teaching methods, which can significantly improve accessibility to educational opportunities for people with special needs. We can highlight the example of online platforms and digital materials; these allow learners to access learning content in an adapted format, such as texts in larger fonts, audio recordings or video content with subtitles. In addition, interactive tools and applications can enable individual adaptation of the learning process, which increases the effectiveness of learning and the engagement of learners. The legal regulation in the field of education of people with special needs in Slovenia is based on the Act on Equalizing the Opportunities of the Disabled and the Act on the Guidance of Children with Special Needs. This legislation determines the rights and obligations of educational institutions regarding the provision of adaptations for people with special needs. In practice this means that institutions must ensure accessibility to all educational resources and services, including digital platforms and technologies, but sometimes legal commitments are a burden to institutions, as there is no guaranteed systemic funding for their implementation. With the successful implementation of education, we condition the development of competences and the latter can be applied to all final stakeholders, both people with special needs and people, who do not have demonstrated special needs. As far as we discuss the developed competences for digital literacy, of course we cannot bypass the models, that take care of the development of these competences. We have developed such a model.

3 A unique model of lifelong learning, that develops both green and digital competences

We start from the concept of a special example of good practice of lifelong education and learning of green and digital skills for all social groups. They were designed and developed at the Faculty of Logistics of the University of Maribor as part of the NOO project "DigInGreen". The acronym NOO defines the financial mechanism, namely the Recovery and Resilience Mechanism, from which operations, addressing the transition to a green, digital and resilient society are financed. As part of this project, the Faculty of Logistics of the University of Maribor has determined a research and development niche, that is aimed at the development of green and digital competences through lifelong learning and focus on various areas, which include both short-term and long-term goals for the development of social studies, information sciences and social skills. The short-term goals include training individuals to use digital literacy tools and practices, that improve the efficiency of many processes, while the long-term goals aim for the sustainable development and strengthening of digital literacy at all levels of the population, especially with an emphasis on understanding complex challenges and possible approaches for people with special needs. To ensure inclusive education, it is necessary to adapt teaching materials and methods, that enable equal access to knowledge and skills. For example, courses and workshops can include adapted digital interfaces, that are also accessible to people with visual or hearing impairments and tools, that enable easier management of digital content. We also know about the implementation of individual distance educations, that enable less mobile individuals to participate and do it more easily. Good practices include collaboration with various stakeholders, including non-governmental organizations, that liaise with people with special needs and developers of digital technologies to ensure comprehensive support and adaptations of learning content. In addition, it is important to promote lifelong learning and ensure constant updating of competences, which contributes to greater employability and inclusion of everyone, including people with special needs in the labor market. Digitization and the development of green and digital competences through lifelong learning are important steps towards ensuring equal opportunities for all, including people with special needs. With legal frameworks and good practices we can create an inclusive environment, that promotes sustainable development and digital literacy for everyone. But for this it would be necessary to actively increase financial resources and educate personnel about new approaches, advantages and tools for increasing an inclusive educational environment.

4 Acquired competences are the basis for developed communication skills with an emphasis on digital literacy

Digitization represents a major challenge, as the appropriate knowledge of users, including people with special needs, represents an essential pool of skills for the efficient operation of many processes. At the Faculty of Logistics of the University of Maribor, we prepare, develop and implement short workshops, that cover a wide variety of topics, such as: research into the management of sustainability and resilience in supply chains, digitization, interdisciplinary and applied knowledge. The use of skills in the field of digitization enables efficient data collection and analysis, as well as high-quality tracking and optimization of various processes. With the appropriate knowledge for all users, we want to get closer to up-to-date and reliable information. In lifelong education and learning within the "DigInGreen" model, we focus on offering all interested participants educational workshops in the field of digitization, such as: planning and implementation of digitization, use of simulation tools as decision support, information and computer security, use of artificial intelligence tools, information and digital literacy, methods of communication, creation of video content. We enable participants to study selected topics in depth and participate in concrete tasks and practical examples. This type of method of implementing the lifelong learning model has proven to be very successful in imparting and acquiring new knowledge and skills. As an educational institution, we see the development of lifelong learning according to the "DigInGreen" model in using digital tools with the end user in mind, including users with special needs.

4.1 Model implementation

Our most effective and also the most innovative form of work or activity is the framework of the workshops, that we offer as part of the project. All of them are innovative in terms of content, as they all address topics, that are strongly related to “Society 5.0”. The main ideas are: digital, sustainable and resilient. All workshops are interconnected and together provide a comprehensive insight into the topic of sustainable and digitalized future for all walks of society. Their innovation lies in the method of imparting knowledge, as it is not a lecture.

These are experiential workshops, that encourage participants to come to certain insights on their own. Former concepts of learning and teaching have been abandoned and learners need experiential learning to quickly assimilate the elements, that then make up the so-called “micro education”.

4.2 Following the principles of an egalitarian society – “Society 5.0”

The “DigInGreen” lifelong learning model is defined by the principles of the “Society 5.0”, therefore an egalitarian society in its entirety. We follow: equal opportunities; all stakeholders of our project - participants in the planning of activities, implementation of workshops, participation in workshops - have the same opportunities to participate. Our basic criteria are the demonstrated area competence of the individual and potential gaps in knowledge. We offer all interested parties’ equal opportunities to participate in the project. Non-discrimination; we treat individuals equally. Individuals are not compared to someone else because of gender, nationality, race or ethnic origin, religion or belief, disability, age, sexual orientation or other personal circumstance. Accessibility for the disabled and people with special needs; for all participants in the activities of the “DigInGreen” lifelong learning model we provide suitable materials, that contribute to the development of their digital and communication skills, using appropriate teaching methods and ensuring the correct guidance.

4.3 Model performance analysis

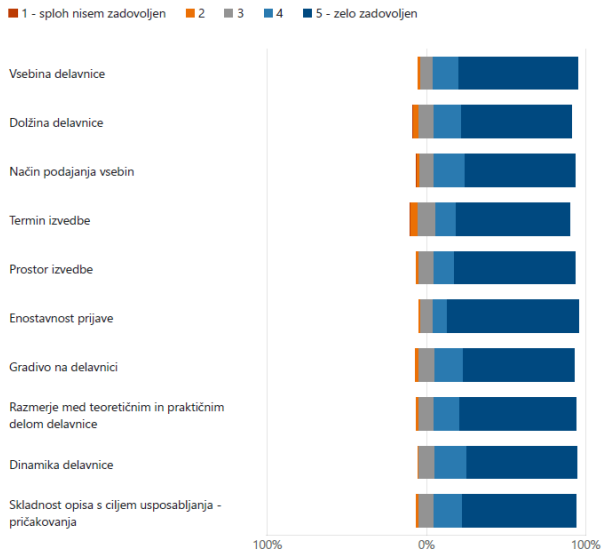

Figure 1: Model performance analysis

In order to determine the effectiveness of the proposed model of lifelong learning and education to improve sustainable and digital literacy within different social groups, we conducted an analysis of satisfaction at the level of the participant. In the sample, we analyzed the following parameters: content of the workshop, length of the workshop, method of delivering content, place of performance and its accessibility, ease of registration, accessibility of material, relationship between theoretical and practical elements, dynamics and compliance with individual expectations. 66 % of the participants expressed their intention to deepen and upgrade the knowledge they acquired at the workshop. 95 % of them will also recommend participation in the workshop to their colleagues, acquaintances and business partners. Most of the participants pointed out that at the attended workshop they upgraded their existing or acquired new knowledge to improve their digital and sustainable skills.

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The Moore's Law for Education and the Need for Inclusion

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***Abstract*—From within the electronics industry, Gordon Moore observed an exponential rate of development of technology. Over time, the same pace of development has been observed for most human activities, resulting in an exponential growth in the volume of accumulated knowledge. This phenomenon also has adverse consequences, especially the increasing difficulty of the educational process, mainly in the scientific and engineering fields, which ultimately results in an increase in school dropout. To cope, we will have to initiate the inclusion of students in the new context, through measures that will support for long term a Moore's law for education. To begin with, we propose several measures, such as increasing the share of visual representations of knowledge or applying the recommendations of the Bologna Process more rigorously.**

***Index Terms*—Moore's Law, Visual Representation of Knowledge, Bologna Process, Inclusive Education, System Engineering**

I. The Moore's Laws and Education

In 1965, Gordon Moore, Intel CEO & Co-founder, made a perspicacious empirical observation: *the number of transistors in integrated circuits doubles every two years*. This observation became the well-known First Moore's Law. In the following decades, and until today, the law has been verified and even knowingly applied in the management of the electronics industry. Moreover, the exponential development pattern noticed by G. Moore has been observed in many more areas of human activity: (1) Moore's Second Law (Arthur Rock's Law): the cost of a semi-conductor chip fabrication plant doubles every four years; (2) More than Moore: the Moore's law is now beginning to be revalued in the sense of performance indexes per chip instead of sheer number of transistors per chip; (3) Moore's Law for Knowledge: the general human knowledge doubles every year [1]; and (4) Moore's Law for Everything: addresses our entire society as a whole [2].

An undesirable consequence of the Moore's Law for Knowledge appears in education: *young students face more and more difficulty the increased volume and complexity of the knowledge they have to assimilate*. Therefore, we are witnessing an alarming increase in school dropouts. In 2001 G. Moore complained: "*It's hard to come up with ways to increase productivity in education*" [3]. Eventually one can observe that Moore's Law is beginning to make its presence felt in education too [3].

We believe that the current situation requires a new fundamental approach, capable to sustain in the long term a proper Moore's Law for Education, helping students to include into the Moore's Law for Knowledge era. For this, we must increase the efficiency of learning, so that it keeps pace with the increase in the volume of knowledge. This approach is encouraged by the statement according to which learning resources are practically unlimited [4].

II. Psychological Theories Explaining the Phenomenon

A. Cognitive Load Theory

Cognitive load theory (CLT), developed by John Sweller, provides a valuable framework for addressing the challenges posed by exponential growth in knowledge and its implications for education. CLT posits that working memory has a limited capacity for processing information. As the volume and complexity of educational content increase, the cognitive load on students also rises. This escalation in cognitive load can lead to cognitive overload, where students struggle to process or retain information effectively, ultimately resulting in reduced learning efficiency and increased dropout rates [5], [6]. To counteract these issues, strategies that manage cognitive load, such as simplifying complex information and utilizing multimedia tools to present knowledge visually, are essential. These strategies help accommodate the rapid advancements described by Moore's Law in education, thereby supporting more effective learning experiences.

Van Merrienboer and Sweller emphasize that recent developments in CLT highlight the importance of designing instructional methods that manage cognitive load effectively, especially when dealing with complex learning scenarios [7]. By integrating these principles into educational practice, educators can better support students in handling the growing complexity of their studies.

B. Self-Determination Theory

Self-determination theory (SDT), developed by Deci and Ryan, emphasizes the essential psychological needs for autonomy, competence, and relatedness as central to motivation and learning [8]. The exponential growth of knowledge, as highlighted by Moore's Law, may challenge students' sense of

competence and autonomy, especially when the pace of learning feels overwhelming or unmanageable. This can adversely impact their motivation and academic performance. According to SDT, when students perceive their learning environment as supportive of their need for autonomy, they are more likely to experience intrinsic motivation and engage more deeply with the material. Similarly, providing constructive feedback and fostering meaningful interactions with peers and educators can enhance students' sense of competence and relatedness, which are crucial for maintaining motivation and engagement [9].

Research supports the idea that educational practices aligning with SDT principles can lead to more effective learning outcomes. For instance, Guay, Ratelle, and Chanal argue that optimal learning environments, which cater to students' psychological needs, contribute to better educational outcomes [10]. They found that when students experience a high degree of self-determination within their learning contexts, they are more likely to engage actively and perform well academically.

In light of these insights, incorporating measures that support the psychological needs identified by SDT - such as providing opportunities for self-directed learning, ensuring frequent and constructive feedback, and facilitating collaborative and supportive peer interactions - can help mitigate the negative effects of rapid knowledge expansion. This approach not only addresses the challenges posed by Moore's Law for education but also promotes more inclusive and effective educational practices that cater to diverse student needs.

C. Information Processing Theory

Information processing theory, as developed by Atkinson and Shiffrin, provides a framework for understanding how information is encoded, stored, and retrieved [11]. This theory becomes increasingly relevant as the volume of information grows exponentially, presenting challenges for processing and organizing vast amounts of data effectively. According to the theory, cognitive strategies such as chunking and rehearsal are crucial for managing large data sets, which can help students process and retain information more efficiently.

Chunking involves breaking down complex information into smaller, manageable units, making it easier to encode and recall [12]. Rehearsal, which includes techniques like repetition and active engagement with the material, also plays a significant role in strengthening memory retention. Integrating these cognitive strategies into educational practices can aid students in navigating the challenges associated with the rapid expansion of knowledge. For example, employing visual aids, interactive tools, and other multimedia resources can enhance students' ability to process and retain information by presenting it in more digestible formats [13].

Incorporating information processing techniques into teaching methodologies supports increased inclusion and provides effective support mechanisms for students facing the complexities of modern education. By applying these strategies, educators can help students manage cognitive load more effectively, fostering an environment where learners are better equipped to handle the demands of rapid knowledge growth.

D. Complex Adaptive Systems Theory

Complex adaptive systems theory (CAST) provides a contemporary cognitive psychological perspective that integrates concepts from Systems Engineering. CAST focuses on how systems, including educational systems, adapt and evolve in response to environmental changes [14]. This theory emphasizes the dynamic interactions among various components of a system and the necessity for flexibility in adapting to rapid changes.

In the context of Moore's Law for education, CAST posits that educational systems must be designed to be adaptable and resilient to the exponential growth in knowledge. As knowledge expands at an accelerating rate, educational environments must continuously evolve to meet diverse learning needs and integrate new technologies and methodologies. This adaptability involves creating learning systems that can effectively incorporate feedback and undergo iterative improvements to refine educational practices [15].

CAST also highlights the importance of feedback loops and iterative processes in educational settings. By applying CAST principles, educators can develop more responsive and inclusive educational systems. For instance, leveraging iterative feedback mechanisms and promoting flexibility in teaching approaches can help address the challenges associated with rapid knowledge expansion, ultimately supporting long-term student success [16].

By implementing CAST, educational institutions may create settings that are more suited to managing the complexity of modern education and responding to the needs of fast knowledge expansion, as outlined by Moore's Law.

Understanding the psychological underpinnings of educational challenges in the context of rapid knowledge expansion provides valuable insights into how to support students effectively. By applying theories such as cognitive load theory, self-determination theory, information processing theory and complex adaptive systems theory, educators can develop strategies to enhance learning outcomes and address the needs of a diverse student population. In addition to supporting the inclusion of all students in a changing educational environment, these strategies aid in managing the growing body of information.

III. Concrete Inclusion Measures

A. Improving the Bologna Process Application

School dropout is all the more expensive the more advanced the student is on a higher level of preparation and the larger the target group. That is why we will focus with priority on students in the undergraduate stage.

The Bologna Declaration (19 June 1999) proposed a higher educational system with two main cycles, undergraduate and graduate, leading to the master and/or doctorate degree (Fig. 1). Access to the second cycle requires successful completion of first cycle of minimum three years. The first cycle degree (Bachelor) is already relevant to the European labour market as an appropriate level of qualification.

A key issue is the balance between mass and elite higher education [17]. This balance is perfectly designed, but our

observations (direct, empirical, and at a restricted scale) point out that many professors apply elite standards for the mass level, leading to scholar dropout. Besides personal attitudes, this might also be caused by a possible lack of attention paid to the mass level compared to the elite one. There are important differences between mainstream and elite education. The inclusiveness of mass education is meant to be broad, but its depth remains shallow, as does its specialization and rigor. On the other hand, elite education is supposed to be deep, rigorous, and specialized, thus losing out on inclusiveness. That is why the next measures will point to possible technical solutions leading to effectiveness, notably in mass education.

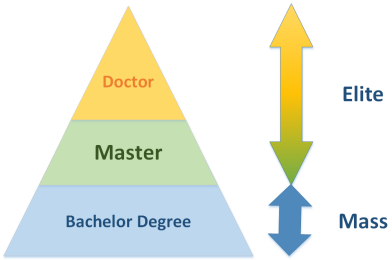

Fig. 1. The higher education structure (Bologna Process)

B. Visual Representation of Knowledge

Homo Sapiens is a diurnal species, essentially relying on sight [18]: 90% of information transmitted to the brain is visual; 50% of the brain's surface is used for the vision; and visual information gets to brain 60.000 times faster than text.

These facts lead us to the conclusion that we should look to favorize the visual representation of knowledge, especially when addressed to the undergraduate students [19]. Figure 2 illustrates how visual adds enhance texts' understanding [18].

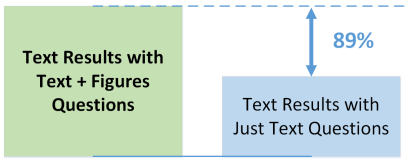

Fig. 2. Better formulated questions lead to better results

Visuals can break down complex concepts into more digestible parts, making it easier for students to grasp intricate ideas. Diagrams, flowcharts, and mind maps can illustrate the relationships between different concepts, helping students understand how they interconnect. Moreover, visuals are often more memorable than text alone. The dual-coding theory suggests that information presented both visually and verbally is more likely to be remembered, as visual representations can reinforce learning by providing multiple ways to process and recall information. When considering student motivation, visuals can make learning more engaging and interesting, potentially increasing student motivation and participation. Visual tools like graphs and charts encourage students to analyze data and identify patterns, trends, and outliers, and they help visualize problems and brainstorm solutions, fostering critical thinking skills.

As previously mentioned, in fields like science, technology, engineering, and mathematics, visualizations such as graphs, models, and simulations are crucial for understanding abstract and complex concepts. Visual tools can illustrate historical timelines, sociological theories, and literary analyses, making these subjects more accessible and engaging. To give an example, we mention that visual reasoning is beginning to be adopted even in areas where formal mathematical approaches seemed immutable, such as automation. These approaches are specific to Artificial Intelligence methods, which, let's not forget, seek to emulate human reasoning. In the broadest sense, in automation, one can observe a revaluation of methods based on quantitative or even qualitative time analysis, such as the analysis of the phase trajectory of the control error, which has appeared since the nineteenth century, comparing to methods based on the precise frequency analysis (transfer functions, pole placement, etc.). More specifically, we can mention: (1) The sliding mode [20]; (2) The qualitative analysis [21]; (3) The self-adaptive fuzzy-interpolative controllers [22]; and (4) Sculpting the state space [23].

Systems engineering (SE) is an increasingly significant scientific field that successfully manages multidisciplinary and very complex systems (including educational ones). SE applications are based almost entirely on visual software packages: UML (Unified Modeling Language), IDEF (Integration Definition), QFD (Quality Function Deployment), etc.

C. The Top-Down Approach

SE is proposing another way to increase education's efficiency, which is derived from its holistic feature: embracing the Top-Down approach [24]. The top-down approach means essentially fewer details and more comprehension.

Bottom-Up teaching starts with small details and broadens the scope of the lessons step by step as students master the skills. This way is rigorous, yet instruction-driven, cumbersome, and time-consuming, eventually suited for elite education and company specific training.

The strategy of top-down teaching begins with the big, abstract concept and works down to the specific details, according to the available time. This motivates students to learn through direct interaction and their own experience and is fast and suited to mass education. The Top-Down Approach in education provides a structured and motivating way to learn, promoting a deeper and more integrated understanding of subjects while aligning well with real-world problem-solving and diverse learning styles. It is structured and linear, ideal for subjects where a foundational understanding is crucial, aiming for a comprehensive understanding by building from general to specific. Students gain an overall understanding of the subject, helping them see how individual parts fit into the bigger picture. This broad perspective can enhance comprehension and retention of detailed information. By understanding the ultimate goals and applications of what they're learning, students can be more motivated to engage with and master the detailed content. Knowing the relevance and end goals of their studies can make the learning process more meaningful and interesting. Moreover, starting with general

concepts allows students to quickly grasp the subject's scope and identify areas that need more focus. This can make the learning process more efficient, as students can prioritize their efforts on more challenging aspects once they understand the overall framework.

Given the current complexity of education, illustrated in section 2, a mechanical application of any of the methods proposed above is virtually impossible. Hybrid solutions have the highest chance of success. Let's give an example from digital electronics: the Hardware Description Languages (HDL). HDLs admit two types of descriptions for the same circuit: Behavioral and architectural, which are interchangeable according to needs (Fig. 3). The behavioral description is top-down functional, while the architectural is bottom-up structural.

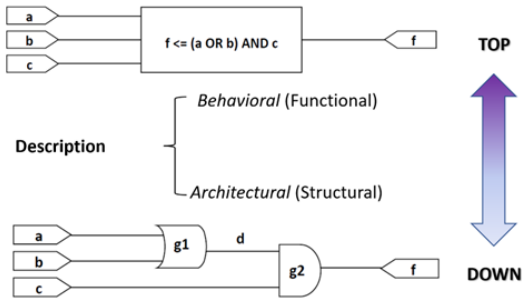

Fig. 3. The HDL descriptions

IV. Conclusion

The paper discusses the ever-widening gap between the volume of general knowledge, which obeys Moore's law of exponential knowledge development, and the effectiveness of education, which cannot keep up. The effect of this gap is critical for young people, especially for undergraduates, who have a high dropout rate. This is a peculiar case of inclusion, because it is addressing a wide group of perfect valid persons: virtually any student. In order to promote their inclusion in the context of Moore's law for knowledge, several fundamental measures are proposed in order to give education a greater dynamic: the more rigorous application of the Bologna Process system, the prioritization of visual methods of representation and manipulation of knowledge and the broader application in education of methods derived from Systems Engineering, such as the top-down approach.

Incorporating visual representation of knowledge in higher education not only caters to diverse learning styles but also enhances comprehension, retention, engagement, and critical thinking. By leveraging the power of visuals, educators can create a more effective and enriching learning environment that prepares students for both academic and real-world challenges. The application of such a set of measures is a large, lasting action and will require the involvement of all teachers, whose task is difficult because they will have to start by changing themselves.

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Multimedia Based Sign Language Dictionaries: How are Potential Users Involved?

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Abstract

Sign languages are rich visual-gestural languages that serve as the primary means of communication for the d/Deaf community. Despite their complexity and cultural significance, sign language dictionaries face challenges in terms of documentation, accessibility, and usability. Despite their linguistic richness, the development of comprehensive and user-friendly sign language dictionaries remains limited, especially in terms of adequate user testing, leading to a gap between technological advances and user satisfaction.

This paper examines the history and evolution of sign language dictionaries, from the early printed versions to interactive digital formats. It highlights their key features and technological advances and discusses the benefits of integrating modern technologies such as motion capture and artificial intelligence into sign language dictionaries to improve the accuracy and accessibility of sign language resources. The paper emphasizes user-centered design and calls for a thorough evaluation involving diverse target groups, including d/Deaf, hard of hearing, and hearing users. By addressing the current lack of empirical testing, this paper proposes a hybrid approach to the development of sign language dictionaries that are accessible, effective, and culturally sensitive, ensuring equal access to communication and information for all.

Keywords

online dictionary, sign language, sign language dictionary, user testing, evaluation

1 Introduction

The natural language of the d/Deaf, where "deaf" refers to a physiological state, while "Deaf" refers to a member of the Deaf community [1], is sign language, characterised by its unique visual-gestural modality, with each sign functioning as a lexical unit within a comprehensive grammatical system. These languages are fully-fledged and serve as important means of communication for people with varying degrees of deafness, whether prelingual or postlingual.

Despite their richness, sign languages face significant challenges in terms of documentation and supporting materials, like textbooks, grammar books and dictionaries [2]. High-quality sign language dictionaries are rare, and those that exist often suffer from poor accessibility and usability. Modern multimedia technologies offer a promising solution for a better representation of the spatio-temporal content. These technologies can be used to create more accessible and effective dictionaries that meet the target users' needs [3]. Yet, there is a notable lack of testing and evaluation of these dictionaries with all target audience groups [4]. This gap highlights a critical problem where effectiveness and practicality of these resources are often assumed rather than empirically tested.

This paper explores the development and key features of multimedia Sign Language Dictionaries (SLD), focusing on appropriate empirical testing with target groups. This could improve accessibility and usability, as well as better meet the needs of the Deaf community, their relatives, friends, and anyone who wishes to communicate in sign language.

2 Technical Aspects of Sign Language Dictionaries

In the interconnected world, access to information in one's natural language is a fundamental right that is essential for equal participation and involvement in society. Language is a carrier of culture, identity and knowledge. When people have access to information in their natural language, they can better engage and break down the barriers that exclude people from important conversations and opportunities. If information is only available in a few languages, most people become marginalised and their voices go unheard.

Conventional methods of information dissemination fall short when it comes to sign languages. General dictionaries rely on words, phonetics, pronunciation, and text-based explanations that are inadequate for sign languages. Sign languages are visual and spatial, and include hand and body movements as well as facial expressions which can modify sign meaning. To accurately represent these elements, SLDs must use additional means of communication such as videos, or other alternatives like animations, 3D animations, 360 videos, spatial videos and in addition, specialised notations [5].

Developing effective SLDs requires a hybrid approach that combines features of both learner's and explanatory dictionaries. Learner's dictionaries simplify definitions and provide clear examples to help beginners. Explanatory dictionaries provide detailed descriptions and a broader vocabulary for advanced users [6]. An ideal SLD would include a learner's section with videos demonstrating basic signs, accompanied by 3D animations and text descriptions, with the goal to focus on fundamental vocabulary and common phrases, making it accessible to beginners. The explanatory part would cover complex signs with multiple examples in different contexts. This hybrid model would ensure that SLDs are versatile resources for all users, promoting equal access to information and supporting the development of sign language skills. By creating advanced hybrid SLDs that embrace

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the visual and dynamic nature of sign languages, inclusion and equality would be promoted in the best possible way.

2.1 History and Development

The history and development of SLDs reflect the evolving understanding and appreciation of sign languages. The first sign language dictionaries were created in the 20th century [7] providing a valuable resource for both the Deaf and hearing communities. These dictionaries were printed works that used static images, line drawings of signs and textual explanations to depict the signs, which helped to somewhat bridge the gap in communication. These early dictionaries, while pioneering, had significant limitations when it came to accurately capturing the dynamic and spatial nature of sign languages. The static nature of used images often failed to convey the fluid and expressive aspects of sign languages, often making it very hard for people to understand and learn the signs correctly [3, 4].

A significant advancement in the representation of sign language was achieved with the introduction of notation systems. The first notation system was developed in 1960 by Stokoe, which was closely followed by SignWriting (1974) and HamNoSys (1985) notation systems. They use pictures and abstract symbols to describe the elements of each sign, which makes analysis of sign language structure possible. To describe a sign accurately, five parameters are needed: movement, handshape, location, palm orientation and non-manual signals [4, 8]. Printed SLDs used four of the five parameters to describe included signs, which allowed for easier categorisation as well as more efficient searching, since it was possible to organise signs by their characteristics instead of alphabetically [7].

Video technology made a revolutionary advance for SLDs. Early video dictionaries which began appearing in the late 20th century and used 2D video to demonstrate the signs [9, 10]. These video dictionaries provide a more accurate representation of signs compared to static images, as they show body movements and facial expressions. However, 2D video still lacks spatial information, which is crucial for fully capturing the three-dimensional nature of sign languages [11].

The development of 3D avatar dictionaries has addressed some of the limitations of 2D videos by incorporating spatial information. These systems use computer-generated avatars to perform signs, offering users to depict signs from multiple viewing angles, which facilitates better understanding and learning. Despite these advances, 3D avatars often struggle to adequately reproduce natural facial expressions and body movements, which are integral parts of signing, causing the Deaf community to not yet fully accept 3D avatars [12].

The most advanced SLDs today are exploring the use of sophisticated interactive systems to improve inclusion and interaction. Researchers are utilising technologies like motion capture, augmented reality and artificial intelligence to create more natural and accurate representations of signs. These systems aim to capture the full complexity of sign languages, including accurate facial expressions and subtle body movements [13, 14]. E.g. interactive platforms may allow users to view signs from different angles, slow down movements to study them in detail, and even converse with virtual assistants in sign language in real time.

Scientific publications have documented these advances and highlighted the associated technical and social challenges. Studies have examined the effectiveness of various technologies and their acceptance in the Deaf community, emphasising the importance of cultural sensitivity and user-centred design in the development of these aids [15, 16].

2.2 Advantages

Sign language dictionaries offer numerous advantages that significantly support the learning process and enhance communication and inclusion. They provide a standardised way of showing and understanding signs, which helps to standardise their meanings for different users and contexts. This promotes the recognition and use of the sign language, raises awareness and increases the participation of the d/Deaf in society. In addition, these dictionaries enable anyone to learn new signs or refresh their knowledge, ensuring accurate and effective communication, regardless of skill level - whether beginner or certified sign language interpreter. As a comprehensive resource, sign language dictionaries play a crucial role in promoting inclusion and bridging communication gaps between d/Deaf and hearing people [3, 11].

2.3 Key Features

SLDs have evolved from simple printed resources to sophisticated, interactive tools that are essential for learning, communication and inclusion. Initially, these dictionaries were based on static images and textual explanations, which were basic but limited in their ability to capture the full nature and details of sign language.

Modern SLDs [3, 6, 11, 17, 18, 19] have evolved considerably, incorporating a robust entry structure that typically includes the lemma, a video demonstration, and a detailed explanation. Each entry can also provide usage examples and information on frequency of use, along with grammatical details, synonyms, antonyms and collocations. Visual aids and notation systems such as Stokoe, HamNoSys, SignWriting further break down the components of each sign, improving understanding and learning.

The search function in these dictionaries is versatile and allows users to find signs by entering a word or phrase, search by sign components, or by thematic groups. The search results are listed by relevance, ensuring the most accurate match.

Interactivity is a key feature of modern SLDs. Video content offers controls to play, pause, change playback speed and jump to specific sections. Some dictionaries offer multiple synchronised 2D videos filmed from different viewing angles for better understanding, or even 3D avatars with 360-degree views, giving users the ability to freely change rotation or perspective.

As up-to-date and unlimited resources, online SLDs continually add new information, avoiding the limitations of printed versions. This approach mitigates the pressure of deciding which entries to include and allows for quick updates, keeping the dictionary current and comprehensive.

Additional features of modern SLDs increase their usefulness and educational value. Instructions on how to use the dictionary effectively, information on the history and context of sign language, and up-to-date information on the latest developments keep users informed and engaged. Features such as the "word of the day" encourage regular learning and exploration of new signs. These interactive features lead to better learning outcomes. More advanced SLDs incorporate additional features, allowing users to participate in quizzes and games, practise with structured exercises, and save and print customised vocabulary lists. In addition, SLDs can also support language rehabilitation by providing tools for continuous practise and improvement.

3 User Centered Design and Evaluations

The development of SLDs has mainly focused on its features, programming processes, and design. Numerous articles and papers meticulously describe the intricacies of these aspects, often emphasising the technical and linguistic challenges. However, there is a glaring absence in the literature when it comes to user evaluation of these dictionaries with the users. Since SLDs are used by deaf, hard of hearing and hearing users, these solutions should be tested and evaluated by all target groups with comparable tools.

User testing is crucial to the development of any effective educational resource, which is especially true for SLDs. Many studies have shown that involving end users in the testing phase is crucial to ensure effectiveness, efficiency and user satisfaction. One of the most widely used methods for this purpose is User Centered Design (UCD) [2]. This methodology emphasises effectiveness, efficiency and user satisfaction. Effectiveness ensures that the tools or services fulfil the intended purpose, efficiency minimises the effort and time required for users to achieve their goals, while user satisfaction creates a positive and engaging user experience. UCD focuses on improving usability and aims to develop tools that are intuitive and user-friendly. Ideally, SLD design should follow all UCD steps, including thorough user testing and evaluation. Unfortunately, in practise, many SLD development projects tend to skip the crucial fourth step of UCD — evaluation with actual users.

This omission leads to a gap between the theoretical benefits of SLDs and their practical usability. Without empirical evaluation, developers miss out on important feedback that could lead to improvements and adjustments. As a result, SLDs may not fully meet the needs and preferences of the d/Deaf and hard of hearing communities and hearing users, limiting their effectiveness as a learning or helping tool.

3.1 Target Users

The users of SLDs are diverse and they use these tools for various reasons, e.g. to learn a sign language, to interpret, to prepare for specific interpretations or to test their knowledge. Understanding these different user groups is essential for the creation of effective and accessible dictionaries.

Users can be categorised according to their purpose: Sign language learners who are seeking to expand their vocabulary, interpreters who need accurate signs for communication, teachers who use SLDs as teaching tools, and developers who are creating or improving sign language resources. Another categorisation is by hearing status: d/Deaf people for whom sign language is a primary form of communication and hearing people who use SLDs for learning, interpreting or teaching.

Sign language competence also defines user categories: Beginners who are just starting to learn, advanced beginners with basic proficiency, proficient users who engage in complex interactions, proficient users who often work in a professional context, and experts, including native signers and experienced certified interpreters or educators. It is important to understand all different user groups through user studies. They provide insight into how the different groups interact with SLDs, their specific needs, challenges and preferences. This knowledge is invaluable when it comes to customising features, increasing usability and improving accuracy to ensure SLDs are effective and user-friendly for all experience levels within the sign language community [2, 3, 20].

3.2 Evaluation Studies

The evaluation of SLDs can focus on both technical criteria and user experience. Categorising features of SLDs and determining what should be evaluated are crucial steps in this process.

From a technical perspective, the evaluations often look at how well the dictionary code or service works. However, this type of evaluation is insufficient, if the user experience is not taken into account. An effective evaluation should also include an assessment of functionality and usability, ideally involving the target audience. For example, the evaluation of an Electronic Malaysian Sign Language Dictionary [21] was conducted with actual users and provided valuable insights into its effectiveness. In contrast, most SLD evaluations often involve non-target groups of users, typically in very small numbers, which limits the relevance of the obtained feedback.

Unfortunately, many SLD projects do not report on user testing at all. Instead, they rely on simple functional testing or use metrics such as Google Analytics as a substitute for evaluation. This approach overlooks important aspects of user interaction and satisfaction.

A few articles emphasise the importance of thorough user evaluation and show how user feedback can lead to improvements. A study on the users of an online dictionary of sign languages titled "Proposing an instrument for evaluation of online dictionaries of sign languages" [4] provides a proposed framework for conducting comprehensive evaluations and further illustrates the benefits of involving users in the testing process.

3.3 Guidelines and Importance

The evaluation of sign language dictionaries is crucial to ensure that they are effective, user-friendly, and meet the needs of their diverse users. Key aspects of evaluation must include testing specific features, assessing usage and usability, ensuring ease of use and reviewing the quality of videos and content. Feedback and ideas from the community are invaluable for further development and improvement of any dictionary.

An evaluation of SLD should include all target user groups, including the d/Deaf and hard of hearing people, as well as professional interpreters, teachers and other hearing learners, in order to gain comprehensive insights. Methods that include interviews are preferable to written surveys to obtain more in-depth, nuanced feedback [22]. In a separate ongoing study, we were able to demonstrate that it is important to use tools translated into sign language for all users whose natural language is sign language, in addition to semi-structured interviews with participants. To summarise, it is important to tailor the evaluation methods to the specific user group and allocate sufficient time for thorough testing and feedback collection. Although there are some differences between countries in terms of certified interpreters and legal obligations, each method should consider all possible options to reduce the pressure on users by providing them with a comfortable environment and relaxed user testing to minimise the negative impact of testing methods on the final results.

The importance of these evaluations cannot be overemphasised as they lead to a better end product or service. Systematic evaluations improve functionality, usability, and overall quality, and ensure that the SLD or any other product or service actually serves the target audience for which it is intended. This iterative process ensures that the final product truly meets the needs and expectations of its users, resulting in a more effective and user-friendly sign language dictionary.

4 Conclusions

The evolution of sign language dictionaries from printed images to advanced interactive systems reflects significant technological and linguistic advancements. While early efforts provided basic resources, modern approaches strive to capture the complexity and richness of sign languages. As research and technology advance, the goal is to develop inclusive, accurate, and widely accepted resources that empower the Deaf community and improve communication for all. Sign language dictionaries have thus become indispensable, continually updated resources that support learning, foster inclusivity, and bridge communication gaps between deaf and hearing individuals.

To bridge this gap, it is essential that future SLD development incorporates comprehensive user testing into their methodologies. By doing so, developers can ensure that their dictionaries are not only linguistically and technically sound, but also genuinely useful and accessible for their intended users.

In conclusion, for SLDs to be truly effective, evaluations must extend beyond technical functionality and include thorough user testing. This involves categorising features appropriately, assessing content accuracy, and involving all targeted user groups to ensure the dictionaries meet the actual needs of the Deaf and Hard of hearing communities, as well as all other user groups who are using SLDs.

Finally, our research on SLDs and user testing methods has identified some exemplary approaches [20, 21, 22] that integrate users into the design, development, and evaluation stages. On the other hand, however, we could not find a suitable tool for user testing that was adapted to or created in sign language. This highlights a significant area for improvement, particularly in ensuring that solutions meet user needs without assuming that every solution and current evaluation methods are good enough.

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(In)Accessibility of Slovenian E-commerce the Year Before the European Accessibility Act

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Abstract

The European Accessibility Act (EAA, Directive (EU) 2019/882) aims to harmonize accessibility requirements, with a significant focus on e-commerce services due to their socio-economic impact. This study manually assessed 26 key EN 301 549 requirements, aligned with WCAG 2.1 success criteria at levels A and AA, to provide more relevant results for future accessibility trend comparisons and to advocate for necessary awareness and education initiatives. We examined 20 major and original, Slovenian e-commerce platforms expected to fall within the EAA's scope. None of the websites were fully accessible; each failed at least 13 out of the 26 selected requirements, with an average of 17.1 criteria unmet per website. Our findings highlight the urgent need for improved accessibility to ensure digital inclusivity in Slovenia and identify specific accessibility and usability issues that must be addressed to achieve compliance and bridge existing digital barriers.

Keywords

Accessibility, E-commerce, European Accessibility Act, WCAG, EN 301 549, Design for all, EN 17161, Accessibility culture

1 Introduction

With the increased digitalization of e-commerce and beyond, it is crucial that digital solutions are inclusive and accessible to everyone, including individuals with permanent, temporary, or situational disabilities. International studies show that 95.9% of the top one million home pages had detected WCAG 2 failures [1].

Recent studies in Europe reveal that 94% of European websites fail to meet accessibility requirements [2]; however, these large-scale studies primarily rely on automated accessibility testing due to its speed, convenience, and low effort.

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Unfortunately, automated accessibility testing is quite limited and cannot cover all success criteria and accessibility requirements [10]. Furthermore, it can never definitively determine conformance [3].

Such tests are unable to address context-based accessibility requirements, which can only be evaluated by a human. As a result, they often fall short in detecting real accessibility issues [4].

Testing the accessibility of websites and native mobile applications using automated tools can therefore only provide a superficial impression of the state of accessibility [5].

The main objective of the European Accessibility Act (EAA) is to harmonize accessibility requirements for a wide range of essential services and products, including e-commerce services, starting from 28 June 2025. The EAA does not specify a particular accessibility standard to be used. Instead, it emphasizes that accessibility should be achieved by systematically removing and preventing barriers, preferably through a universal design or "design for all" approach. [6].

Studies using manual testing for accessibility are sparse due to the significant time investment and specialized knowledge required. Our intention with this study was to manually audit the accessibility of 20 representative Slovenian e-commerce websites, present an overview of our findings, highlight the most significant barriers for people with disabilities, and briefly suggest ways to prevent or address these accessibility issues.

Based on our experience from other audits, we expected to find that all these websites would be inaccessible.

2 Methods

Since the EAA does not define a specific technical standard, we used selected parts of EN 301 549 accessibility requirements to evaluate functional performance statements.

These requirements are mandated by the Web Accessibility Directive (Directive (EU) 2016/2102) [7], which applies to the public sector in the European Union.

Our study focused on a selection of 26 relevant accessibility requirements from section 9 (check table 1) of the EN 301 549 (version 3.2.1) [8] standard during our manual evaluation, supported by different tools (contrast checker, static code

validators (HTML, CSS and ARIA) and developer tools built in browsers).

The selection of websites was based on three criteria:

1. The company has at least 10 employees.
2. The company has an annual turnover of at least 2 million euros.
3. The website is original Slovenian e-commerce, rather than being a translation of content from international companies.

The sampling of webpages was conducted based on the following essential end-user digital journeys:

- Home page and navigation mechanisms.
- Product search, filtering, comparison.
- Add to cart procedure.
- Registration and login mechanisms.
- Contact and customer support functions.

The manual accessibility audits were conducted from April to May of 2024, by four auditors: two senior auditors with multiple years of experience, one auditor with a couple of years of experience, and one junior auditor. The results were coordinated and verified to ensure the highest possible quality and reliability.

To ensure the integrity of our findings and maintain confidentiality, we anonymized the e-commerce platforms under study. This approach allowed us to objectively highlight the barriers identified, aiming to raise awareness and mitigate potential biases.

3 Results

All websites failed to conform to the EN 301 549 and WCAG 2.1 standards at both A and AA levels.

On average, each website had 17.1 accessibility issues out of 26 selected criteria. The two worst-performing websites failed 20 out of 26 criteria, while the best-performing website failed 13 out of 26 criteria.

The specific accessibility requirements that all websites failed include:

- 9.1.2.2 Captions (pre-recorded) – 10 sites of 20 used videos and all the videos were without captions of any kind.
- 9.1.1.1 Non-text content – mainly missing or wrong alternative text on images and functional icons.
- 9.1.3.1 Info and relationships – mainly wrong or missing semantics of HTML code.
- 9.1.4.3 Contrast (minimum) – mainly text contrasts that were below 4.5:1 for normal size texts.
- 9.4.1.3 Status messages – mainly for features like add to cart, filter/search result changes and some form validations.

Table 1: Accessibility failures detected with manual accessibility testing of selected EN 301 549 requirements of 20 e-commerce sites

EN 301 549 Requirement	Failed sites	% of failed sites
9.1.2.2 Captions (pre-recorded)	10/10 *	100%
9.1.1.1 Text alternatives	20/20	100%
9.1.3.1 Info and relationships	20/20	100%
9.1.4.3 Contrast (minimum)	20/20	100%
9.4.1.3 Status messages	20/20	100%
9.2.4.1 Bypass blocks	18/20	90%
9.2.4.4 Link purpose (in Context)	18/20	90%
9.2.4.7 Focus visible	18/20	90%
9.3.3.2 Labels or instructions	17/20	85%
9.1.4.5 Images of text	16/20	80%
9.2.2.2 Pause, stop, hide	16/20	80%
9.2.4.6 Headings and labels	15/20	75%
9.2.4.3 Focus order	15/20	75%
9.3.3.3 Error suggestion	15/20	75%
9.2.1.1 Keyboard	15/20	75%
9.1.4.11 Non-text contrast	15/20	75%
9.1.3.5 Identify input purpose	14/20	70%
9.1.4.1 Use of colour	12/20	60%
9.3.3.1 Error identification	11/20	55%
9.3.1.1 Language of page	9/20	45%
9.1.4.10 Reflow	8/20	40%
9.2.4.2 Page titled	8/20	40%
9.1.4.4 Resize text	5/20	25%
9.2.4.5 Multiple ways	4/20	20%
9.2.1.2 No keyboard trap	2/20	10%
9.1.3.4 Orientation	1/20	5%

* 9.1.2.2 Captions (pre-recorded) was only tested on 10 sites as the other 10 did not have any videos.

The secondary goal of manual accessibility testing was to document specific issues that can be used for further research. We are only briefly reporting them here:

- Use of **CAPTCHA** was often conducted with inaccessible solutions that were totally blocking blind people relying on screen readers.
- Modal implementations, especially **cookie consent** modal windows, were often inaccessible for multiple groups of users, especially blind screen reader users and keyboard only (or assistive technologies based on keyboard). This also has further legal implications for data collection consent management.
- Unstoppable, auto-playable **carousels** loaded with information that is unusable for all people.
- Pages **coded as English with Slovene texts** and components that use English alternative texts for screen readers on pages with Slovene language.
- Inaccessible **mobile ("hamburger") menu** buttons, often totally unusable for keyboard-based assistive technologies, screen readers and voice input.

- **260 tab presses needed to bypass** site navigation and get to the content of the page.
- **Background images** coded as decoration including important information.
- When pages are zoomed in or in landscape mode on mobile devices, the site framework like navigation, footer, and sticky buttons cover almost 90% of the screen, thus making content practically invisible.

Results of manual accessibility testing of the selected EN 301 549 requirements / WCAG success criteria, show that even if all 20 sites were to pass various types of automatic accessibility testing (which they did not), they would not conform to accessibility requirements and would be inaccessible to certain groups of users, especially screen reader users, keyboard-only (and similar assistive technologies) users, users with visual impairments and deaf users or users with hearing impairments.

4 Discussion

The study confirmed our expectation that all websites audited were inaccessible to groups of users, especially people with disabilities. The pervasive neglect of web accessibility in Slovenian e-commerce not only excludes users with disabilities but also represents a missed opportunity for businesses to reach a broader audience.

A year before the new accessibility legislation is enforced, we would like to see better results – less inaccessibility, highlighting the need for increased awareness and education among stakeholders, project managers, web developers and designers, content providers, and everyone else involved in the planning, production, maintenance, and implementation of e-commerce.

Besides people with permanent disabilities, we also need to consider situational and temporary disabilities that are often left out of demographics and statistics. It is important to be aware of the negative implications of inaccessibility on society as well as its negative impact on the business sector.

Automatic accessibility testing alone can never be enough to test for conformance to accessibility standards, but it is nevertheless a useful complementary tool, helping to make manual auditing slightly faster and more efficient. There are numerous automatic accessibility testing tools that also have issues with false positives (reporting accessibility issues falsely) [10] and human interpretation will always be vital for quality of the end results.

We would like to point out that it is obvious that there is ample evidence that accessibility needs to be integrated into organizations from top to bottom, and it is also evident that standards such as Design for All (EN 17161:2019) [9] and EN 301 549 get insufficient attention. We encourage stakeholders and all interested persons to study, implement, and share knowledge to raise awareness, improve accessibility at scale, and with that enable more people to use their services for common benefits.

We are aware of multiple limitations of this study, but would like especially to point out the following:

- We scaled down the scope of testing with the full EN 301 549 set of requirements to expedite testing. Testing a full list of requirements would most likely produce even worse results, but our selection was based on the relevance of requirements for e-commerce.
- Keeping the selected 20 e-commerce websites intentionally undisclosed makes comparison of trends of the same websites impossible, but we still believe that they are a well-chosen and relevant representative sample for high-level inaccessibility situation indication and may be compared with similar websites on a requirement basis.
- Our scope was limited to a set of the most vital parts of the user journey, and testing beyond that would most probably find more failures, but we wanted to focus on the most important parts from an end-user perspective instead of mapping the situation of the technically wider but less realistic scenarios.
- We would like to involve people with different disabilities to support the study with parallel usability testing, using their own ways and assistive technology, but that was not possible due to limited resources.

5 Conclusion

This study's findings highlight the pervasive inaccessibility of Slovenian e-commerce websites, with none of the 20 audited sites fully conforming to EN 301 549 and WCAG 2.1 standards. Each e-commerce website failed an average of 17.1 out of 26 selected criteria, with issues ranging from missing captions and alternative texts to inadequate contrast and problematic navigation mechanisms. These shortcomings exclude users with disabilities and represent missed opportunities for businesses to engage a broader audience.

As the European Accessibility Act's implementation approaches, it is imperative to raise awareness and educate stakeholders, including project managers, web developers, designers, and content providers. Improving accessibility is not only a legal obligation and financial repercussion prevention, but also a moral and business imperative. Automatic testing tools, while useful, cannot replace the nuanced insights gained from manual audits.

Therefore, a combination of both methods, with a focus on manual evaluation, is essential for meaningful progress toward digital inclusivity. When baseline conformance is guaranteed and there are no obvious barriers, we highly recommend the involvement of people with disabilities, to further improve the usability aspects beyond technical guidelines and standards.

Addressing accessibility issues benefits everyone, including those with temporary or situational disabilities, and enhances the overall user experience. The study underscores the need for ongoing efforts to bridge digital barriers and ensure that e-commerce platforms are accessible to all users, thereby fostering an inclusive digital environment in Slovenia.

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Digital Inclusion of Children with Special Needs in Extracurricular Sports Activities

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Abstract

This article explores the inclusion of children with special needs in extracurricular sports activities, focusing on necessary adaptations for their full participation. It analyzes the current state of sports offerings in the Maribor region and identifies challenges faced by sports clubs. Key recommendations include specific coach training, systematic program adjustments, and the use of digital tools to enhance engagement and track progress. A handbook for coaches is presented, offering strategies and adaptations for various groups of children with special needs. The aim is to ensure accessible sports activities for all children, promoting their social, emotional, and physical development.

Keywords

Children with special needs, inclusion, sport clubs, inclusive sport activities, assistive technologies

1 Introduction

The inclusion process is based on the mindset that children have diverse abilities, expectations, and needs, but can learn and develop together in a suitably designed environment. In a positive school climate, where diversity is valued, every child can realize their potential [3]. The Slovenian »Placement of Children with Special Needs Act« facilitates the inclusion of children with special needs into regular educational programs with adapted implementation and additional professional assistance [6]. For effective work and active involvement of all participants, teachers must understand the characteristics of the children and the necessary adjustments concerning content, tools, environment, and other factors.

Inclusion extends beyond education to other areas of life, such as work, cultural life, leisure, recreation, and sports, although it is rarely organized in these fields. This article focuses on sports, which play a significant role in the lives of individuals by maintaining physical and mental health, boosting self-esteem, fostering friendships, and integrating into the broader social environment [1]. Organized sports activities should be accessible to all, as they offer numerous benefits to everyone [2]. Including children with special needs in sports activities requires properly trained staff, suitable equipment and tools, and environmental and content adjustments. For successful inclusive sports training, it is crucial that coaches and other professionals in sports understand the specific needs of different groups of children with special needs, implement necessary adjustments during the training process, and remain open to exploring new possibilities and solutions [5].

In recent years, digital tools have become essential in adapting sports activities for children with special needs. Modern technologies, such as exercise tracking apps, virtual reality, and interactive training programs, enable adaptations that facilitate inclusion in sports activities [7]. These tools not only ease the implementation of training but also increase children's motivation, allow monitoring of progress, and adapt activities to their needs and capabilities.

Through a review and analysis of the current situation, conducted via survey research, we investigated the possibilities for including children with special needs in organized sports activities in the Maribor area and the surrounding regions, and the knowledge of this field among the leaders of sports clubs and associations. Special emphasis was also placed on the use of digital tools, which can significantly contribute to improving the quality of sports programs for children with special needs.

Based on the analyzed research results, which will be described in the following sections, and the review of documented good practices from abroad, we have developed a handbook [4] providing guidelines for successfully implementing an inclusive training process. This handbook aims to enable coaches to effectively work with children with special needs within regular sports programs.

2 Empirical research

2.1 Problem definition and purpose

The issue of including children with special needs in organized extracurricular sports activities is critical, as we observe in practice that this group of children has limited opportunities to participate in mainstream programs of sports clubs and associations.

The purpose of the research was to analyze the existing situation and identify barriers preventing the inclusion of these children in sports activities. By doing so, we aimed to contribute to a better understanding of the issue and develop guidelines for working with each group of children with special needs in sports.

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2.2 Objective of the empirical research

The primary objectives of the empirical research were:

- To determine the opportunities available for children with special needs to participate in extracurricular sports activities in the Maribor area and its surroundings.
- To identify the barriers and reasons why sports clubs/associations reject children with special needs.
- To propose solutions and formulate guidelines to improve the inclusion of children with special needs in sports activities.
- To examine the role of digital tools in adapting sports activities for children with special needs.

2.3 Methodology

The research was conducted in three parts. Initially, we performed a local environmental scan by contacting 13 disability organizations via telephone to gather data on the availability of sports programs for children with special needs and the possibilities for their inclusion. In the second part of the research, we employed a survey method to collect data on the existing practices and challenges faced by sports clubs/associations in including children with special needs in their regular sports programs.

The survey questionnaire, answered by the leaders of the sports clubs/associations, consisted of ten closed-ended and two open-ended questions. A total of 48 local sports clubs and associations, covering 18 different sports disciplines, participated in the research.

Regarding the use of digital tools in sports activities, we conducted interviews and a brief review of studies published in journals. The handbook written following the research is based on the conceptual framework of foreign sports organizations that exemplarily implement inclusion in sports practice. To deepen our understanding of the inclusive paradigm, we attended online courses organized by their umbrella organizations, studied the methods and principles essential for achieving inclusion in sports, and supplemented these insights with our own experiences.

3 Analysis of the sports offer by disability organizations

The analysis of the sports offerings by disability organizations in in Slovenia (town Maribor area and its surroundings) revealed that while the range of sports activities is extensive, no association allows participation by children, only by their adult users.

From the analysis of the second part of the research, in which the leaders of sports clubs/associations reported on their experiences and challenges in including children with special needs in their regular programs, we found that most leaders first inquire about the child's disability, impediment, or deficiency and implement certain adjustments in their work. Data on the number of children with special needs included in regular sports programs was not provided by most sports clubs/associations. Those that did provide information reported having only one to six children with special needs in their sports clubs/associations.

The main reasons cited for non-inclusion were the lack of trained personnel capable of making appropriate adjustments, hindrance to the progress of other participants, and fear of responsibility.

The analysis of the inclusion of children with special needs in sports clubs and associations showed a highly varied situation. Key findings from the analysis can be linked to foreign practices, identifying the main reasons for the non-inclusion of children with special needs in additional sports activities as follows:

Social environment:

1. Negative societal attitudes towards individuals with special needs.
2. Low level of trainer qualifications: sports clubs and associations reported that their trainers have limited knowledge and experience working with children with special needs. Most surveyed trainers expressed a need for additional education and training.
3. Inappropriate attitudes and communication towards children with special needs.
4. High costs: the groups with children with special needs are significantly smaller in number compared to others, as a higher degree of individualization is necessary for the safe conduct of training. It is also necessary to provide more coaches.

Physical environment:

1. Access issues and inadequate equipment (facilities, devices, tools).
2. Lack of programs that enable children with special needs to engage in organized sports.
3. Unadapted existing programs: although some clubs implement adjustments to their sports programs, these are often not systematic or specific enough for individual groups of children with special needs. The most common adjustments include changes in the intensity of training and individually tailored tasks.

Personal reasons:

1. Lack of confidence among trainers in their abilities.
2. Lack of confidence among parents in the abilities of trainers.
3. Time constraints for parents.
4. Financial constraints for parents.
5. Lack of parental knowledge about the importance of sports activities for their child's quality of life, available sports programs, and possible adaptive equipment and tools that would enable their child to safely engage in chosen sports activities.

Use of digital tools:

1. Digital tools, such as exercise tracking apps, virtual reality, and interactive training programs, are rarely used. However, the clubs that have introduced them reported positive effects, including increased motivation among children, better progress tracking, and more tailored training programs.

Based on these findings, we have written a handbook that formulates guidelines for improving the inclusion of children with special needs in sports activities.

4 Handbook for inclusive coaches

The handbook, developed based on the findings of our research, aims to empower coaches to successfully implement inclusive sports activities [4]. It includes guidelines and recommendations for working with children with special needs, with an emphasis on adaptations that enable these children to fully participate in organized sports activities.

The first part of the handbook defines and describes the inclusive paradigm, addressing the knowledge gaps among sports professionals on how to approach, communicate, and establish successful relationships with children with special needs.

A successful inclusive coach must possess specific knowledge and skills for working with children with special needs and create an encouraging environment where all participants can actively engage and realize their potential.

The inclusive approach of a coach is based on empathy, understanding, and respect. This requires careful planning of sports activities and adapting methods, the environment, equipment, tools, and content. Using respectful and positive language is crucial for successful communication. Coaches must develop skills to adapt the training process, be innovative in creating a motivational environment, and be adept and understanding in resolving conflicts.

The handbook describes the so-called inclusive spectrum, which includes various methods and approaches to integrate children with special needs into sports activities. Based on foreign practices, we derived inclusion models (TREE, STEP, and CHANGE IT), which are practical tools designed to support coaches in adapting and modifying sports activities.

Additionally, the handbook outlines an important friendship system that promotes peer cooperation and creates a supportive network for children with special needs.

The second part of the handbook provides detailed guidelines for adapting sports training for each group of children with special needs.

By following these recommendations and guidelines, coaches can contribute to a more inclusive environment where every child feels accepted and valued.

5 Proposed adaptations for implementing inclusive sports training

When implementing inclusive sports training, it is crucial to understand the specific needs of each child, the limitations they face, and the specific adaptations required to enable safe participation in sports activities, along with the appropriate digital tools. Each child has unique characteristics that affect their abilities and needs during training.

The following summarize key adaptations for each group to ensure full participation and optimal development of every child.

5.1 Children with Intellectual Disabilities

Adaptations for children with intellectual disabilities include using simple and clear instructions. Significant time should be dedicated to reinforcement, and it is essential to strive for a predictable and structured training environment. Coaches should encourage positive interactions and praise achievements, thereby increasing the child's motivation and self-esteem.

Relevant digital tools include applications for visualizing exercises (as videos or pictures), which help children understand and follow instructions. Additionally, coaches can use apps to create structured training schedules, allowing children to better plan and execute activities.

5.2 Blind and Visually Impaired Children

For blind and visually impaired children, it is crucial to adapt the training environment to be safe and accessible. The use of auditory signals, tactile markers, and verbal descriptions of exercises can significantly enhance understanding and safety. Coaches must pay attention to the orientation and mobility of these children, ensuring they feel safe and accepted.

Digital tools include auditory applications that guide children through exercises and devices for auditory orientation. These tools can help children navigate the space and participate in training without additional barriers. Additionally, the use of braille displays for presenting information about exercises is beneficial.

5.3 Deaf and Hard-of-Hearing Children

Adaptations for deaf and hard-of-hearing children include using visual signals, gestures, and clear facial expressions. Coaches must ensure that all visual representations of tasks are clear and visible. Communication should be adapted so that children can follow instructions and participate in the training process without difficulty.

Digital tools include speech-to-text applications and video instructions with subtitles. Coaches can also use video calls with sign language interpreters to facilitate communication.

5.4 Children with Speech and Language Disorders

When working with children with speech and language disorders, it is important to use short and simple instructions and visual aids. Coaches should encourage communication in various ways, including gestures, picture cards, and other visual tools to facilitate understanding and participation.

Digital tools include visual communication apps and interactive storytelling apps that assist in learning and communication. Applications for creating picture communication boards are also useful, enabling children to express their needs and desires more easily.

5.5 Children with Motor Disabilities

Adaptations for children with physical disabilities involve adjusting exercises according to their physical abilities and using specific equipment, such as wheelchairs or orthopedic aids. Coaches need to be creative in designing exercises that allow participation from all children, regardless of their physical limitations.

Digital tools include motion control applications that aid in rehabilitation and virtual reality for simulating various sports activities. Movement tracking devices can also be used to monitor progress and adjust exercises based on capabilities.

5.6 Children with Long-term Illness

For chronically ill children, it is crucial to consider their health limitations and adjust the intensity of the training. Coaches must be aware of the children's health conditions and any contraindications for specific physical activities. Training should be tailored to enhance the health and well-being of the children.

Digital tools include health and fitness tracking apps that allow for adjusting training programs based on health conditions. Apps for recording symptoms and medications are also useful, enabling children to monitor their health status and adjust their activities as needed.

5.7 Children with Learning Disabilities

Adaptations for children with learning disabilities involve using multisensory approaches and offering various learning methods. Coaches should use a combination of visual, auditory, and kinesthetic methods, providing additional support and time for understanding instructions.

Digital tools include interactive learning and brain training apps that help improve cognitive functions and motor skills. Applications for creating visual schedules and monitoring progress during training are also beneficial.

5.8 Children with Autism Spectrum Disorders

Adaptations for children with autism spectrum disorders include creating a structured and predictable environment and using visual schedules and clear rules. It is important to reduce (or increase) sensory stimuli and adapt the training to allow focus and sustained attention.

Digital tools include apps for creating visual schedules and social stories that help understand and adapt to changes. Sensory integration apps are also useful, helping children manage sensory stimuli during training.

5.9 Children with Emotional and Behavioral Disorders

For children with emotional and behavioral disorders, it is important to create a supportive and stable training environment. Coaches should use positive reinforcements, set clear boundaries and rules, and be consistent in their training approach. Adaptations should enable children to manage their emotional and behavioral challenges and participate in sports activities.

Digital tools include apps for meditation and emotional regulation that help children manage stress and anxiety. Apps for recording and monitoring emotional states are also useful, enabling children and coaches to recognize behavior patterns and adjust training accordingly.

6 Conclusions

The inclusion of children with special needs in organized sports activities is crucial for their social, emotional, and physical well-being. This article presents various adaptations necessary for the successful integration of this group of children into sports activities. We found that adaptations depend on the specific needs of each group of children, making it essential for coaches to understand and recognize these characteristics and needs, maintain a positive attitude, be open to adjusting the training process, and seek innovative solutions.

Adaptations for individual groups of children with special needs are essential for the effective implementation of inclusive sports training. With the right approach and the use of digital tools, coaches can create an inclusive environment where each child feels accepted and valued, contributing to their optimal development and full participation in sports activities.

The use of digital tools is fundamental in facilitating these adaptations and enabling the full participation of children with special needs in sports. Applications for visualizing exercises, auditory and visual signals, interactive stories, motion control, and health monitoring are just some of the tools that can significantly improve the quality of training and increase children's motivation.

It is also important to emphasize the need for continuous education and training for coaches working with children with special needs. Only with appropriate knowledge and skills can they create an inclusive and supportive environment.

Future efforts should focus on continuing research and developing new approaches and technologies to support inclusion in sports. This will ensure that sports are accessible to all children, regardless of their abilities or special needs, providing them with equal opportunities for holistic development.

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A micro-Learning Units Package for Improving Inclusive Digital Education in HEI

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Abstract

In Higher Education Institutions (HEIs), digital inclusion plays a crucial role in providing equitable and just access to educational materials for every student, irrespective of their varied origins, capacities, or impairments. To leverage HEIs and their ability to implement an inclusive educational system, this work considers identifying the factors that impact e-inclusion in HEIs to create a new content package of micro-learning units. These will cover categories such as leadership techniques, teamwork and networking, infrastructure needs, professional development, pedagogical support systems, classroom implementation, assessment procedures, and digital competency. The structured pedagogical content is supplied to the user through a recommendation model that constitutes an online self-evaluation tool.

Keywords

Inclusion, Learning Unit, Higher Education Institutions, Education, Educational Content

1 Introduction

Digital technologies have revolutionized the landscape of Higher Education Institutions (HEIs), enhancing accessibility and facilitating innovative teaching and learning methods. However, this digital transformation also underscores the imperative for digital inclusion, ensuring that all students have equitable access to educational resources regardless of their diverse backgrounds and abilities. Digital inclusion in HEIs is not merely about providing access to digital tools but involves a comprehensive strategy that encompasses leadership, infrastructure, professional development, and pedagogical innovations [6, 2].

Micro-learning units are small, self-contained learning modules designed to deliver targeted educational content in a flexible and accessible manner. These units can be particularly effective in promoting digital inclusion by allowing students, teachers, and HEI staff to engage with material at their own pace and according to their individual learning needs. Recent studies have shown that micro-learning can enhance engagement and retention by breaking down complex subjects into manageable segments [1, 3]. To create a comprehensive package of micro-learning units aimed at improving inclusive digital education, it is essential to identify the key factors that impact e-inclusion in HEIs. These factors include leadership techniques, teamwork and networking, infrastructure needs, professional development, pedagogical support systems, classroom implementation, assessment procedures, and digital competency. By addressing these areas, the learning units can be tailored to provide practical and actionable insights that support educators and administrators in fostering an inclusive digital environment [4, 5].

This paper presents the development of a *micro-Learning Units Package* designed to enhance inclusive digital education in HEIs. By incorporating the identified factors that impact e-inclusion, this package aims to provide a structured and flexible pedagogical content delivery system. The micro-learning units will cover various essential categories and will be supplied to users through a recommendation model that includes an online self-evaluation tool. This approach ensures that the learning experience is personalized, responsive to individual needs, and conducive to fostering a more inclusive digital education environment.

The remaining paper is organized as follows. Section 2 addresses the key factors previously identified as enablers for digital inclusive education, and Section 3 describes the Learning package, its structure and content. Finally, Section 4 concludes the paper.

2 Factors for Inclusive Digital Education as Building Blocks

Identifying the factors that affect digital accessibility is here considered a previous starting point for constructing educational content. Policymakers, educators, and institutions can create plans and initiatives to support e-inclusion in HEI by recognizing these elements and how they interact. In this case, a set of micro-learning units was produced, making educational content available that relays and is organized based on the structure of the identified factors [4, 5].

The overall methodology consisted of four different stages. Firstly, a theoretical framework of inclusive digital education was developed, considering technology, pedagogy, content, management aspects, and different e-learning settings and modes. From this analysis, factors and indicators were obtained. Secondly, online workshops for refinement and validation of the variables and indicators were conducted in five countries (Italy, Portugal, Slovenia, Spain, and Turkey). In the workshops, the audience discussed and evaluated the framework, the factors, and the indicators). With the framework, the micro-learning package was created, consisting of a wide range of units as e-learning materials that cover all the factors and indicators previously identified. Thirdly, a second set of workshops was conducted to refine and validate the e-learning materials produced. Finally, a piloting stage was implemented in five European Universities, where management

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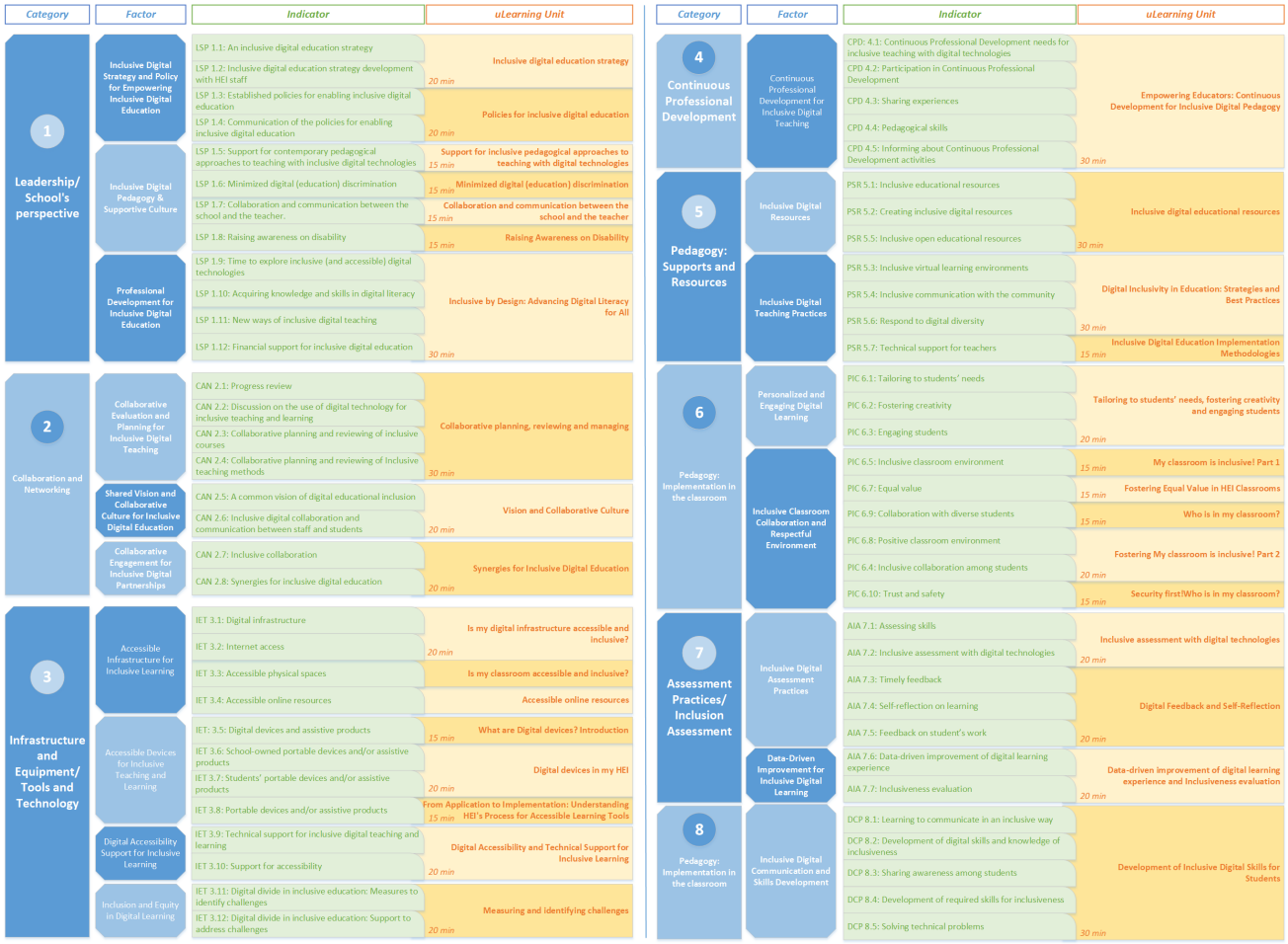

Figure 1: Micro-Learning Units Mapping with Categories, Factors, Indicators, and Estimated Duration

and teachers were invited to test the entire pipeline and evaluate its performance.

The model of factors enabling inclusive digital education was categorized into 8 categories: (1) Leadership/ School's perspective; (2) Collaboration and Networking; (3) Infrastructure and Equipment/ Tools and Technology; (4) Continuous Professional Development; (5) Pedagogy: Supports and Resources; (6) Pedagogy: Implementation in the classroom; (7) Assessment Practices/ Inclusion Assessment; and (8) Student Digital Competence/ Student's Perspective, where each category embraces 1 to 4 factors. Besides each category, the theoretical model that identifies the factors is operationalized by considering a set of indicators. By tracking these indicators, stakeholders can gain insights into the effectiveness of digital inclusive education initiatives and identify areas needing improvement. In the context of digital inclusive education, an indicator is a specific measure or metric that provides information about the extent to which digital education resources and opportunities are accessible, equitable, and effective for all learners. These indicators help assess and monitor various factors such as access to technology, digital literacy, inclusivity, engagement, policy support, and educational outcomes, allowing educators, policymakers, and stakeholders to identify strengths, gaps, and areas needing improvement in implementing digital inclusive education.

For the first category, Leadership/School's perspective, three factors are considered: (1.1) Inclusive Digital Strategy and Policy for Empowering Inclusive Digital Education: This factor reflects the importance of an inclusive digital strategy, collaboration with leaders and teachers, and the establishment of enabling policies to reduce barriers to learning and participation; (1.2) Inclusive Digital Pedagogy & Supportive Culture: This factor encompasses supporting contemporary pedagogical approaches with inclusive digital technologies, minimizing digital discrimination, and fostering collaboration and communication between HEI staff and the organization; (1.3) Professional Development for Inclusive Digital Education where scheduled time for staff to explore inclusive digital technologies and supporting their acquisition of digital literacy knowledge and skills are considered.

When considering the second category, Collaboration and Networking, a set of three factor are considered: (2.1) Collaborative Evaluation and Planning for Inclusive Digital Teaching: highlighting the importance of reviewing progress in teaching and learning with inclusive digital technologies, discussing the advantages and disadvantages of inclusive teaching, and engaging in collaborative planning for inclusive courses and teaching methods; (2.2) Shared Vision and Collaborative Culture for Inclusive Digital Education: This factor emphasizes the importance of promoting a common vision of digital educational inclusion

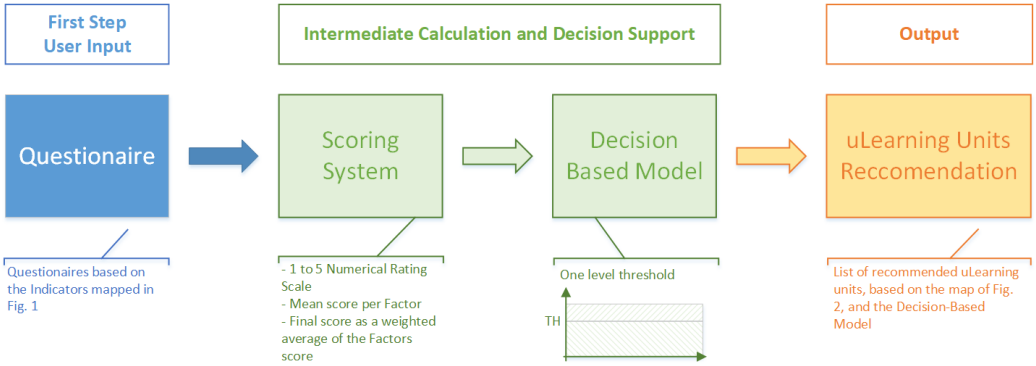

Figure 2: Recommendation Tool Model

among the main actors in the institution (management, pedagogical staff, students, and parents), as well as fostering inclusive digital collaboration and communication between staff and students; and (2.3) Collaborative Engagement for Inclusive Digital Partnerships: This factor highlights the importance of enabling inclusive collaboration with local communities, caregivers, and parents through digital technologies, as well as actively collaborating with other HEIs or organizations to support the use of inclusive digital technology.

Regarding Infrastructure and Equipment/ Tools and Technology, the third category, four factors are considered: (3.1) Accessible Infrastructure for Inclusive Learning: This factor highlights the importance of both digital and physical infrastructure in creating an inclusive learning environment; (3.2) Accessible Devices for Inclusive Teaching and Learning: This factor emphasizes the importance of providing accessible digital devices and assistive products for inclusive teaching in HEI; (3.3) Digital Accessibility Support for Inclusive Learning: This factor emphasizes the importance of HEI providing support for digital accessibility in order to facilitate inclusive learning; and (3.4) Inclusion and Equity in Digital Learning: This factor emphasizes the importance of HEI's efforts to identify and address the digital divide and challenges related to students' learning needs and socio-economic backgrounds in the context of digital learning.

Only one factor is identified for the fourth category, Continuous Professional Development: (4.1) Continuous Professional Development for Inclusive Digital Teaching. This factor emphasizes the importance of HEI leaders discussing and addressing continuing professional development needs for inclusive teaching with digital technologies. It also highlights the importance of providing staff with opportunities to participate in CPD and fostering the sharing of experiences within the school community.

Concerning the fifth category, Pedagogy: Supports and Resources, two factors are considered: (5.1) Inclusive Digital Teaching Practices: This factor emphasizes the importance of HEI teachers using virtual learning environments and digital technologies in an inclusive way, as well as being trained and instructed on how to address student diversity; and (5.2) Inclusive Digital Resources: This factor emphasizes the importance of HEI staff searching for inclusive digital educational resources, creating digital resources to support inclusive teaching, using inclusive open educational resources, and developing and updating resources that support inclusive learning and participation.

The sixth category, Pedagogy: Implementation in the classroom, involves three factors: (6.1) Personalized and Engaging Digital Learning: This factor emphasizes the importance of HEI staff using digital technologies to personalize and tailor their teaching to student's individual needs, incorporating digital learning activities that foster creativity, and setting inclusive digital learning activities that actively engage and motivate all students; (6.2) Inclusive Classroom Collaboration and Respectful Environment: This factor focuses on promoting inclusive collaboration and creating a respectful classroom environment using digital technologies; and (6.3) Enhanced Pedagogical Digital Inclusiveness: This factor emphasizes the focus on enhancing digital inclusiveness among pedagogical staff.

The seventh category, Assessment Practices/ Inclusion Assessment, embraces three factors: (7.1) Inclusive Digital Assessment Practices: This factor emphasizes the importance of HEI staff using inclusive and accessible digital technologies for assessing students' skills; (7.2) Digital Feedback and Self-Reflection: This factor emphasizes the importance of HEI staff using inclusive digital technologies to provide timely feedback to students, enable students to self-reflect on their own learning and facilitate peer feedback on other student's work, and (7.3) Data-Driven Improvement for Inclusive Digital Learning: This factor highlights the focus on leveraging digital data analysis and evaluation metrics to identify students' needs and improve their inclusive digital learning experience.

Finally, the last category, Student Digital Competence/ Student's Perspective, is considered with one factor: (8.1) Inclusive Digital Communication and Skills Development: This factor emphasizes the importance of HEI ensuring that students learn to communicate in an inclusive way using digital technologies and that they develop their digital skills and knowledge on inclusiveness across subjects. The factor reflects the focus on promoting inclusive communication practices and fostering the development of digital skills in relation to inclusivity.

3 The Micro-Learning Units Package

Based on the factors previously identified and described in Section 2, a newly package of micro-learning units was created. A micro-learning unit is a small, focused segment of educational content designed to teach a specific skill or concept in a brief period. These units are typically short, ranging from a few minutes to about 15 minutes, and are meant to be easily digestible and accessible. To organize the micro-learning units and to guarantee

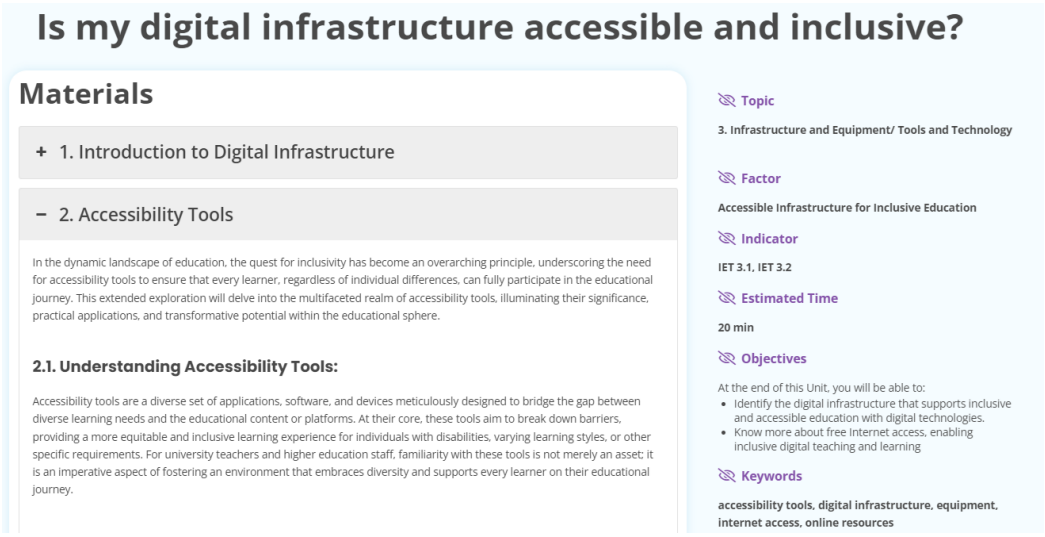

Figure 3: Example of a Micro-Learning Unit Content

their integrity, the units are correlated to the indicators associated with each factor, also allowing directing the reader with the help of a self-evaluation tool as described in Fig. 2. The figure presents a comprehensive framework for the micro-Learning Units Package aimed at improving inclusive digital education in Higher Education Institutions (HEIs). It is organized into several categories, each addressing specific factors contributing to digital inclusion. Each category is further divided into factors, indicators, and corresponding micro-learning units with specified durations.

The user is first invited to answer a questionnaire that relies on the indicators. From this point, a scoring system evaluates the user's perception of each factor, and globally, in its aptitude in relation to digital and inclusive education. Then, a decision-based model advises the user on which micro-learning units it should be involved in. The estimated time frame for each unit varies from 15 to 30 minutes, depending on how many indicators it covers, since some indicators are cross-correlated and are thus blended into one micro unit. A total of 32 micro-learning units constitute the overall package, totaling seven hours, although the purpose of the tool is for the user to only study the units related to the topics they least mastered. Besides, the tool can be used cyclically, meaning it can be used several times until the overall score obtained from the self-evaluation reaches a satisfactory value, allowing the user to manage the learning path. Both the self-evaluation tool and the micro-Learning unit contents are allocated online at www.set4inclusion.eu. Figure 3 exemplifies how the unit *"Is my digital infrastructure accessible and inclusive?"*, related to indicators *"IET 3.1: Digital infrastructure"*, and *"IET 3.2: Internet access"*, associated to the factor *"Accessible Infrastructure for Inclusive Learning"*, under the category *"Infrastructure and Equipment/Tools and Technology"* is presented to the user.

When considering the presented micro-Learning package, wider content is broken down into small, manageable pieces, making it easier for learners to consume and understand, where each unit targets a single, specific learning objective, ensuring that learners can quickly grasp the intended concept or skill. Designed to be accessed on-demand through the self-evaluation tool, it allows learners to engage with the material at their own pace and on their own schedule. Also, the concise and focused nature of micro-learning units can improve retention by minimizing cognitive overload and reinforcing key points through repetition and varied presentation. Although the micro-Learning units are integrated into a larger educational framework, they are also effective as standalone lessons.

4 Conclusion

Using a self-evaluation tool, a set of micro-learning units previously mapped using factors and indicators of inclusive digital education is made available to a user through a recommendation model.

The global set of micro-training units covers a broad set of skills, considered based on the factors that involve inclusive digital education. With this procedure, the personnel involved in higher education institutions, teachers or staff, acquire the necessary skills to provide truly inclusive digital education in their institution.

Acknowledgments

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Segmentation of students with special needs at UL

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ABSTRACT

This paper deals with the identification and interpretation of segments of students with disabilities at the University of Ljubljana. The data on which this segmentation is based are the students' responses to a dedicated questionnaire created through an operationalization process according to the selected aspects and objectives of the segmentation.

The segmentation aimed to identify homogeneous groups of students with disabilities in order to 1. improve the understanding of students' needs, 2. prepare reliable data for the selection of technological support for students and 3. create the basis for a subsequent project on ICT-based support for special needs students.

Through the operationalization process, we identified five areas (aspects), namely 1. Technology and overcoming study barriers, 2. Technology and study outcomes, 3. ICT and Study Obligations, 4. ICT and Study Skills, and 5. Opportunities to use ICT technology. Based on student responses, we identified segments for the first three areas, with all three areas well covered by three segments each. We identified three segments in each area: 1. Technology Enthusiasts (accept everything), 2. Skeptical Users (reject everything but the exceptions), and 3. Picky Users (accept almost everything but the exceptions). From the second and third segments, we extracted the main characteristics by technology and by activity. The results are applicable for the next steps in technology support for students with special needs.

KEYWORDS

user segmentation, special needs students, segmentation algorithm

1 INTRODUCTION

Effective technological support for students with special needs is crucial for modern teaching and learning at universities. Over the last decade, the landscape of teaching and learning has changed rapidly [17].On the other hand, the rapid development of information and communication technologies [6] and studies on technological support for students [4] has added a variety of new support options. There is no effective technological support without prior knowledge of the needs of the users - in our case, the specific needs of our students.

In this paper, we present the operationalization of the segmentation instrument (aspects and questions) and the results of the segmentation of students with disabilities at the University of Ljubljana (UL). The initial goal of segmentation is to plan and implement effective and needs-based support for students with disabilities at UL.

We have concluded that this study does not require ethical review. The study is fully consistent with the purpose of collecting data from students with disabilities and its results will be used for the direct benefit of the population.

1.1 Aims of the student segmentation

The main aim of the segmentation is to learn about the main groups of students with disabilities in relation to the opportunities for technological support for their studies provided by the university. The sub-objectives are:

(1) Identify the groups of students with disabilities at UL along with their basic characteristics.
(2) Identify meaningful groups of active students with disabilities.

To achieve the goal ad 1. we designed a questionnaire. The design of the questionnaire resulted in 12 questions, with 5 main sub-questions and a larger number of sub-questions.

To achieve objectives ad 2, we conducted an extensive data analysis (see Sec. 4) and consulted domain experts.

2 STATE OF THE ART

2.1 User segmentation

User segmentation is the process of dividing users into different groups or segments based on common characteristics. It was developed in the field of business and management. An organization can segment users by language preference, product version, geographic region or user personality [1]. A similar segmentation has been successfully applied to other areas, e.g. to the users of ICT and also to the area of ICT in special education [6].

Data mining techniques entered the field quite early on [21]. Machine learning-based techniques are the most important approach to user segmentation today [2].

Successful segmentation methods lead to homogeneous subgroups of users. A necessary next step is to understand these segments, i.e. to define and understand their typical representatives. Such a representative is called a persona, and to clearly understand the part of their behavior that is relevant to them, they are described as a living person [20]. A persona is therefore a fictional character whose characteristics and goals best fit the segment.

2.2 Operacionalisation

Operationalization is a process of 1. selecting relevant aspects of the designed instrument (set of questions) and 2. selecting an initial set of questions representing the selected aspects. There is a long history of research on this approach [16]. It is based

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on human expert judgment. The aim of operationalization is to construct a measurement instrument that is used in data collection [12]. The validity and reliability of the resulting instruments are of central importance and the research community has developed strict guidelines on how to achieve and ensure this [3]. In our case, we have focused on relevant aspects of technological support for students with special needs.

2.3 Unsupervised clustering for user segmentation

User segmentation is a subfield of the highly developed field of customer segmentation. Machine learning techniques found their way into customer segmentation decades ago [19]. From various data mining approaches [21], the focus shifted to neural networks [18] and deep learning [15].

Unsupervised clustering with visualization of the cluster hierarchy is a necessary step in customer segmentation [11]. In the case of this study, understanding the user segments obtained is very important. The technique of explainable customer segmentation is discussed in [14].

3 MATERIALS AND METHODS

3.1 Operacionalisation and existing instruments

The operationalization procedure of this research focused on the existing support for students with special needs at our and other universities. Theoretical knowledge and practical experiences in supporting students with special needs were also taken into account. This is crucial to achieve good validity and reliability of the resulting instrument in fewer iterations.

To incorporate existing measurement instruments related to the use and benefit of assistive technologies, we also examined available measurement instruments. As early as 1996, the authors of [7] developed a scale "Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST)". The instrument contains 18 items and two dimensions. The construct was later reviewed in [8], where 12 items were further selected.

A scale called the Psychosocial Impact of Assistive Devices Scale (PIADS) was developed by the authors of [13]. The PIADS is a 26-item self-report questionnaire to assess the impact of an assistive device on functional independence, well-being and quality of life. The construct is three-dimensional and includes 1. competence (measures feelings of competence and effectiveness), 2. adaptability (indicates willingness to try new things and take risks) and 3. self-esteem (indicates feelings of emotional health and happiness).

The authors Dijcks et. al developed a scale (one-dimensional construct) to assess the quality of service delivery in the provision of assistive technology (KWAZO) [9]. It aims to assess the quality of the provision of assistive devices from the customer's perspective. The instrument consists of seven questions relating to accessibility, knowledge, coordination, efficiency, flexibility and user influence. The reliability of the scale is rated as very good.

As a result of all considerations, we decided to include the following aspects:

(1) Technology and overcoming study barriers
(2) Technology and study outcomes
(3) ICT and Study Obligations
(4) ICT and Study Skills
(5) Opportunities to use ICT technology

To cover these five aspects, we also constructed, selected and modified questions that led to the final instrument (not listed here for space reasons).

3.2 Participants and data collection

The selected population is all UL students with disabilities. Given the estimated number of 700 to 800 such students, the entire population was included in the sample.

The data collection was carried out by the University of Ljubljana (UL) administration services. They provided us with a list of all students with special needs at ULat UL. We then manually screened this list with the baseline descriptions and selected 723 respondents.

The inclusion criteria for selection were self-selected categories of special needs selected by the students at the time of enrolment. They covered general special needs, and deficits from disabilities (hearing, vision, speech, physical, emotional, mental health). There were no exclusion criteria for selection into the sample.

3.3 Unsuprvised clustering for user segment determination

We applied the unsupervised clustering technique K-Means with dendrogram visualization [5]. The feature space was a space of participant responses, no dimensionality reduction or location-dependent transformation [10] or similar was used. The Euclidean distance is used for K-means clustering. Other distances lead to similar clusters. Since all responses were on the same Likert scale, no prior scaling was performed. We used elbow curves to determine the optimal number of segments and basic statistics to determine the most important characteristics of the selected segments. The initial number of clusters was set to $k = 12$.

4 EXPERIMENTAL RESULTS

4.1 Student data

The sampling method chosen was to send emails to the e-mail addresses provided by the students with disabilities at the time they obtained their special education student status. The inclusion and exclusion criteria were specified in subsection 3.2. The questionnaire was administered via the web-based system 1ka (https://www.1ka.si/d/sl) and the questionnaire with response categories is available on request. Invitees received an email with explanations and instructions.

The invitations were sent out in three phases

(1) First invitation: by e-mail from the university e-mail address;
(2) Second invitation: via the Disability representatives at the faculties and academies;
(3) Third invitation: via the Association of Students with Disabilities

The invitation was sent to 733 people. A total of 18 (3.4%) responses to the first invitation were received within one week, next 7 to the second invitation and next 18 to the third invitation, altogether 43 (5.9%). At the time of study design, we estimated that the response rate of respondents would be around 10%. We did not formally identify the reasons for this low response rate, but we did gather some opinions. These can be grouped as follows:

(1) There is enough freely available technology that I can use myself and I do not need any special support from the university;
(2) In the responders' mind, the university does not have enough technical support to help individuals;

We present the results of the segmentation according to the criteria specified in Subsec. 3.1 identified aspects.

4.2 Basic statistics

The breakdown of the 43 respondents by gender can be found in Fig. 1 (top left), where NA indicates those who did not wish to state their gender.

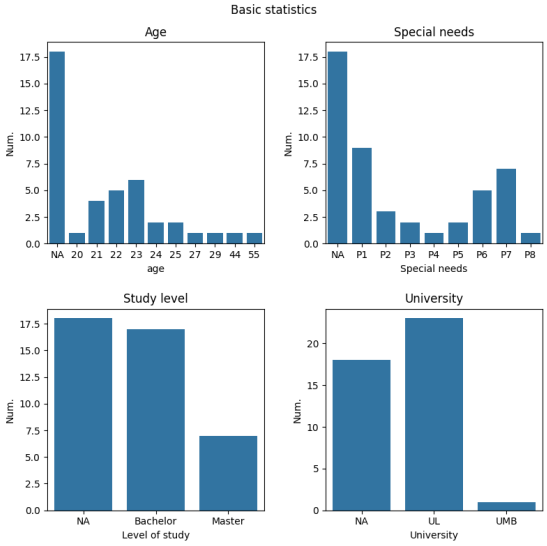

Figure 1: Response of participants: by gender (top left), age (second row left), special needs (second row right), study style (third row left) and university (third row right), where UL stands for the University of Ljubljana and UMB for the University of Maribor

The histogram by age is shown in Fig. 1 (center left), where NA denotes those who did not want to reveal their age. Respondents aged 44 and 55 were excluded from the analysis. The responses by special needs are shown in figure 1 (middle right), where the meanings of the special needs are as follows:

P1: 'Deficits in certain areas of learning (dyslexia, dysgraphia, dyscalculia ...)',
P2: 'Physical disability',
P3: 'Partial or total hearing loss',
P4: 'Partial or total loss of vision',
P5: 'Speech-language difficulties',
P6: 'Emotional and behavioral disorders',
P7: 'Long-term or chronic illness',
P8: 'Autism spectrum disorder',

In terms of university, one student was from the University of Maribor and 18 students did not specify their university. We assume that most of the students were from the University of Ljubljana.

As there are not enough complete responses for aspects Q4 and Q5 (less than 15) to draw more reliable conclusions, we only report the results for the first three aspects Q1: Technology and overcoming study barriers, Q2: Technology and study outcomes and Q3: ICT and Study Obligations.

The interpretation of the identified segments is based on manual inspection of identified clusters' specifics such as frequency of answers etc. Due to lack of space, we cannot reproduce these figures here.

4.3 Aspect Q1: Technology and overcoming study barriers

The main question was: "Please indicate how important each of the ICT assistive technologies listed is to you in overcoming the challenges you face in your studies due to your own specific needs."

Seg.	Q1a	Q1b	Q1c	Q1d	Q1e	Q1f
1	4.3	4.0	5.6	6.2	5.9	6.2
2	4.4	3.9	2.9	2.5	2.3	2.9
3	4.1	3.6	5.0	5.2	4.8	6.2
	Q1g	Q1h	Q1i	Q1j	Q1k	Q1l
1	5.9	4.1	6.1	5.5	4.9	6.0
2	2.2	3.5	4.0	3.6	3.2	3.4
3	5.3	3.6	3.5	3.8	3.9	5.3

Table 1: Aspect Q1: Averages of answers per segment.

According to the inertia curve and the dendrogram of the development of the segments, the number of identified segments can be set to 3 or 5. In line with the segment structure, we have opted for three segments.

The observed characteristics by segment are:

Seg. 1: The answers to all questions are the highest, i.e. all technologies are rated as very important. These are **technology enthusiasts**.
Seg. 2: Most questions are answered with low values. These are **technology sceptics**. Little importance is attached to most technologies, with the exception of e-materials, e-environments and multimedia content. This segment therefore scores well for e-materials, but not for content conversion tools, etc.
Seg. 3: Importance varies considerably on average. These are those who believe in and use some technologies but not others. They rate most technologies well, with the exception of visual and design customization tools.

4.4 Aspect Q2: Technology and study outcomes

The guiding question was: "Please indicate how important each of the ICT support services listed is to you in overcoming the challenges you face in your studies due to your own specific needs."

The number of segments was determined by combining the dendrogram and the "inertia" curve". We decided on 3 segments.

The observed characteristics by segment are:

Seg. 1: Technologies are of varying importance. These are **critical users**. They rate most technologies well, with the exception of audio-to-sketch, dictation, e-interpreting and audio-to-text tools.
seg. 2: They rate all technologies as very important. This is **technology Enthusiasts**, the first segment from a segmentation into two segments.

Seg.	Q2a	Q2b	Q2c	Q2d	Q2e	Q2f
1	3.4	3.0	3.4	2.6	3.1	4.3
2	4.4	6.0	4.9	6.2	6.3	5.8
3	1.5	1.5	1.0	1.0	1.0	1.0
	Q2g	Q2h	Q2i	Q2j	Q2k	
1	4.1	3.9	4.3	3.0	6.3	
2	5.0	5.0	5.3	5.7	6.2	
3	2.5	1.5	1.5	2.5	2.0	

Table 2: Aspect Q2: Averages of answers per segment.

Seg. 3: All technologies are classified as unimportant. These are **technology sceptics**. They classify most technologies as unimportant, with the exception of electronic communication and customized hardware.

4.5 Q3: ICT and Study Obligations

The guiding question was: "Please indicate to what extent you consider the use of ICT support important to fulfil the study requirements listed below."

Seg.	Q3a	Q3b	Q3c	Q3d	Q3e	Q3f	Q3g
1	4.2	3.6	2.4	2.2	4.4	2.2	5.4
2	4.2	4.5	5.0	4.9	5.0	4.9	5.9
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table 3: Aspect Q3: Averages of answers per segment.

The number of segments was determined by combining the dendrogram and the "inertia" curve". We estimate that a reasonable number of segments is again 3.

The observed characteristics by segment are:

Seg. 1: The technologies are characterized by different applicability. These are **Critical Users**, which are Segment 1 of a two-segment segmentation. All technologies are classified as useful, with the exception of ICT to support independent work, to support group work and to support examination requirements.

Seg. 2: In this segment, all technologies are rated as very useful. This is **Technology Enthusiasts**, which is virtually identical to segment 2 of the two-segment segmentation.

Seg. 3: Here, the majority of respondents consider the technologies to be of little use. These are technology . They describe all technologies as not very useful, with the exception of support for direct distance learning.

5 CONCLUSIONS AND DISCUSSIONS

The student response rate was relatively low (5.8%, total $N = 43$). For the first three aspects listed in subsection 3.1, we found meaningful segmentations (for the last two aspects, there was not enough data to create segments). We did not find any common segments between the aspects. Obtained segments were expected and it was confirmed a useful grouping of students is doable. Further investigation of the segments would require at least 10 new responses in the first three aspects. In the near future, we will study the usage patterns of these students based on carefully designed case studies.

ACKNOWLEDGMENTS

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Introducing a Solution:
The Self-Evaluation Tool in Practice*

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Abstract / Povzetek

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Digitalization of education in Higher Education Institutions can have many positive impacts on students and their learning success still, at the same time, it can also pose a significant barrier for some students, especially students with different disabilities or special needs. Digital inclusion is crucial in providing equitable and just access to educational materials for every student, irrespective of their origins, capacities, or impairments. The structured pedagogical content is supplied to the user through a recommendation model that constitutes an online Self-Evaluation Tool to determine the inclusiveness of their digital education. [1].

Keywords / Ključne besede

Digital Education ,Inclusiveness, equality, disabilities.

1 Introduction

In modern education, continuous improvement is key to both student and organizational success. One effective method to foster this growth is through self-evaluation. The Self-Evaluation Tool is a practical solution designed to empower institutions to assess digital inclusion, set goals, and track progress over time.

Based on that, the theoretical framework of inclusive digital education including all 3 elements, technology, pedagogy, content, and management aspects, considering different e-learning settings and modes is the base foundation to develop a Self-Evaluation Tool for HEI on inclusive digital education in HEI. [2].

Self-Evaluation Tool has to be used as a practical guide for the management to define the good and not-so-good things about digital education and communication about inclusion. On the other hand, a Self-Evaluation Tool for HEI teachers on inclusive digital teaching practice is used as a practical guide for the teachers to define the good and not-so-good things about their digital teaching practice concerning inclusion. (Bennett, 2021)

The article focuses on the introduction of the Self-evaluation Tool **developed under the Erasmus+ project "SET4Inclusion".** The SET4Inclusion project is a European collaborative initiative designed to tackle these challenges by developing and implementing a Self-evaluation Tool tailored for HEIs. [3].

1

Figure 1:The tool on the website set4inclusion.eu

Figure 2 :Self evaluation tool questions with multiple choice answers.

2 How does it works

The self-evaluation tool serves as a practical guide for the management and teachers to define the good and not-so-good things about their digital education and communication concerning inclusion.

Our Self-Evaluation Tool is a practical guide **for HEI management to help them assess the capabilities of the HEI regarding inclusive digital education.** It consists of many questions, representing influence factors, described through specific indicators. This self-evaluation tool is also a practical guide for HEI teachers to help them assess the capabilities of their teaching practice about inclusive digital education. It consists of many questions, representing influence factors, described through specific indicators.

Structured Reflection for users are prompted to review their access to the digital inclusion practices, focusing on relevant performance indicators:

Twelve questions regarding Leadership/ School's perspective. These questions are designed to evaluate the support provided to teachers in digital literacy for inclusive digital education. The responses and subsequent questions are categorized into different variables, which will be used to determine the final results of the report. The categories for responses are: Not applicable, Totally agree, Agree, Somewhat agree, Disagree, and Totally disagree.

The following section is Collaboration and Networking. It consists of eight questions that support the progress in inclusive teaching and learning with digital technologies.
The third section involved Infrastructure and Equipment. It is developed with twelve questions that cover the digital infrastructure that supports inclusive and accessible education with digital technologies.

Next, a section called Tools and Technology, and aims to investigate technology itself. Continuing Professional Development section contains five management-related questions that support us in acquiring the knowledge and pedagogical skills necessary for inclusive education.
From the Teacher's perspective, the Pedagogy, Supports, and Resources section contains 7 questions about how it is developed to provide inclusive digital resources to support their inclusive teaching.¡

Pedagogy, Implementation in the classroom, consists of seven questions that cover Digital technologies in the classroom to facilitate the organization of teaching groups in which students can collaborate by valuing the diversity of each one. The student's perspective covers thirteen questions that are related to the proper use of the technology as an inclusion tool.

Figure 3: Percentage of answers by categories.

Finally, the tool offers the results with a percentage of answers by categories. Once you have done the self evaluation, the E-platform where the tool is located, automatically creates a smart report for the users of Self-Evaluation Tools with links to recommended e-learning content according to the result of the self-evaluation. You can find the tool in multiple languages.

3 Conclusion

In conclusion,the Self-Evaluation Tool is a powerful solution for those seeking to improve their performance and grow in their careers. By providing a structured way to reflect, set goals, and track progress, this tool empowers individuals to take charge of their development and contributes to the overall success of the organization. The pilot study of the Self-Evaluation Tool developed under the SET4Inclusion project has yielded significant insights into the tool itself, and its effectiveness for the development of Digital Inclusion in HEIs.

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ANALYSIS OF THE SELF-EVALUATION TOOL: A PILOT STUDY*

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ABSTRACT

This article focuses on the analysis of the self-evaluation tool developed under the SET4Inclusion project, with a particular emphasis on its application within the context of a pilot study. Pilot studies are crucial for testing the validity and reliability of new tools or methods. The primary objective of this pilot study is to evaluate the effectiveness of the Self-Evaluation Tool (SET) developed within the SET4Inclusion project in facilitating e-inclusion processes in higher education institutions (HEIs). The pilot study began with the preparation of an invitation letter, which was sent to potential participants. The pilot study involved participants from higher education institutions in five different European countries: Turkey, Portugal, Slovenia, Italy, and Spain. The number of HEIs participating in the piloting was at least five, with at least fifty HEI teachers involved.

KEYWORDS

SET4Inclusion project, Self-Evaluation Tool, Micro Learing Units

1 INTRODUCTION

The rapidly evolving dynamics within higher education have made inclusivity and accessibility more significant than ever before. The increasing number of students with diverse learning needs, including those with disabilities, necessitates a comprehensive approach to ensure equitable access to education. The rise of digital tools and technologies offers novel opportunities to foster e-inclusivity, particularly within Higher Education Institutions (HEIs). This process not only contributes to enhancing student success rates but also plays a vital role in promoting fairness and justice in education. Inclusivity is closely linked to student satisfaction and academic achievement, making it a strategic priority for HEIs [2].

Modern higher education systems are increasingly focused on acknowledging student diversity and creating educational environments that effectively respond to this diversity.

The SET4Inclusion project is a European collaborative initiative designed to tackle these challenges by developing and implementing self-evaluation tools tailored for HEIs. These tools are intended to help institutions critically assess their current practices, identify gaps, and take concrete steps toward creating a more inclusive educational environment. By enabling institutions to analyze their performance, self-evaluation tools create an internal cycle of continuous improvement [1]. They provide not just a snapshot of the current state but also support the development of forward-looking improvement strategies. When viewed through the lens of inclusivity, such tools significantly enhance the capacity of learning environments to cater to the needs of all students, irrespective of their backgrounds or abilities.

This article focuses on the analysis of the self-evaluation tool developed under the SET4Inclusion project, with a particular emphasis on its application within the context of a pilot study. Pilot studies are crucial for testing the validity and reliability of new tools or methods. They serve as a foundational step before wider implementation and can provide valuable insights into the practical challenges and opportunities associated with new initiatives [3]. In this study, key elements such as the functionality of the self-evaluation tool and the developed micro-learning units in diverse contexts, areas requiring improvement, and user feedback will be thoroughly evaluated. The results of the pilot study have facilitated necessary adjustments to the tool and units before their broader application in various HEIs across Europe.

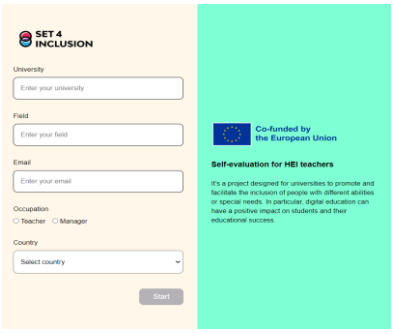

Figure 1: Home page of Self-Evaluation Tool

*Article Title Footnote needs to be captured as Title Note
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Figure 2: Home page of e- learning materials

2 METHODOLOGY

The primary objective of this pilot study is to evaluate the effectiveness of the Self-Evaluation Tool (SET) developed within the SET4Inclusion project in facilitating e-inclusion processes in higher education institutions (HEIs). The pilot study began with the preparation of an invitation letter, which was sent to potential participants. This letter provided detailed information about the project, the scope of the pilot study, and the tools that participants would be evaluating. Links to the tools and a survey were included in the invitation, allowing participants to engage directly with the materials.

The tools developed for the project, including the Self-Evaluation Tool and the associated micro-learning units, were distributed to participants via email. Participants were given a two-week period to complete their evaluations. At the end of this period, they were asked to complete a survey that provided feedback on their experiences with the micro-learning units and the self-evaluation process.

2.1 Participants

The pilot study involved participants from higher education institutions in five different European countries: Turkey, Portugal, Slovenia, Italy, and Spain. The number of HEIs participating in the piloting was at least five, with at least fifty HEI teachers involved. Participants were selected based on voluntary participation, and efforts were made to ensure diversity by including individuals from various departments and academic levels. This approach aimed to gather a wide range of perspectives and insights, thereby enriching the study's findings.

Table 1: Number of participants

No	Participants	f(x)
1	HEI participating	5
2	HEI teachers	50

2.2 Instruments

The key instruments used in this research were the Self-Evaluation Tool and the Micro Learning Units developed within the SET4Inclusion project. The Self-Evaluation Tool was designed to assist HEIs in assessing their e-inclusion processes, identifying areas for improvement, and implementing strategies to enhance inclusivity. The Micro Learning Units complemented the tool by providing focused, easily accessible learning content that could be used to support inclusive practices within the institutions. Participants used these tools to evaluate and reflect on the e-inclusion processes in their respective institutions.

2.3 Data Collection

The key instruments used in this research were the Self-Evaluation Tool and the Micro Learning Units developed within the SET4Inclusion project. The Self-Evaluation Tool was designed to assist HEIs in assessing their e-inclusion processes, identifying areas for improvement, and implementing strategies to enhance inclusivity. The Micro Learning Units complemented the tool by providing focused, easily accessible learning content that could be used to support inclusive practices within the institutions. Participants used these tools to evaluate and reflect on the e-inclusion processes in their respective institutions.

2.4 Data Analysis

The data collected from the surveys were systematically analyzed using graphical representation methods to visualize the feedback and results. These graphs provided clear insights into the effectiveness of the Self-Evaluation Tool and the micro-learning units. The feedback from participants was thoroughly reviewed, with particular attention paid to their suggestions for improvements and their overall experience with the tool. The analysis revealed several key areas where the tool could be refined and optimized to better meet the needs of HEIs and their diverse student populations.

The pilot study's findings provided valuable information that will inform the further development and dissemination of the Self-Evaluation Tool. The insights gained from this study will help ensure that the tool is effective, user-friendly, and capable of supporting HEIs in their efforts to create more inclusive learning environments. As the tool is refined and prepared for broader application, these findings will serve as a crucial foundation for its successful implementation.

In conclusion, the pilot study of the Self-Evaluation Tool developed under the SET4Inclusion project has yielded significant insights into the tool's effectiveness and the user experiences associated with it. The feedback gathered from participants has highlighted both the strengths and areas for improvement, which will be addressed in the subsequent development phases. By incorporating these insights, the tool will be better equipped to support HEIs in fostering inclusivity and accessibility in their educational offerings. The study also underscores the importance of pilot testing in the development of educational tools, as it provides a critical opportunity to refine and enhance the tools before they are implemented on a larger scale.

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Definition of a Framework for Self-Evaluation Tool: Optimizing Evaluation Practices for Enhanced Performance in HEI

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Abstract

This paper proposes a framework for a self-evaluation tool to support the evaluation of inclusive digital education in Higher Education Institutions (HEIs). The idea was motivated by the COVID-19 pandemic, which emphasised inequalities in digital learning, particularly for students with Special Educational Needs and Disabilities (SEND). The enhanced digitalisation of education showed that many students and professionals struggled to engage with online content due to rigid teaching methods and inaccessible resources. By focusing on inclusivity, the proposed framework aims to address these challenges by tackling digital technologies to create adaptive, equitable learning environments for diverse student needs. The framework will support HEIs in evaluating and enhancing their digital education practices, ensuring all students can fully participate and succeed in education.

Keywords

Inclusive Digital Education, Self-Evaluation Tool, Higher Education Institutions, Special Educational Needs and Disabilities

1. Introduction

In the rapidly evolving higher education, integrating Information and Communication Technology (ICT) has become essential for enhancing teaching and learning processes. However, ensuring that digital education is inclusive—particularly for SEND students—remains a significant challenge [4]. This paper addresses the challenges exposed by the COVID-19 pandemic, particularly the accelerated digitalization of teaching and learning in higher education, which has disproportionately disadvantaged SEND students. Recognizing that several students struggle with online education, it is fundamental to promote inclusiveness as a key solution. HEIs aim to create an inclusive digital environment that supports students from the earliest stages of education (from primary school to higher education), helping them reach their full potential. We believe this endeavor would be supported by a self-evaluation tool, providing specific feedback to HEIs and helping increase inclusive digital education capabilities in formal and non-formal settings [1].

Within the scope of Erasmus+ SET4Inclusion project (2023-1-SI01-KA220-HED-000160853) the partners developed a theoretical framework for inclusive digital education to address the HEIs challenges and prepare for a self-evaluation tool. This framework was built upon the well-established TPACK model (Technological Pedagogical Content Knowledge), which guides the integration of ICT in education. TPACK outlines the essential knowledge areas for effectively integrating technology into teaching, such as technological knowledge (focusing on accessibility), pedagogical knowledge (emphasizing Universal Design for Learning - UDL), and content knowledge (innovative applications of new technologies to overcome barriers for SEND students). The TPACK framework also incorporates the latest standards, such as the Web Content Accessibility Guidelines (WCAG 2.2), and insights from contemporary research. Additionally, we aimed to include the SELFIE tool for self-reflection on schools' digital capabilities [2], an evaluation survey promoted by the European Commission, by integrating a stronger focus on inclusivity. Our framework and developed self-evaluation tool aim to identify and describe the key factors and indicators that define inclusive digital education, providing HEIs with an inclusive tool to evaluate and enhance their digital education practices. The development of the framework involved several key tasks:

- A literature review, which included 131 papers and explored existing research, best practices, and the challenges of implementing inclusive digital education (due to the length it is not included in this

*Article Title Footnote needs to be captured as Title Note
†Author Footnote to be captured as Author Note

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paper, however, it is available as one of the deliverables of SET4Inclusion project.
- Development of two surveys — one targeting HEI staff and another focused on SEND students— to gather insights on their experiences and needs. The surveys were performed with the help of Google Forms and the reports will be available as one of the deliverables of the SET4Inclusion project.
- The co-development workshops involving collaboration with HEIs partners, researchers, and experts. The report is available as one of the deliverables of the SET4Inclusion project.

The results from the listed activities present a foundation for the final framework that will enable HEIs to create and maintain inclusive digital learning environments, ensuring access to education for all students. It is also the foundation for developing self-evaluation tools and other project results, providing a structured basis for institutions to assess and enhance their practices. The main results, for which described framework is necessary, are the following:
- Two Self-evaluation tools for HE institutions and HE teachers to determine the inclusiveness of their digital education,
- A set of micro-learning units on Inclusive digital education for HE leaders and HE teachers,
- Collection of several good practices on Inclusive digital education,
- E-learning platform as a central knowledge point for Inclusive digital education.

2. Definition of the framework

To make digital education and communication in HEIs more accessible and inclusive for all other students, a theoretical framework of inclusive digital education was defined, considering different possible e-learning settings and modes (ICT-supported classroom learning, distance e-learning, hybrid, blended learning, self-paced, guided etc.). A theoretical framework for inclusive digital education was created based on a literature review, survey and workshops, presented in the following sections.

2.1. The literature review

First, a literature review was conducted to (1) identify good practices for inclusive digital education, (2) identify the challenges of inclusive digital education, and (3) identify the factors that affect inclusive digital education. The aim was to identify the relevant literature in journal papers, articles published in conferences, reports, and other relevant sources. The search was conducted in different databases and search engines, such as Scientific databases: WoS, ScienceDirect, IEEExplore, ACM, Google Scholar, Search engines: Google. The included literature was in English, dated from 2017 or newer. One hundred thirty-one literature units were identified and recorded. Based on the results from the literature review, factors that impact inclusive digital education were defined and later validated with the help of a survey.

The literature review provided an idea of levels of inclusiveness within digital education, which are divided into eight categories, further defined by factors and evaluated with indicators on a Likert scale from strongly agree to strongly disagree, presented in the following paragraphs [3]. The categories are the following: (1) Leadership/ School's perspective, (2) Collaboration and Networking, (3) Infrastructure and Equipment/ Tools and Technology, (4) Continuous Professional Development, (5) Pedagogy: Supports and Resources, (6) Pedagogy: Implementation in the classroom, (7) Assessment Practices/ Inclusion Assessment and (8) Student Digital Competence/ Student's Perspective.

Category Leadership/ School's perspective includes the following factors:
- (1.1.) Inclusive digital strategy education strategy
- (1.2.) Collaborative digital strategy development
- (1.3.) Contemporary pedagogical approaches
- (1.4.) Scheduled time to explore digital teaching
- (1.5.) Efforts to minimize discrimination,
- (1.6.) Collaboration and communication encouragement between school and teacher,
- (1.7.) Inclusion policies,
- (1.8.) Digital literacy.

The examples of indicators for each factor are transformed into statements in the self-evaluation tool, connected to the leadership/school's perspective, and are shown in Figure 1. For example, "Inclusive digital strategy would" is evaluated based on an indicator: "At our HEI we have an inclusive digital education strategy". The same principle is applied to all other factors in other categories.

Figure 1: Category Leadership/ School's perspective

Category Collaboration and Networking includes the following factors:

- (2.1.) Progress review,
- (2.2.) Discussion on the use of technology,
- (2.3.) Collaboration of HEI, local communities, caregivers and parents,
- (2.4.) Synergies for Blended Learning,
- (2.5.) Staff, governors, students and parents/careers share a philosophy of inclusion,
- (2.6.) Teachers plan, teach and review in partnership and
- (2.7.) Encouraged collaboration and communication between students and teachers.

Category Infrastructure and Equipment/ Tools and Technology includes the following factors:

- (3.1.) Accessible infrastructure and tools,
- (3.2.) Digital devices and assistive products for teaching,
- (3.3.) Internet Access,
- (3.4.) Technical Support,
- (3.5.) Available digital devices and assistive products for learning,
- (3.6.) Devices and assistive products for students,
- (3.7.) Measures to identify the digital divide,
- (3.8.) Support to address the digital divide,
- (3.9.) Bring your device and assistive products,
- (3.10.) Reduced physical barriers,
- (3.11.) Assistive products,
- (3.12.) Online libraries,
- (3.13) Fairly distributed resources.

Category Continuous Professional Development includes the following factors:

- (4.1.) Discussion of CPD needs,
- (4.2.) Participation in CPD activities,
- (4.3) Face-to-face or online sharing experiences between staff.

Category Pedagogy: Supports and Resources includes the following factors:

- (5.1.) Online educational resources,
- (5.2.) Creating digital resources,
- (5.3.) Using virtual learning environments,
- (5.4.) Communicating with the school community,
- (5.5.) Open educational resources,
- (5.6.) Staff development activities help staff to respond to student diversity,
- (5.7.) Student difference is used as a resource for teaching and learning and
- (5.8.) Staff develop resources to support learning and participation.

Category Pedagogy: Implementation in the classroom includes the following factors:

- (6.1.) Personalization according to students' needs,
- (6.2.) Fostering students' creativity,
- (6.3.) Engaging and motivating students,
- (6.4.) Student collaboration,
- (6.5.) Everyone is made to feel welcome and treated with respect,
- (6.6.) The partnership between staff and parents/careers,
- (6.7.) Students are equally valued,
- (6.8.) Staff and students treat one another as human beings, and discipline is based on mutual respect,
- (6.9.) The school arranges teaching groups so that all students are valued, and differences are understood,
- (6.10.) Training and education on inclusiveness.

Category Assessment Practices/ Inclusion Assessment includes the following factors:

- (7.1.) Assessing skills,
- (7.2.) Digital assessment,
- (7.3.) Timely feedback,
- (7.4.) Self-reflection on learning,
- (7.5.) Feedback to other students,
- (7.6.) Using data to improve learning,
- (7.7.) Evaluation metrics.

Category Student Digital Competence/ Student's Perspective includes the following factors:

- (8.1.) Learning to communicate and
- (8.2.) Digital skills across subjects.

2.2. The survey

Two surveys were conducted. The first survey was conducted to acquire empirical evidence about teachers' perceptions of inclusive digital education in their classrooms. The survey was constructed based on the existing literature, where we identified the most significant factors that can affect inclusive digital education (such as Inclusive Digital Strategy and Policy for Empowering Inclusive Digital Education, Inclusive Digital Pedagogy & Supportive Culture and similar). Over 100 survey responses positively rated the proposed framework, with moderate variability. The responses suggest that while many respondents rated the indicators highly, there were diverse opinions among the participants, particularly in areas such as Infrastructure and Technology (IET) and Pedagogy: Implementation in the Classroom (PIC), where variability was slightly higher. These findings highlight areas of strength as perceived by respondents and potential areas for further improvement and targeted interventions. The positive feedback on professional development, collaboration, and digital competence underscores the importance of continuing, supporting and enhancing these aspects within educational institutions. The second survey was conducted to acquire empirical evidence about students' perceptions of inclusive digital education.

Overall, the survey results highlight strong satisfaction with various dimensions of educational practice, particularly in leadership, collaboration, infrastructure, pedagogy, assessment practices, and digital competence. The consistently high median scores and excellent internal consistency across indicators suggest that respondents

perceive these areas positively, reflecting well-implemented practices and supportive educational environments.

2.3. The co-creation workshops

The framework co-creation workshops were designed to refine and validate the framework for inclusive digital education, focusing on finalizing the key factors and indicators. During the ten conducted workshops in various European countries, participants engaged in collaborative discussions to shape the framework's layout, ensuring it accurately reflects the needs and challenges of inclusive digital education. The workshop's outcomes included the creation of validated self-evaluation questionnaires and refining indicators that would later be used for the development of the SET and micro-learning units. These online workshops played a critical role in fine-tuning the variables and indicators that form the foundation of the self-evaluation tool, ensuring they are both relevant and effective for HEIs.

3. Self-evaluation tool based on the framework

A self-evaluation tool [5] was created based on the developed framework, which encompasses key factors and indicators of inclusive digital education. This tool is designed to serve as a practical guide for management and educators within HEIs, enabling them to assess and identify strengths and areas for improvement in their digital education and communication practices related to inclusion. In addition to its evaluative function, integrated with an E-platform, the self-evaluation tool aims to raise awareness about the importance of inclusive digital education among stakeholders. The implementation of these practical tools, along with the provision of free learning opportunities through the E-platform, is expected to contribute significantly to fostering more inclusive digital education environments within HEIs.

The results of the self-evaluation tool are presented in (Figure 2). For each category, suggestions on how to improve inclusion in HEI are provided, which are connected to micro-learning units, one of the additional outputs of the project.

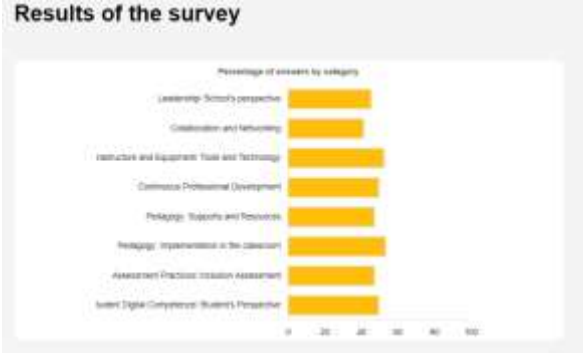

Figure 2. Final results of the self-evaluation tool, based on the framework

4. Conclusion

This paper has established a comprehensive framework for a self-evaluation tool to optimize evaluation practices within HEIs, mainly promoting inclusive digital education. The framework is designed to address the disparities that became evident during the rapid digitalization of education, especially those affecting students with Special Educational Needs and Disabilities. By equipping HEIs with this evaluative tool, the framework seeks to create more equitable and adaptive learning environments that can better accommodate the diverse needs of all students.

The future stages of this work will involve the systematic collection and classification of at least 15 exemplary practices from five partner countries of the project in the domain of inclusive digital education. These practices will be categorized according to the framework's components—self-evaluation tools and e-learning materials—and will be methodically documented using textual and multimedia formats. This iterative process will refine the framework and extend its relevance and effectiveness across various educational settings. Applying this framework is expected to lead to improved learning outcomes, promoting greater inclusivity and equity in higher education.

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Good practices in creating an inclusive environment in Education Institution

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Abstract / Povzetek

The shift toward digital education has created opportunities and challenges in ensuring inclusion for all students, especially for those with disabilities or special needs. To promote inclusivity in digital education within higher education institutions (HEIs), the ERASMUS+ project SET4Inclusion initiated a Call for Good Practices, inviting educators and institutions to share effective practices across various areas, such as leadership, infrastructure, and pedagogy. Out of 15 collected and evaluated good practices, five exemplary practices were selected for their impact on fostering inclusive learning environments. This paper presents these five practices, offering insights and recommendations for HEIs to enhance digital inclusivity in their educational offerings.

Keywords / Ključne besede

Inclusion, digital education, inclusive pedagogy

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1 Introduction

The digitization of education offers transformative potential to enhance student learning outcomes by providing flexible, personalized learning opportunities. However, it also presents significant challenges, particularly for students with disabilities or special needs who may face barriers if their diverse learning requirements are not adequately addressed. As higher education institutions (HEIs) cater to an increasingly diverse student population, ensuring that digital education is inclusive and accessible to all students has become a critical priority.

To address this need, the ERASMUS+ project SET4Inclusion was established to enhance inclusive digital education in higher education. The project aims to foster environments where all learners feel valued, regardless of their abilities or needs. An important initiative of the project was the Call for Good Practices, which invited educators and educational institutions to share examples of their inclusive digital practices. The call focused on various areas, such as leadership, collaboration, infrastructure, professional development, pedagogy, and assessment, encouraging contributors to highlight how they prioritize inclusion and adapt to diverse student needs.

2 Good Practices

To collect good practices on inclusive digital education, several methodological steps were employed. A call for good practices was developed and widely disseminated by all project partners, who translated and promoted the call to maximize reach across different regions.

A standardized template was developed to guide submissions, ensuring consistency in how good practices were described, including details such as context, methodologies and lessons learned. A total of 15 submissions were received from four countries, providing a diverse array of practices related to inclusive digital education.

An online workshop was conducted with all project partners to present and discuss each submitted practice. This collaborative workshop served as a preliminary evaluation forum where participants could provide feedback and highlight key aspects of each practice.

Following the workshop, a detailed survey was created based on the project's established factors and indicators for inclusive digital education. This survey facilitated a systematic evaluation by all partners.

The received practices were also categorized according to the SET4Inclusion Digital Education Framework, aligning them with specific inclusion areas such as leadership, collaboration, technology, professional development, pedagogy, assessment, and student competence. Table 1 summarizes the distribution of practices across these categories.

The data in the table indicate a broad distribution of practices across various inclusion areas, with a notable emphasis on pedagogical supports and resources, infrastructure and technology, and student digital competence. This distribution suggests a balanced approach to inclusive digital education, addressing both the technical and pedagogical aspects needed to create equitable learning environments.

Table 1: Covered inclusion areas by received practices

Inclusion areas	No. of practices
Leadership/School's perspective	60,0%
Collaboration and Networking	33,3%
Infrastructure and Equipment/Tools and Technology	66,7%
Continuous Professional Development	60,0%
Pedagogy: Supports and Resources	86,7%
Pedagogy: Implementation in the classroom	53,3%
Assessment Practices/Inclusion Assessment	26,7%
Student Digital Competence/Student's Perspective	66,7%
Other areas	6,7%

This approach ensured a robust and systematic process for identifying, evaluating, and categorizing good practices in inclusive digital education, promoting the exchange of effective strategies across diverse educational contexts.

This paper presents the best five practices identified through this evaluation process, offering insights and practical guidance for other institutions seeking to enhance their inclusive digital education initiatives. Brief overview of these exemplary practices illustrates their potential to enhance an inclusive educational environment in higher education.

2.1 "Inclusive Glossary of Mathematical Terms: A Hybrid Pedagogical Tool for the Inclusive Education of Deaf and Hearing Children" by José Carlos Neves, and Carla Sousa (Portugal)

The Inclusive Glossary of Mathematical Terms (GIM) is an educational tool to support deaf children, particularly those using Portuguese Sign Language (LGP). GIM combines physical cards and digital videos to create a memory game that enhances mathematical learning through interactive play. It fosters inclusivity by allowing both deaf and hearing children to learn together. It is accessible online and includes an adaptation of Brazilian Sign Language (LIBRAS).

GIM is designed for primary and preschool teachers and is user-friendly, requiring no advanced technical skills. Developed through collaboration among experts in education, design, animation, and deaf culture, it ensures the content is relevant and accessible. Teachers specializing in deaf and hard-of-hearing (DHH) students contributed to the development and testing, involving 120 children across three schools. The game has shown positive impacts on student engagement and learning outcomes.

The game integrates physical cards with animated videos to illustrate mathematical concepts. These cards can be used with a mobile app that displays corresponding videos in LGP or LIBRAS, making it adaptable to different classroom settings. The game's components can be produced at low cost through laser cutting or 3D printing or printed on paper for traditional use.

Research supports GIM's effectiveness in teaching mathematics and sign language to young children, particularly DHH students. However, further studies are needed to explore its application in various educational contexts and assess its long-term impact on learning.

2.2 "The Inclusive working group at Faculty of Business UHU" by Alfonso Infante Moro (Spain)

Accessibility for individuals with specific needs in digital education is a fundamental obligation for universities. Alfonso Infante Moro, who leads the "special needs technical unit" at the University of Huelva's Faculty of Business and Tourism, has been instrumental in promoting this principle. Since its presentation at the 2021 International Congress of University and Disability, the model continues to play a crucial role in ensuring inclusive education at the university level. Under Infante's leadership, the faculty advocates for all students' right to access higher education and emphasizes the necessity of digital accessibility provisions.

Spanish regulations, such as the Ley General de Derechos de las Personas con Discapacidad (General Law on the Rights of Persons with Disabilities, 2013) and the Plan de Acción para las Personas con Discapacidad (Action Plan for Persons with Disabilities, 2014-2020), highlight the importance of inclusivity

in higher education. However, the digital aspects of accessibility still require significant attention to ensure that all students can fully participate. The University of Huelva's Faculty of Business has addressed these needs by organizing educational technology conferences focusing on inclusion and diversity. A dedicated working group led by Alfonso Infante promotes inclusive practices and classroom accessibility, supporting students across various degree levels through tailored adaptations and collaboration with clinical health specialists.

Innovative digital tools, such as synchronous subtitles, have been implemented to support students with hearing impairments, benefiting a broader student population. Approximately 0.3% of the faculty's students require specific educational support, and efforts continue to enhance their digital learning experiences. Beyond the University of Huelva, Infante advocates for a standardized system of inclusive practices across European universities. His work contributes to developing a Standards Guide for the Inclusion of University Students with Disabilities, aimed at improving access and support for students in the digital era.

2.3 "EcoDigi: A Practice for Sustainable Digital Transformation in Adult Education" by Silvia Doratiotto (Italy)

EcoDigi is an initiative to promote digital transformation in adult education while prioritizing environmental sustainability and inclusivity. The project supports the development of digital readiness in an eco-friendly and accessible way, addressing the needs of adult learners, including those with disabilities or special needs. EcoDigi emerged in response to the growing reliance on digital platforms during the COVID-19 pandemic, recognizing both the opportunities for inclusion and the need to minimize environmental impact. The project helps educators and institutions adopt more sustainable and inclusive practices by providing self-assessment tools, teaching materials, and guides.

The initiative targets a broad audience, including adult learners, educators, specialists, and NGOs involved in education and sustainability. Through specialized training, EcoDigi will create a pool of skilled trainers across partner countries, strengthening the capacity of adult education providers to act as leaders in their communities. The project will produce several vital resources, including a self-assessment tool, a report on best practices, an online platform, and guidelines for creating green and accessible education.

EcoDigi also plans to host webinars and organize an international conference to promote the exchange of good practices across partner countries. The initiative aims to ensure that digital transformation in adult education is sustainable and inclusive, contributing to a greener and more equitable digital society in Europe.

2.4 "Innovative XR Technologies Research and Development Center (YETAM-XR)" by Irfan Simsek (Turkey)

The Innovative XR Technologies Research and Development Center (Yetam XR) at Istanbul University-Cerrahpaşa, led by Associate Professor Irfan Simsek, focuses on advancing virtual reality (VR) and augmented reality (AR) technologies in education and industry. Supported by the Istanbul Development Agency, Yetam XR develops 3D virtual technologies tailored for academic and industrial applications. The centre offers educational programs in 3D modelling, visual design, animation, and Unity programming, ranging from beginner to advanced levels, equipping participants with theoretical and practical skills for the professional use of VR and AR technologies.

Yetam XR integrates advanced technologies into educational environments, transforming traditional learning with immersive and interactive content. The centre prioritizes inclusivity, ensuring its educational tools are accessible and adaptable to diverse learning needs. Equipped with state-of-the-art VR headsets and 3D modelling tools, Yetam XR provides a high-quality digital learning experience.

The centre's projects include the Virtual Factory Simulation, hands-on experience with virtual industrial machines, and the Basic First Aid VR Project, which trains students in emergency response. Additionally, the Occupational Health and Safety Project educates workers and students on safety through VR simulations of hazardous situations, providing valuable real-world experience in a safe environment.

While Yetam XR has successfully enhanced education with immersive technologies, challenges remain, such as limited access to VR equipment for some students. There is also a need to develop more inclusive content for students with disabilities. Future plans include expanding educational content, increasing collaborations with schools and industry partners, and refining programs to meet evolving needs based on feedback from educators and students.

2.5 "INTUX - Introducing training on user Testing with people with disabilities into UX design and related higher education program" by Boštjan Šumak, Maja Pušnik and Katja Kous (Slovenia)

The INTUX project, "Introducing training on user Testing with people with disabilities into UX design and related higher education programs", focuses on making UX design education more inclusive by integrating accessibility into user testing. The project addresses a gap in UX design practices, where people with disabilities are often excluded from testing, leading to products that do not fully meet their needs.

A vital outcome of the project is a specialized training course for UX design students, teaching them how to conduct user testing with people with disabilities. This course is supported by a handbook for university staff, guiding the creation of more inclusive teaching environments. This ensures that students are prepared to design accessible products and meet the challenges they will face as professionals.

The project also develops a framework to integrate these training modules into UX design programs, embedding accessibility into the curriculum. Additionally, it empowers people with disabilities by educating them about their rights in user testing and encouraging their active participation in the design process.

For higher education institutions, INTUX enriches educational programs by incorporating inclusive practices. By adopting the training modules and recommendations, institutions ensure that their students graduate with the skills to design

accessible products and services, aligning with growing societal and professional expectations for inclusion and accessibility.

3 Conclusion

The ERASMUS+ project SET4Inclusion has emphasized the critical importance of fostering inclusive digital education environments within higher education institutions. By systematically collecting and evaluating a diverse range of good practices, the project has illuminated various strategies and tools that can effectively address the needs of all learners, particularly those with disabilities or special needs. The five exemplary good practices presented in this paper highlight innovative approaches to creating accessible learning environments, from hybrid pedagogical tools that integrate digital and physical elements to enhance mathematical understanding, to comprehensive frameworks that address multiple dimensions of inclusivity such as leadership, pedagogy, and technology infrastructure.

These findings suggest that successful inclusive digital education requires a holistic approach that combines technological solutions with pedagogical innovation and collaboration among educators. As digital education continues to evolve, the insights and recommendations drawn from these good practices provide a valuable roadmap for higher education institutions aiming to enhance their inclusivity efforts. Future research should continue to explore the scalability and adaptability of these practices across different educational contexts, ensuring that all students, regardless of their backgrounds or abilities, have equitable access to high-quality digital education.

Note that there is a section break at the end of references to balance the columns (and this text is a part of the new section). If you have no space left at the end of your paper, you can delete it.

Acknowledgments / Zahvala

This paper was prepared based on the results of the ERASMUS+ SET4Inclusion project: Self-Evaluation Tools for e-Inclusion in Higher Education Institutions. Therefore, we would like to express our sincere gratitude to all the authors who contributed their valuable practices in response to our call and to everyone involved in the successful development of the project.

Technological Speech Adaptation for Professional Work as a Lawyer and Law Professor: A Case of a Patient with Multiple Sclerosis

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Abstract

This paper presents a case study of a female patient with multiple sclerosis (MS) who has successfully adapted to the challenges of her condition through the use of advanced assistive technologies. Focusing on the use of speech-generating devices and predictive text software, this study highlights the practical applications of these tools in supporting her career as a lawyer and lecturer. The findings underline the critical role of technology in maintaining professional roles and the patient's resilience in overcoming significant physical disabilities.

Keywords

Speech-generating device, AAC technology, communication methods, SwiftKey, mobility, voice

1 Introduction

Multiple sclerosis (MS) is a chronic, progressive neurological condition that affects the central nervous system, leading to a wide range of physical and cognitive impairments. Among these, communication difficulties are common, particularly in cases where the disease progression results in the need for a tracheostomy, as it impairs the patient's ability to speak [1]. This paper presents a case study of a female patient with MS who, despite facing severe communication barriers due to a tracheostomy and loss of speech, has successfully adapted to the challenges of her condition through the use of advanced assistive technologies.

The central focus of this study is on speech-generating devices and predictive text software, specifically the Tobii Dynavox i-16 and Microsoft SwiftKey, and their role in enabling the patient to maintain her dual professional roles as a lawyer and a lecturer. These technologies, part of the broader category of Augmentative and Alternative Communication (AAC) systems, have been demonstrated to significantly improve communication capabilities for individuals with severe speech impairments [2].

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The aim of this research is to evaluate the effectiveness of these tools in supporting her professional activities and to explore the strategies she employed to overcome the physical limitations imposed by MS. By examining her journey, the study underscores the importance of resilience, adaptability, and the integration of technology in enabling individuals with disabilities to remain active in high-demand professions.

The paper is organized as follows: Section 2 describes the methods used, including the case study approach and data collection techniques. Section 3 presents the results of the study, with discussions on communication methods, technological advancements, and adaptive strategies. The conclusion offers insights into the potential for future technological developments to further enhance the quality of life for individuals with severe disabilities.

2 Empirical Research Procedure

2.1 Problem Definition and Purpose

The primary problem addressed in this empirical research is understanding how a patient with a 12-year diagnosis of multiple sclerosis (MS), who has a tracheostomy and is unable to speak, has adapted to her professional roles as a lawyer and lecturer. The study also seeks to evaluate the role that assistive technologies play in enabling her to maintain her professional activities despite severe physical limitations. The purpose of this research is to explore both the emotional and practical aspects of her adaptation process, providing insights into the benefits and limitations of technological interventions in helping her continue to work in high-demand professional environments.

2.2 Objective of the Empirical Research

The objective of this empirical research is to identify the key strategies and tools that allow a person with severe MS to adapt to and continue working in professional settings. The study focuses on understanding how the patient copes with the limitations imposed by her condition and examines the impact of assistive technologies on her ability to perform her professional tasks. Specifically, the research aims to:

- Investigate how the participant has adapted emotionally and practically to her condition, focusing on her mindset, routines, and coping mechanisms.
- Identify the technological interventions that facilitate her ability to work as a lawyer and lecturer, with a particular focus

on the use of assistive devices like speech-generating tools and predictive text software.

• Analyse the practical implementations and challenges of using assistive technologies in real-world professional settings such as courtrooms and lecture halls.

2.3 Methodology

This research employs a qualitative case study methodology, chosen for its suitability in exploring complex real-life phenomena, particularly when the boundaries between the phenomenon and its context are not clearly evident [3]. The case study focuses on a single participant-a female patient with a 12-year diagnosis of MS, who has a tracheostomy and is unable to speak-allowing for an in-depth analysis of her experiences, adaptations, and the role of assistive technologies in her professional life.

2.3.1 Procedure

The study involved data collection through in-depth interviews with the participant and systematic observations of her professional activities, including lectures and court sessions. These methods provided firsthand insights into how assistive technologies are applied in her day-to-day life, allowing for a detailed exploration of their practical uses and effectiveness [4].

2.3.2 Measuring Instruments

The effectiveness of various assistive technologies was assessed using several tools, chosen based on their role in aiding communication and mobility. Key instruments included:

• Speech-Generating Device (Tobii Dynavox i-16): Used to convert text to speech, this device was analysed for its usability, customization options, and reliability in different professional environments [5].

• Predictive Text Software (Microsoft SwiftKey): Evaluated for its predictive capabilities, learning curve, and integration with other devices, focusing on its efficiency in aiding communication [6].

• Augmentative and Alternative Communication (AAC) Systems: These systems were analysed for their speed, accuracy, and user-friendliness during interactive professional sessions [7].

2.3.3 Research Questions

The following research questions guided the investigation:

• How has a patient with MS adapted to her professional roles as a lawyer and lecturer? The study explores the emotional and practical strategies the participant employed to adjust to her condition and continue working. It aims to reveal how she overcame challenges, adjusted her routines, and adopted new tools to maintain her career.

• What technological interventions have facilitated her continuation as a lawyer and lecturer? The research identifies key technological aids, such as speech-generating devices and predictive text software, that assist her in communicating effectively and performing professional tasks.

• What are the practical implementations and challenges associated with the assistive technologies she utilizes? This question addresses the real-world applications of the assistive technologies, evaluating both their strengths and limitations in various professional settings like courtrooms and classrooms.

2.3.4 Participants

A single female participant with a 12-year diagnosis of MS, who has a tracheostomy and is unable to speak, was selected for this case study. This unique case allows for an in-depth exploration of her adaptation to her condition and the role of assistive technologies in her professional life. The personalized focus on one participant enabled a detailed examination of her experiences, providing valuable insights that might be diluted in a study involving multiple participants.

3 Results

The collected data refers to the information gathered during the study on how the patient adapted to her condition and utilized various assistive technologies to maintain her professional roles. This data was gathered through comprehensive interviews, observations, and assessments of the tools she used, such as the Tobii Dynavox speech-generating device and Microsoft SwiftKey predictive text software.

Figure 1: Tobii Dynavox i-110, dry-erase board and Tobii Dynavox i-16 (All photos are from the personal archive of the participant of the study)

The data were analysed to identify recurring themes related to the efficacy of these technological aids, challenges encountered, and their overall impact on her professional life as a lawyer and lecturer. The results aim to provide insights into how the assistive technologies supported her communication and work, as well as the practical implementations of these tools.

3.1 Early Communication Methods

Initially, the participant's primary channel of communication was the dry-erase board. Because she could not speak, she used the avenue to document (write) her cases or notes, which was effective then, especially in classrooms. The students acquired comprehensive notes, which allowed them to gain vast knowledge of European law. A dry-erase board is an effective interactive teaching tool, considering that lecturers can project notes to help students understand complex concepts [8].

However, this approach was slow and laborious. However, this approach was slow and laborious, leading to delays in covering the syllabus and impacting the efficiency of her work. Additionally, within a few weeks, she lost the ability to write with her right arm, necessitating the search for alternative communication methods. This early phase is illustrated in Figure 1, which shows the Tobii Dynavox i-110, dry-erase board, and Tobii Dynavox i-16.

3.2 Technological Advancements

The improvement in technology made communication easier for her. Kumar et al. (2019) and Unwin (2017) asserted that technology enables instant communication, irrespective of geographical limitations [9, 10]. Kumar et al. (2023) and Sahoo and Choudhury (2023) added that applications, software, and voice-controlled devices (wheelchairs), which are elements of the latest technologies, facilitate easier communication with MS patients, illustrating their criticality in her life [11, 12]. Mainly, she uses a speech-generating device that converts text to speech. She controls the narration by typing on the keyboard of Tobii Dynavox i-16. In addition, she uses Microsoft SwiftKey, a predictive text software, to improve her communication speed, ensuring that she is competitive in class and court. Google Inc. (n.d.) stated that SwiftKey is an intelligent keyboard that learns a person's writing style to hasten writing [13]. These tools enabled her to communicate more efficiently, maintaining competitiveness in her professional roles. A real-world example of her using the Tobii Dynavox i-110 and i-16 in public is shown in Figure 2.

Figure 2: A patient with MS in public with Tobii Dynavox i-110 and i-16 (All photos are from the personal archive of the participant of the study)

3.3 Lecturing Strategies and Public Engagement

The technologies mentioned above play an integral role in the preparation and execution of her lectures. She is an organized individual who prefers to define the lecture's content and prepare in advance. Thus, a few days prior to a class, she usually types out her speech using the predictive text system. This technology gives her enough notes and follow-up assignments or questions to engage the classroom. Narang et al. (2022) noted that an open discussion forum is an evidence-based strategy that bolsters students' engagement and awareness of the coursework [14]. During interactive sessions, she utilized augmentative and alternative communication (AAC) systems to compose feedback, although this process required patience from the audience due to time delays. Despite these challenges, her lectures remained thorough and engaging.

3.4 Evolution and Adaptation

Since the onset of her condition, she has realized the significance of transforming and adapting to the emerging life changes and latest technologies. Cahill (2020), Singh (2021), and Sampathkumar (2020) argued that change is inevitable, warranting individuals to modify their behaviours or actions to succeed [15, 16, 17]. She actively researched and adopted new systems to facilitate communication, recognizing the importance of evolving alongside technological developments.

The evolution of AAC technology has been particularly beneficial, reflecting advancements in both hardware and software that support her ability to communicate sophisticated ideas and engage professionally. Her current use of the Tobii Dynavox i-16 in her daily professional life, at both work and home, is shown in Figure 3.

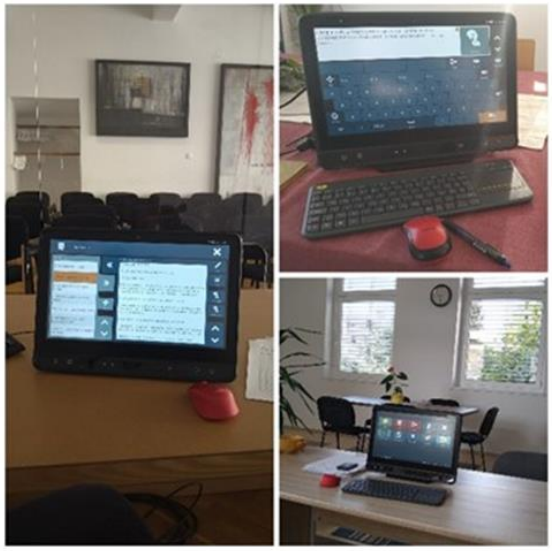

Figure 3: A patient with MS uses the Tobii Dynavox i-16 nowadays at work and home (All photos are from the personal archive of the participant of the study)

4 Conclusion

This study examined how a patient with multiple sclerosis adapted to her condition to continue her professional roles as a lawyer and lecturer. The findings address the research questions as follows:

The patient adjusted her mindset and routines to accommodate her physical limitations. She demonstrated resilience by seeking alternative methods to fulfil her professional responsibilities, including extensive preparation and the use of assistive technologies. Her determination enabled her to overcome initial setbacks and maintain her career.

Key technological aids, such as the Tobii Dynavox i-16 speech-generating device and Microsoft SwiftKey predictive text software, were instrumental in facilitating her communication. These tools supported her professional tasks by compensating for her lost abilities, allowing her to prepare lectures, engage with students, and represent clients effectively.

The assistive technologies were implemented in real-world settings, such as classrooms and courtrooms. While they significantly enhanced her communication capabilities, challenges included the slower pace of real-time interactions and the need for audience patience during interactive sessions. Technical issues and the learning curve associated with new devices also presented obstacles. Nonetheless, these technologies succeeded in enabling her to continue her professional activities.

In conclusion, the case study underscores the critical role of advanced assistive technologies in supporting individuals with severe disabilities to maintain their professional roles. The patient's experience highlights the importance of adaptability.

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Zvezek I

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Volume I

Konferenca o zdravi dolgoživosti
Conference on Healthy Longevity

Urednika / Editors

Martin Lipovšek, Boštjan Petrič

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Ljubljana, Slovenia

PREDGOVOR

Po velikem uspehu Konference o podaljševanju življenja, ki smo jo leta 2023 izvedli v okviru mednarodne multikonference Informacijska družba na IJS, smo se letos organizatorji odločili, da ponovimo zgodbo in konferenco še dodatno izboljšamo. Tudi tokrat je bil namen dvojen: povezovanje strokovnjakov, ki se ukvarjajo s podaljševanjem življenja na sicer nepovezanih področjih, ter promocija ideje o podaljšanju življenja med javnostjo. Je konferenca dosegla zastavljene cilje?

V primerjavi z lanskim letom smo tokrat v živo lahko poslušali ne le vse domače, temveč tudi nekatere od tujih govorcev. Iz Nemčije se nam je pridružil Alexander Tietz-Latza, ki je s perspektive pravnika govoril o pravici do podaljševanja življenja, iz ZDA pa Melissa King, ki je delila svoje bogate izkušnje iz agitacije in lobiranja za raziskave preprečevanja staranja. Znanstveniki, ki se v malih državah ukvarjajo z določenimi področji, so vajeni ustrezno majhnih zneskov: Kingova ima iz Washingtona izkušnje z borbo za večstomilijonske zneske, ki je bila večkrat tudi uspešna, in ob njeni pripovedi je bila pozornost poslušalcev zagotovljena. Več vrhunskih strokovnjakov se nam je pridružilo tudi prek videopovezave: Adam Buben iz Nizozemske, Ilya Stambler iz Izraela in Bryan Johnson iz ZDA.

Ne le da smo uspeli poleg že omenjenih pridobiti še izvrstne domače predavatelje, temveč se nam je prvič doslej pridružila tudi predstavnica Ministrstva za zdravje Vesna Marinko. Za razliko od večine znanstvenih konferenc, ki so namenjene majhni tarčni skupini strokovnjakov, je bila naša odprta za širšo javnost, in javnost je z veseljem tudi prišla. Lanska konferenca je bila obilno obiskana tako v živo kot preko videoprenosa, toda ali so obiskovalci dejansko prišli, ker bi jih tema zanimala? Številni odzivi, ki smo jih organizatorji prejeli po zaključku, potrjujejo, da je res tako. Letošnji prvi odzivi občinstva nakazujejo, da tudi tokrat ni nič drugače.

Martin Lipovšek, Boštjan Petrič

FOREWORD

After the great success of the Life Extension Conference, which we held in 2023 as part of the international multiconference Information Society at the Jožef Stefan Institute, this year the organizers decided to repeat the event and further improve the conference. Once again, the purpose was twofold: to connect experts working on life extension in otherwise unrelated fields and to promote the idea of life extension among the public. Did the conference meet these
goals?

Compared to last year, this time we were able to hear not only all the Slovenian speakers live but also some international ones. Alexander Tietz-Latza from Germany joined us to talk about the right to life extension from a legal perspective, and Melissa King from the USA shared her extensive experience in advocacy and lobbying for anti-aging research. Scientists in small countries are used to working with relatively small budgets, while King, during her visits to Washington, has fought for hundreds of millions of dollars, often successfully; needless to say, she had the audience's attention. Several top experts also joined us via video link: Adam Buben from the Netherlands, Ilya Stambler from Israel, and Bryan Johnson from the USA.

Not only did we manage to bring in excellent Slovenian speakers in addition to all the foreign ones already mentioned, but for the first time, we were also joined by a representative from the Ministry of Health, Vesna Marinko. Unlike most scientific conferences, which are aimed at a small target group of experts, ours was open to the general public - and the public gladly attended. Last year's conference was well-attended both in person and via video stream, but did the attendees come because they were genuinely interested in the topic? Numerous responses that we received afterward confirm that they were. Early feedback from this year's audience suggests that the second Life Extension Conference was no different.

Martin Lipovšek, Boštjan Petrič

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Vitalna dolgoživost – izzivi in priložnosti za bodočo družbo

Danes smo priča naraščajočemu pričakovanemu trajanju življenja, ki je v zadnjih desetletjih izjemno porasla zaradi ugodnejših zdravstvenih, prehranskih, ekonomskih in socialnih razmer kot odraz različnih odkritij ter novih spoznanj v znanosti in družbi ter njihovih aplikacij v vsakdanjem življenju. Starejše se sicer zaradi pojavnosti starostne oviranosti in različnih kroničnih bolezni večkrat obravnava kot posebno skupino, potrebno specializirane pomoči na področju medicine, sociale, politike, zakonodaje, bivanjskih razmer, servisnih služb, posebnih organizacij in podobno. Zato ne čudi razmišljanje, da je »znanost podaljšala življenjsko dobo, vendar to pomeni daljšo starost«.

Res je, staranju ne morem ubežati – z leti se začnejo kopičiti okvare in napake v telesu, ki se odražajo kot upad fizičnih in kognitivnih sposobnosti in razvoj kroničnih bolezni, vendar danes znanost ponuja več, kot le podaljševanje »starega« življenja! In kaj nam ponuja znanost o biologiji staranja? V zadnjem desetletju smo priča eksploziji različnih aktivnosti in znanstvenih odkritij na tem področju, nekateri to imenujejo kar revolucija znanosti na področju dolgoživosti. Področje biologije staranja imenujemo tudi biogerontologija, ki obravnava predvsem mehanizme staranja, in geroznanost, ki obravnavane mehanizme staranja povezuje s pojavom kroničnih bolezni. Te raziskave skušajo odgovoriti na vprašanja na molekulskem in celičnem nivoju ter na nivoju organizma, zakaj in kako se staramo ter ali je mogoče omiliti/upočasniti procese staranja, predvsem s preprečevanjem razvoja starostnih tegob in kroničnih bolezni in tako podaljšati zdrava leta življenja.

In kakšne so možnosti za vitalno dolgoživost? V prispevku bomo predstavili vplive genetske zasnove in okolja (življenjskega sloga) na procese staranja in novejša spoznanja o možnostih uporabe geroterapevtikov ter celičnih in genskih terapij za vitalno dolgoživost.

Vital Longevity – Challenges and Opportunities for Future Society

Today, we are witnessing increasing life expectancy, which has significantly risen in recent decades due to improved health, nutrition, economic, and social conditions, reflecting various discoveries and new understandings in science and society and their application in daily life. Older individuals are often treated as a special group due to the prevalence of age-related disabilities and various chronic diseases, requiring specialized assistance in medicine, social services, politics, legislation, housing conditions, service agencies, special organizations, and more. This gives rise to the notion that "science has extended lifespan, but that means longer old age."

Indeed, aging is inevitable—over time, defects and errors accumulate in the body, reflected in a decline in physical and cognitive abilities and the development of chronic diseases. However, today's science offers more than just the extension of "old age." So, what does the science of aging biology offer us? In the past decade, we have witnessed an explosion of various activities and scientific discoveries in this field, with some even calling it a revolution in longevity science. The field of aging biology, also known as biogerontology, primarily deals with the mechanisms of aging, while geroscience links these mechanisms with the emergence of chronic diseases. These studies aim to answer questions at the molecular, cellular, and organismal levels about why and how we age and whether it is possible to alleviate or slow down aging processes, especially by preventing the development of age-related ailments and chronic diseases, thus extending the healthy years of life.

What are the possibilities for vital longevity? This article will present the influences of genetic makeup and the environment (lifestyle) on the aging processes and recent findings on the potential use of gerotherapeutics, as well as cellular and gene therapies, for achieving vital longevity.

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Gordana Kalan Živčec

8 stebrov zdravja – kaj lahko naredimo sami in kaj so priložnosti medicine – Gordanina Metoda

Zdravje in kakovostna dolgoživost sta neposredno povezani. Kakovostna dolgoživost je tesno povezana s koncepti, ki so v osnovi enostavni in jih lahko izvajamo samostojno: gibanje, prehrana, počitek, socialni stiki/domače živali, ... tehnike sproščanja. Nadgradimo jih s koncepti medicine: preventiva, prehranska dopolnila in šele na koncu zdravila. Prvi steber zdravja je gibanje - Drugi steber zdravja je prehrana - Tretji steber zdravja je počitek - Četrti steber zdravja je kakovostna socialna mreža in tudi hišni ljubljenčki - Peti steber zdravja je zmanjševanje mentalnega, fizičnega in okoljskega stresa - Šesti steber zdravja je preventiva - Sedmi steber zdravja so prehranska dopolnila - Osmi steber zdravja so zdravila. Hiša stoji na 4 stebrih. Za zdravo življenje jih je potrebno 8. Srečno!

The 8 Pillars of Health – What We Can Do Ourselves and the Opportunities in Medicine – Gordana's Method

Health and quality longevity are directly connected. Quality longevity is closely tied to concepts that are fundamentally simple and can be implemented independently: movement, nutrition, rest, social connections/pets, and relaxation techniques. These are then enhanced by medical concepts: prevention, nutritional supplements, and only as a last resort, medications. The first pillar of health is movement. - The second pillar of health is nutrition. - The third pillar of health is rest. - The fourth pillar of health is a strong social network, including pets. - The fifth pillar of health is reducing mental, physical, and environmental stress. - The sixth pillar of health is prevention. - The seventh pillar of health is nutritional supplements. - The eighth pillar of health is medication. A house stands on four pillars. For a healthy life, eight are needed. Good luck!

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Rok Kopinč

Moč matičnega mlečka pri zdravem staranju

Matični mleček ima že v razvoju čebel vlogo epigenetskega reprogramiranja. Ličinke, ki so hranjene celotno obdobje razvoja izključno z matičnim mlečkom, se razvijejo v čebelje matice, medtem ko se ličinke, ki so hranjene z matičnim mlečkom le prve tri dni, razvijejo v navadne čebele delavke, čeprav sta obe genetsko identični. Matice so še enkrat večje od delavk, za razliko od delavk plodne in živijo do 20-krat dlje. Razlog je v tem, da matični mleček omogoča utišanje določenih genov (genov delavke) in izražanje genov matice. Ker so matice celo življenje hranjene le z matičnim mlečkom, se razlika v izražanju genov ohranja in s tem lastnosti, ki so značilne za čebeljo matico. Če navadno čebelo delavko začnemo hraniti z matičnim mlečkom, začne dobivati nekatere lastnosti matice. Pa lahko takšno delovanje matičnega mlečka pričakujemo tudi pri drugih organizmih? Raziskave kažejo, da matični mleček za 10 do 20 % podaljša življenje tudi pri nekaterih drugih modelnih organizmih , kot so črvi *C. elegans*, vinske mušice, črički in miške. Prav tako poveča odpornost teh živali na stres, kot so UV svetloba, izpostavljenost kemijskim sredstvom in na bakterijske/virusne infekcije. V različnih kliničnih študijah je bilo dokazano, da matični mleček spodbuja procese, ki so sicer povezani z dolgoživostjo in podaljšanjem zdravega obdobja življenja. Tako so dokazali, da matični mleček aktivira enake procese kot kalorična restrikcija, še zlasti glavna sestavina matičnega mlečka, to je 10-hidroksi-decenojska kislina, poveča izražanje sirtuinov. V nedavni klinični raziskavi smo tudi sami potrdili, da aktivira obrambne sisteme, ki ščitijo celice pred oksidativnimi poškodbami ter poviša raven adiponektina, katerega višje ravni so pri ljudeh povezane z dolgoživostjo. Matični mleček vsebuje tudi spermidin, ki je znan po tem, da spodbuja avtofagijo in preprečuje staranje celic.

The Power of Royal Jelly in Healthy Aging

In the development of bees, royal jelly plays a role in epigenetic reprogramming. Larvae that are fed exclusively with royal jelly throughout their entire development become queen bees, while those that are fed royal jelly only for the first three days develop into ordinary worker bees, even though both are genetically identical. Queens are twice the size of workers, are fertile, and live up to 20 times longer. This is because royal jelly enables the silencing of certain genes (worker bee genes) and the expression of queen genes. Since queens are fed only royal jelly throughout their lives, the difference in gene expression is maintained, along with the traits characteristic of a queen bee. If a regular worker bee starts being fed royal jelly, it begins to develop some queen-like characteristics. But can we expect such effects of royal jelly in other organisms as well? Research shows that royal jelly extends the lifespan of some other model organisms, such as *C. elegans* worms, fruit flies, crickets, and mice, by 10 to 20%. It also increases these animals' resistance to stress, such as UV light, exposure to chemicals, and bacterial/viral infections. Various clinical studies have proven that royal jelly promotes processes associated with longevity and the extension of the healthy period of life. It has been shown that royal jelly activates the same processes as calorie restriction, particularly the main component of royal jelly, 10-hydroxy-2-decenoic acid, which increases the expression of sirtuins. In a recent clinical study, we also confirmed that royal jelly activates defense systems that protect cells from oxidative damage and increases levels of adiponectin, which in humans is linked to longevity. Royal jelly also contains spermidine, known for promoting autophagy and preventing cellular aging.

Melissa King

Advocacy in Action: How Patient Advocacy, Public Policy, and Science Communication Drive Scientific Progress and Benefit Society

This talk underscores the vital role of advocacy, policy, and communication in advancing scientific progress, especially in healthy longevity. It illustrates how engaged citizens, through patient advocacy, can drive research funding and policy changes, significantly impacting healthcare outcomes. The presentation highlights the global spread of initiatives like Right to Try laws and stresses the importance of public funding for early-stage research and the need for scientists to actively communicate with the public.

There is a great need in the healthy longevity field for more patient advocacy, public policy, public information through science communications, and global collaborative planning to drive both scientific progress and distributive justice. The impact of patient advocacy on various areas of biomedical research and healthcare is immeasurable, as shown by examples such as California's Propositions 71 & 14 for stem cell research funding, JDRF's efforts in type 1 diabetes research, and HIV/AIDS activism.

Ongoing public policy efforts are of great importance for both research and patients. Efforts like Brain Mapping Day at the US Congress, part of the inspiration for President Obama's Brain Initiative, and the implementation of Right to Try legislation are not always visible to the public at large but impact billions of people. A global overview of Right to Try legislation and similar programs across different regions provides an example of how complex public policy efforts can be when the focus is global.

The role of public funding in scientific advancements is enormous, given that private industry and funding often enter only after initial public investments reduce risk. The critical need for accurate science communication to the public provides an opportunity for scientists and others well-informed about science to engage in outreach and education efforts.

This presentation is a call to action, meant to inspire and empower attendees to become active participants in shaping the future of science and health policy, including and especially around healthy longevity for all.

Alexander Tietz - Latza

The Right to Health and Longevity: An Evolving Human Right?

The recognition and enforcement of the right to health as a fundamental human right can significantly enhance longevity and healthspan. By ensuring access to comprehensive healthcare, promoting preventive measures, interventions, and addressing socio-economic determinants of health, we can advocate a legal framework that supports a healthier population.

Several international human rights instruments, such as the Universal Declaration of Human Rights (UDHR) and the International Covenant on Economic, Social and Cultural Rights (ICESCR), enshrine the right to health. In Europe, the European Social Charter and national constitutions further reinforce this right. Effective implementation of these legal frameworks can lead to better health outcomes.

This right encompasses access to timely, acceptable, and affordable health care of appropriate quality as well as the underlying determinants of health, such as safe drinking water, adequate sanitation, and a healthy environment. The right to health implies that everyone should have access to the necessary health services and conditions that enable them to live a long and healthy life - including Longevity?

Adam Buben

Should Christians Be Opposed to Technologically Achieved Life Extension? Why Kierkegaard Might Make a Bad Transhumanist

It might seem obvious to most readers of Kierkegaard, an important thinker in the Christian tradition, that he would have little interest in, and would probably be radically opposed to, the goals of transhumanism. The difficult part, however, is explaining exactly what he would be opposed to and why. It is true that Kierkegaard does not put much stock in science and technology, but transhumanism is not a monolithic movement; the futurists, philosophers, scientists, and sci-fi enthusiasts who might consider themselves transhumanists have a wide array of hopes and dreams about what technology might eventually be able to do for, and to, humankind. This variety means certain understandings of transhumanism might actually be quite compatible with all sorts of religious traditions, including Christianity. In fact, it is important to many transhumanists that their ideas not be perceived as sacrilegious, irreligious, or heretical, because they think a "broad, diverse coalition" of support for, or at least tolerance of, their agenda is practically and politically necessary for their goals to be realized. Given such intentional inclusivity, we must dig a little deeper into Kierkegaard's views to determine if he would truly be an opponent of transhumanism. There may well be several approaches to explaining "why Kierkegaard might make a bad transhumanist," but mine will be to argue—focusing on the example of technologically achieved life extension—that there is something in his Christian commitments that runs counter to the very spirit of transhumanism.

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Zbornik 27. mednarodne multikonference

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Tone Stanovnik, Matjaž Gams

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PREDGOVOR

V letu 2024 s ponosom nadaljujemo z iniciativo »Legende računalništva in informatike« (krajše »Legende RI«), podnaslovljeno »Galerija slavnih slovenskega računalništva in informatike« ali po angleško »Hall of Fame of Slovenian Computer Science and Informatics«.

Naš glavni motiv je priznati izjemne dosežke raziskovalcev, razvijalcev, inženirjev in vizionarjev na področju računalništva in informatike. Ob tem želimo hkrati zbrati pomembne avtobiografske prispevke, ki bodo gradili zapis zgodovine tega pomembnega področja v Sloveniji. Tako sledimo dvema pomembnima ciljema: ohranjamo strokovnost brez političnih ali ideoloških vplivov ter zagotavljamo demokratičnost in transparentnost v procesu izbire legend. Obenem si prizadevamo, da nikoli ne bi dopustili, da bi izjemni posamezniki ostali neopaženi in ne priznani za svoj prispevek, tako kot je bil nekoč Alan Turing, eden največjih umov v zgodovini računalništva, ki namesto priznanja prejel le kazen zaradi svoje identitete.

V letu 2024 bo programski odbor ocenjeval in nagrajeval na podlagi dejanskega prispevka posameznikov na področju računalništva in informatike, pri čemer bomo še posebej pozorni na njihov vpliv na stroko, družbo in razvoj tehnologij.

Navedimo osnovne dogovore pri Legendah: Dobitniki nagrade Michie-Turing so avtomatsko sprejeti na podlagi poslanih referatov, ki služijo tudi kot avtobiografska zgodovina. Podobno naj bi veljalo za mednarodne nagrade izjemne pomembnosti, medtem ko nacionalne nagrade še niso predmet avtomatskega sprejemanja. Prvo leto pričakujemo od 10 do 20 nagrad, nato okoli 5 letno, zgornja meja naj bi bila okoli 50 prejemnikov.
Postopek predlaganja kandidatov za legendo ostaja odprt, zlasti za predloge s strani društev ACM Slovenija, SLAIS in Informatike. Predlog je potrjen, če zbere več kot polovico oddanih glasov in ne preseže letne ali absolutne omejitve.

Predlogi za legendo so pripravljeni kot prispevki za konferenco IS v obliki 2-4 strani, z ustrezno dokumentirano literaturo, le izjemoma je dovoljen povzetek na eni strani. Predlagatelj lahko predlaga sebe ali koga drugega, več predlogov pa je prav tako dovoljenih. Pri posthumnih nominacijah je potrebno pridobiti soglasje najbližjih svojcev. Prispevek naj bo strukturiran kot življenjepis s poudarkom na dosežkih – znanstveni, praktični, pedagoški, organizacijski – pri čemer je zaenkrat še nekaj svobode pri oblikovanju.
Z novim konceptom želimo še naprej širiti prepoznavnost in promocijo slovenskega računalništva in informatike ter krepiti vlogo informacijske družbe. Vaše sodelovanje, podpora, razumevanje in strpnost so ključni za uspeh te pobude. Iskrena hvala vsem sodelujočim in čestitke sedanjim ter prihodnjim prejemnikom tega prestižnega priznanja!

Tone Stanovnik in Matjaž Gams

FOREWORD

In 2024, we proudly continue with the initiative "Legends of Computer Science and Informatics" (abbreviated as "Legends RI"), subtitled "Hall of Fame of Slovenian Computer Science and Informatics."

Our primary motivation is to acknowledge the exceptional achievements of researchers, developers, engineers, and visionaries in the field of computer science and informatics. At the same time, we aim to gather important autobiographical contributions that will form the historical record of this significant field in Slovenia. In doing so, we pursue two key goals: maintaining professionalism without political or ideological influence and ensuring democracy and transparency in the selection process of the legends. Furthermore, we are committed to never allowing exceptional individuals to go unnoticed or unrecognized for their contributions, much like Alan Turing, one of the greatest minds in computer science history, who was punished instead of being rewarded due to his identity.

In 2024, the program committee will evaluate and award individuals based on their contributions to computer science and informatics, with particular attention to their impact on the profession, society, and the development of technologies.

Let us outline the basic agreements for the Legends: Michie-Turing award recipients are automatically accepted based on their submitted papers, which also serve as autobiographical histories. Similarly, this will apply to internationally prestigious awards, while national awards are not yet subject to automatic acceptance. Each year, we aim to induct approximately 5 new legends into the Hall of Fame.

The process of nominating candidates for the legend status remains open, particularly for proposals from associations like ACM Slovenia, SLAIS, and Informatika. A proposal is confirmed if it receives more than half of the submitted votes and does not exceed the annual or absolute limits.

Legend proposals are prepared as two to four-page contributions for the IS conference, supported by appropriately documented literature, with a one-page summary allowed only in exceptional cases. A proposer may nominate themselves or someone else, and multiple proposals are also allowed. In the case of posthumous nominations, consent from the closest relatives is required. The contribution should be structured like a CV, focusing on achievements—whether scientific, practical, pedagogical, or organizational—with some flexibility in the format.

With this new concept, we aim to further increase the recognition and promotion of Slovenian computer science and informatics and strengthen the role of the information society. Your cooperation, support, understanding, and patience are essential for the success of this initiative. Sincere thanks to all participants, and congratulations to the current and future recipients of this prestigious recognition!

Tone Stanovnik and Matjaž Gams

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Achievements of the Candidate Marjan Mernik
Dosežki kandidata Marjana Mernika

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Abstract

The paper briefly summarizes the main scientific and research achievements of Prof. Dr. Marjan Mernik, as well as his teaching and managerial work at the University of Maribor, Faculty of Electrical Engineering and Computer Science. His scientific and research work covers the field of programming languages, software engineering and evolutionary computing.

Keywords

Computer Science, programming languages, software engineering, evolutionary computation

Povzetek

V prispevku so na kratko povzeti glavni znanstveno-raziskovalni dosežki prof. dr. Marjan Mernika, kakor tudi njegovo pedagoško in vodstveno delo na Univerzi v Mariboru, Fakulteti za elektrotehniko, računalništvo in informatiko. Njegovo znanstveno-raziskovalno delo posega na področje programskih jezikov, inženiring programske opreme in evolucijskega računanja.

Ključne besede

Računalništvo in informatika, programski jeziki, inženiring programske opreme, evolucijsko računanje

1 Introduction

Prof. Dr. Marjan Mernik is a professor of Computer Science at the Faculty of Electrical Engineering and Computer Science, University of Maribor, Slovenia. He completed his Ph.D. in computer science from the University of Maribor in 1998. His dissertation focused on programming language composition and evolution at the syntactic and semantic levels. Since 1998, he has been teaching various courses on Programming, Programming Languages, Compilers, and Evolutionary Computation. He spent a Sabbatical in 2004 at the University of Alabama at Birmingham (UAB), USA, and since then, he has been a visiting professor at UAB until 2017, where he occasionally taught undergraduate class on Programming Languages and a graduate class on Domain-Specific Languages. He was also a visiting professor at the University of Novi Sad, Serbia, from 2010 to 2016. He was advisor to 8 PhD students at the University of Maribor, co-advisor to 5 PhD students at the University of Alabama at Birmingham, and to 1 PhD student at the University of Ljubljana. He was a member of PhD committees at foreign institutions such as the University of Sarajevo, the University of Rostock, the University of Tartu, the Eindhoven University of Technology, the University of Milan, the University of Alabama at Birmingham, the University of Alabama, the University of Cape Town, the Universidade Nova de Lisboa, and the University of Novi Sad.

2 Research Activities

His main research interests lie in the intersection of programming languages, software engineering and evolutionary computation. His research philosophy involves tackling practical problems of real-world complexity and proposing foundational solutions that offer the potential for significant long-term impact on the field of computing. His past work on attribute grammar [1, 2] and current work on Domain-Specific Languages [3-10] and Evolutionary Computation [11-19] demonstrate that he is identifying with and working on major research problems in this field and that he is able to initiate new ways of thinking.

From the start of his career, a primary research interest has been the formal syntax and semantics of programming languages. He has developed various compiler/interpreter generators based on different formal methods, such as attribute grammars, denotational semantics, and operational semantics. To solve the problem of non-modularity, non-extensibility and non-reusability of formal language specifications, which would enable easier language composition, he has proposed the idea of multiple attribute grammar inheritance, which was successfully implemented in the LISA compiler generator tool [1]. Despite that, this work was done during, and shortly after, his PhD thesis; the work regains attention in the young engineering discipline of Software Language Engineering (SLE) [2] with the aim of

*Article Title Footnote needs to be captured as Title Note
†Author Footnote to be captured as Author Note

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establishing a systematic and rigorous approach to the development, use, and maintenance of computer languages, which comprises specification, modelling and programming languages.

In the next step of his career, he was interested in the possibility of automatically generating other language-based tools from formal language specifications, such as editors, debuggers, visualization tools, and animators [4]. While this work emphasizes primarily textual programming languages, it is now extended to domain-specific modelling languages [5].

His research also focuses on the design and implementation of domain-specific languages [3-10]. He is interested in many aspects of domain-specific languages, from domain analysis, design, implementation, validation, maintenance, and their use. All of these phases have been described in his survey paper in the ACM Computing Surveys journal [3], which was extremely well accepted among researchers. This paper has more than 2800 Google Scholar citations, and it is the most cited paper in the area of domain-specific languages. It is also used as a standard teaching material for various courses on domain-specific languages at different universities. On many occasions, he has been regarded by others as a leader in domain-specific language research.

Around the year 2000, he also became interested in another research field - evolutionary computation. He was combining evolutionary computation in a novel way with the research fields of programming languages and software engineering [11-19]. One such problem, which has not sufficiently been solved yet, is the problem of inferring grammars from the set of positive and negative samples. This is the research field of grammatical inference to which he and his co-workers have contributed a new algorithm, MAGIc [13]. The work on grammatical inference has recently been extended to semantic inference of domain-specific languages [17].

Another topic from the field of evolutionary computation in which he is interested is the problem of parameter control. He and co-workers have suggested one of the first approaches for self-adapting control parameters in Differential Evolution (DE) [12]. This work has been published in the prestigious journal IEEE Transactions on Evolutionary Computation and has more than 3600 Google Scholar citations. He has become interested in investigating how different evolutionary algorithms perform exploration and exploitation of the search space. This is a fundamental issue of any search algorithm. The result of this study was published in 2013 [11] in the prestigious ACM Computing Surveys journal and has up to now more than 1500 Google Scholar citations.

His research work culminated in more than 130 journal papers, among them more than 70 in journals with an SCI index (e.g., ACM Computing Surveys, IEEE Transactions on Evolutionary Computation, Applied Soft Computing, Empirical Software Engineering) and in more than 160 conference/workshop papers. Google Scholar ranked his work as H-Index=44, number of citations = 14260. Clarivate Analytics named Marjan Mernik as a highly cited researcher in 2017 and 2018 (the only researcher from computer science from Slovenia). His research ranks among the top 1% of most cited works in the field of Computer Science in 2017 and 2018, earning the mark of exceptional impact. For his research achievements, he was awarded a Silver Sign at the University of Maribor in 2012 and an award for scientific research and educational work at the University of Maribor in 2022. In 2019, he was awarded the Donald Michie and Alan Turing Prize for the Life Achievements of the Slovenian Information Society. In 2024, he received the Entrepreneurs, Academicians & Researchers Guild Award for Lifetime Achievement in Academia and Research from the MathTech Thinking Foundation.

3 Other Activities

He has strong international collaboration, including organizing conferences and workshops, journal special issues, serving on journal editorial boards, and being a member of program committees. He has been an invited speaker at ten conferences. He is a member of seven editorial boards, a journal reviewer for more than 40 journals, and a member of program committees for more than 150 conferences and workshops. He is the Editor-in-Chief of the Journal of Computer Languages (Elsevier) and an Associate Editor of Applied Soft Computing Journal (Elsevier), Swarm and Evolutionary Computation (Elsevier), and Information Sciences (Elsevier). His basic research has been funded by the Slovenian Research Agency, the National Science Foundation (NSF USA) and industrial funds from local companies (Raiffeisen Krekova banka, DEWESoft).

Last but not least, he took on several organizational duties. He was a Chair of the Quality Assurance Committee at the Faculty of Electrical Engineering and Computer Science, University of Maribor, from 2003 to 2011, and Vice-Dean of Research from 2015 to 2018. He was a Chair of the Institute of Computer Science from 2015-2019, where he was responsible for the implementation of the department's objectives and goals, such as following constant changes in computer science and information technologies curricula. Since 2019, he has been a Vice-Dean of International Cooperation and Quality Development at the Faculty of Electrical Engineering and Computer Science, University of Maribor. Since 2019, he has been a Member of the Council of Slovenian Quality Assurance Agency for Higher Education.

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Prispevki Igor Bernika na področju informatike
Contributions of Igor Bernik in the field of informatics

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Povzetek

Prispevek povzema razvojno-raziskovalno, pedagoško in vodstveno delovanje ter dosežke Igorja Bernika v okviru Fakultete za varnostne vede in Fakultete za organizacijske vede Univerze v Mariboru. Njegovo delo spada na področja sistemov za podporo odločanja ter informacijske in kibernetske varnosti.

Ključne besede

Igor Bernik, pedagoška dejavnost, raziskovalna dejavnost, informacijska in kibernetska varnost

Abstract

The paper summarizes the development-research, teaching and management activities and achievements of Igor Bernik within the Faculty of Security Sciences and the Faculty of Organizational Sciences of the University of Maribor. His work is in decision support systems, information, and cybersecurity.

Keywords

Igor Bernik, teaching, research, information and cybersecurity

1 Uvod

Igor Bernik je prvi stik z računalnikom doživel v poznih 80. letih prejšnjega stoletja, ko je sprva načrtoval kariero na področju strojništva. V tem obdobju se je srečal s programiranjem in kmalu odkril svojo strast do tega področja. Postopoma se je vse bolj oddaljeval od tehničnih disciplin in začel usmerjati svojo pozornost v informatiko, pri čemer se je v zadnjih dveh desetletjih posebej posvetil informacijski varnosti. V zadnjih letih je svoje delo osredotočil na varno uporabo informacijske tehnologije z namenom izboljšanja kakovosti življenja. Na svoji strokovni poti je imel čast sodelovati s številnimi posamezniki, ki so pomembno prispevali k njegovemu osebnemu in strokovnemu razvoju ter ga podpirali pri rasti na področju informacijske in kibernetske varnosti. Posebno mesto v njegovem delu zasedajo študenti, katerih dosežki so zanj predstavljali stalno motivacijo za nadaljnje delo in raziskovanje. Mentoriral je skoraj 400 študentov, med katerimi so mnogi dosegli izjemne uspehe v svojih poklicnih karierah.

2 Študij

V poznih osemdesetih letih so se v strojništvo začeli uvajati prvi računalniki in numerično krmiljeni stroji, ki so postajali vse bolj razširjeni. Med študijem strojništva se je prof. dr. Igor Bernik prvič srečal s študijskimi vsebinami s področja programiranja. Zaradi uspešnosti pri študiju je prejel prve ponudbe za sodelovanje s profesorji ter možnost dodatnega zaslužka prek programiranja. V začetku 90. let se je srečal z izzivom, kako razviti poslovni informacijski sistem za uporabnika, ki želi uporabljati računalnik, vendar nima znanja informatike. Leta 1991 se je, na podlagi te potrebe, odločil razviti poslovni informacijski sistem za podjetje, pri čemer je izbral okolje MS Access 1.0. Tako je razvil informacijski sistem, ki je bil verjetno eden prvih poslovnih sistemov v Sloveniji, izdelanih v okolju Windows. Med razvojem tega sistema je ugotovil, da je potrebno pridobiti dodatno znanje o relacijskih bazah podatkov, kar ga je pritegnilo k nadaljnjemu študiju organizacijske informatike.

Na Fakulteti za organizacijske vede Univerze v Mariboru je uspešno zaključil študij organizacijske informatike, med katerim se je še posebej posvetil poslovnim simulacijam in sistemom za podporo odločanju. Aktivno je sodeloval v različnih študentskih projektih, njegov zaključni projekt, diplomsko delo na temo razvoja sistema za zvezno simulacijo v C++ [1], pa mu je prinesel mesto mladega raziskovalca.

3 Zaposlitev na Fakulteti za organizacijske vede

Kot mladi raziskovalec se je prof. dr. Igor Bernik med delom in študijem skozi znanstveni magisterij in doktorat srečal tudi z metodami optimiranja in umetno inteligenco. Imel je srečo, da je sodeloval z odličnimi, danes legendarnimi profesorji informatike. Njegov formalni mentor je bil prof. dr. Miroljub Kljajič, veliko pa je sodeloval in se učil tudi od prof. dr. Vladislava Rajkoviča ter prof. dr. Roberta Leskovarja, ki je bil njegov delovni mentor. Na podlagi opravljenih raziskav je s kolegi objavil izsledke, ki so še danes med visoko citiranimi [2, 3].

*Article Title Footnote needs to be captured as Title Note
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Po zaključenem usposabljanju za mladega raziskovalca ostal na Fakulteti za organizacijske vede, sprva kot asistent, kasneje kot docent. Kot učitelj je sledil razvoju stroke in poleg obstoječih področij poučevanja razvijal tudi nova, kot so managerski in kadrovski informacijski sistemi. V tem obdobju se je prvič srečal s potrebo po varovanju podatkov, najprej osebnih, nato tudi poslovnih. Ugotovil je, da razvoj informacijskih sistemov pogosto zanemari vidike varnosti, zato se je začel posvečati vprašanju, kako zagotoviti varnost informacijskih sistemov, pri čemer je sodeloval tudi s Fakulteto za varnostne vede.

4 Zaposlitev na Fakulteti za varnostne vede

Leta 2008 je bil prof. dr. Igor Bernik povabljen, da svojo strokovno pot nadaljuje na Fakulteti za varnostne vede Univerze v Mariboru. Fakulteta je le nekaj let prej (leta 2003) izstopila iz sistema Ministrstva za notranje zadeve in se pridružila Univerzi v Mariboru, razvojno pa je poskušala (in po dosedanjih rezultatih uspešno) proučevati področje varnosti oziroma varstvoslovja skozi znanstveno-raziskovalno delo in prenašati vrhunsko znanje na študente. Idejni vodji razvoja fakultete, takratna dekana prof. dr. Milan Pagon in prof. dr. Gorazd Meško, sta prepoznala prihodnost v formalnem proučevanju informacijske varnosti. Tako je bil poleg pedagoških in raziskovalnih zadolžitev prof. dr. Bernik postavljen pred izziv vzpostavitve študija informacijske varnosti na fakulteti. S sodelovanjem Fakultete za elektrotehniko, računalništvo in informatiko je bil pripravljen interdisciplinarni visokošolski program Informacijska varnost, ki je bil akreditiran avgusta 2010, prvi študenti pa so bili vpisani že leta 2011. Leta 2014 je bil dr. Bernik mentor prvemu diplomantu [4] tega programa.

Vsebinsko je razvil področje informacijske varnosti in postavil temelje znanstveno-raziskovalni dejavnosti družboslovnega proučevanja informacijske varnosti. Iz tega področja je objavil tudi nekaj temeljnih del v slovenskem jeziku [5, 6, 7]. Njegova raziskovalna dejavnost se je utrdila v mednarodni skupnosti informacijske varnosti, zlasti po izdaji samostojne znanstvene monografije leta 2014 pri založbi Wiley [8].

Leta 2010 se je na področju informacijske varnosti pridružil tudi Blaž Markelj, ustanovljena je bila katedra za informacijsko varnost, ki je v petnajstih letih dosegla številne uspehe [9] in danes šteje štiri člane (pridružita se še Simon Vrhovec, 2014 in Anže Mihelič, 2018). Poleg pedagoškega in znanstveno-raziskovalnega dela je bil prof. dr. Bernik tudi prodekan na področjih izobraževanja, znanstveno-raziskovalnega dela, kakovosti in razvoja, od leta 2023 pa je dekan Fakultete za varnostne vede Univerze v Mariboru.

Prof. dr. Bernik je (so)avtor šestih monografij, 27 poglavij v znanstvenih monografijah, 42 izvirnih in preglednih znanstvenih člankov ter več sto drugih del, njegova bibliografija pa šteje 625 enot. Sodeloval je pri številnih projektih in recenzijah ter je član mnogih strokovnih združenj. Za svoje delo je prejel več domačih in mednarodnih priznanj.

5 Zaključek

Prof. dr. Igor Bernik je profesor, ki si prizadeva, da bi se področje informacijske in/ali kibernetske varnosti osamosvojilo od informatike in varstvoslovja ter ga predstavlja kot ključno vedo prihodnje digitalizirane družbe [10, 11]. Pri tem se osredotoča tudi na digitalno vključenost vseh državljanov v trajnostni razvoj.

Zahvala

Iskrena zahvala vsem financerjem raziskovalnih projektov, ki so omogočili naše delo in napredek, ter vsem kolegicam in kolegom, ki so s svojim znanjem, podporo in novimi izzivi oblikovali mojo pot. Brez vaše podpore in zaupanja ne bi bilo mogoče doseči vsega, kar smo skupaj ustvarili. Vaša prizadevanja in predanost so pustili neizbrisno sled v mojem življenju in delu, za kar sem vam globoko hvaležen.

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Dosežki kandidata Marka Bajca

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Povzetek

V tem prispevku na kratko predstavim svojo dosedanjo karierno pot ter dosežke, povezane z računalništvom in informatiko. Prispevek sem napisal kot kandidat za člana v "Legendah računalništva". Povabila sem bil vesel, a priznam, da me spravilo v zadrego. Biti na nekem področju "legenda", je zares visok družbeni status, ob katerem mnogi dosežki, ki se sicer znajdejo v naših življenjepisih, zgubijo svoj bliščč. Z nekaj samokritike zato kratek opis moje karierne poti in tistih rezultatov, na katere sem sam ponosen.

Abstract

In this paper I briefly describe my career path and achievements so far related to computer science and informatics. I wrote the paper as a candidate for membership in the 'Legends of Computing'. While I was happy to receive the invitation, I must admit it put me in an awkward position. Being a 'legend' in a particular field is truly a high social status, at which many achievements that usually make it to our resumes lose their shine. With a bit of self-criticism, here is a brief description of my career path and those results that I am personally proud of.

Ključne besede

karierna pot, raziskovalno delo, pedagoško delo, vodstvene funkcije, dosežki

Keywords

career path, research work, teaching work, management, achievements

1 Karierna pot

1.1 Na kratko

S "pravimi" računalniki sem se spoznal šele v srednji šoli – Tehnični srednješolski center Branka Breliha, Nova Gorica. Vpisal sem se, ne da bi zares vedel, kam se vpisujem. V osnovni šoli sem res kazal več želje in nadarjenosti za naravoslovno tehnične predmete, vsaj tako so zatrjevale moje učiteljice, a izrazito me ni vleklo nikamor. Še danes večkrat pomislim, da sem računalničar po naključju.

V srednji šoli sem se o računalništvu veliko naučil, predhodnega znanja o tem področju namreč nisem imel, a največ mi je dala fakulteta. Za razliko od srednje šole, kjer sem bil tako imenovani "hardverist" (strojna opema), sem se na faksu raje odločil za programsko opremo. Programiranje me v resnici bolj veselilo kot pa računalniško drobovje. V zadnjih letnikih sem veliko časa prebil na IJS (v resnici v podjetju, ki je delovalo v okrilju IJS), kjer sem pomagal pri izvajanju računalniški tečajev ter pomalem pri razvoju računalniških rešitev. Če ne bi prejel povabila s fakultete, da se zaposlim kot asistent-stažist, bi verjetno končal v industriji. Tako pa sem, zopet skoraj da slučajno, pristal v akademskih vodah. V začetku sem se nekoliko lovil, a sčasoma sem dojel ustroj akademskega sveta, se mu prilagodil in po nekaj vzponih in padcih s 43 leti postal redni profesor.

1.2 Od začetka - zaposlitev na Fakulteti za računalništvo in informatiko

Fakulteta za računalništvo in informatiko Univerze v Ljubljani (v nadaljevanju UL FRI) je bila moj prvi in edini delodajalec. Začel sem kot asistent v Laboratoriju za informatiko, ki ga je takrat vodil prof. dr. Marjan Krisper. Njegova sposobnost za pridobivanje aplikativno-raziskovalnih projektov je presegala takratne storilne zmožnosti laboratorija, saj je ob mojem prihodu imel samo enega člana. Raziskovalno delo je zato nekoliko trpelo, a projekti so bili zanimivi in z vsakim sem se nekaj novega naučil. Med drugim, kako težko je razvijati rešitve za realna okolja, kjer so večji izziv ljudje kot pa sama kompleksnost tehnologije.

1.3 Vključevanje v domače in mednarodne kroge

Po zaposlitvi na UL FRI sem se sčasoma tudi sam vključil v domače in mednarodne raziskovalne ter tudi strokovne kroge. Kot član programskega odbora sem sodeloval pri številnih mednarodnih konferencah, kot so: CAiSE, IEEE RE, IEEE RCIS, ICSOFT, POEM, DB &IS, ADBIS, ICSEA, IBIMA, ME, MUSE, ICIST, OTI ipd. V letu 2009 sem bil povabljen v programski svet priznane mednarodne konference CAiSE (*International Conference on Advances in Software Engineering*), ki je takrat veljala za eno pomembnejših na mojem ožjem raziskovalnem področju. V letu 2013 sem bil izbran za programskega predsednika IEEE konference RCIS 2014 (*Research Challenges in Information Science*) in isto leto tudi za položaj generalnega predsednika konference CAiSE 2016, ki je z več kot 300 udeleženci potekala v Ljubljani. V letu 2018 sem v vlogi generalnega predsednika vodil IEEE konferenco RCIS 2018 v Nantesu. Kot recenzent ali urednik sem sodeloval pri številnih revijah in konferencah.

Moje delo v domačih krogih je najbolj zaznamovalo sodelovanje v Slovenskem društvu informatika. V letih 2005-2013 sem bil aktivno vključen v organizacijo največje slovenske konference o informatiki (DSI), ki je takrat s 500 in več udeleženci potekala pod okriljem društva. V letih 2005-2007 sem vodil programski odbor konference in od 2008 do 2020 sodeloval kot član upravnega odbora društva.

1.4 Ustanovitev Laboratorija za podatkovne tehnologije

Leta 2009 sem na UL FRI ustanovil **Laboratorij za podatkovne tehnologije**. To je bil pomemben mejnik v moji karieri, ki je sovpadal tudi z ustanovitvijo spin-off podjetja **Optilab**. S skupino raziskovalcev (večinoma mladi raziskovalci in nekateri sodelavci

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Laboratorija za informatiko) smo se na pobudo in povpraševanja iz gospodarstva poglobljeno ukvarjali z analizo podatkov, predvsem s področja avtomobilskega in zdravstvenega zavarovanja. Razvijali smo algoritme in na njih temelječe informacijske rešitve, ki so bile v pomoč pri iskanju namernih ali nenamernih nepravilnosti v poslovanju. Področje je bilo raziskovalno in aplikativno zelo zahtevno in je dobro desetletje usmerjalo naše delo, tako v laboratoriju kot tudi v podjetju, s katerim smo ohranili tesne povezave. V tem obdobju sta nastali dve odlični doktorski nalogi [7, 3]. Leta 2011 nam je ARIS podelila priznanje za izjemne dosežke, povezana z omenjenim področjem [8].

Število članov se je v laboratoriju vsa leta povečevalo in s prihodom novih raziskovalcev so se širil tudi portfelj naših raziskovalnih interesov. Med drugim smo se ukvarjali s konceptom **pametnih mest** in v okviru tega z **elektronskim in mobilnim zdravstvom** kot enim izmed pomembnih stebrov omenjenega koncepta. V konzorciju s 25 podjetji in raziskovalnimi organizacijami smo razvijali različne rešitve, naloga našega laboratorija pa je bila povezovanje vseh rešitev v skupno **platformo pametnega mesta** [1]. Eden od rezultatov, ki je nastal v okviru omenjenega sodelovanja, je platforma **Vitabits** [1] za spremljanje pacientov na daljavo (telemedicina). Z dovoljenjem UL smo pravice intelektualne lastnine kasneje prodali zainteresiranemu podjetju, ki je rešitev plasiralo na trg.

Veliko napora smo v takratnem obdobju vlagali tudi v preučevanje **interneta stvari** (IoT) in aplicirali svoja dognanja v okviru različnih aplikativnih nalog. Z željo, da zainteresirani jasnosti prikažemo širino področja in številne rešitve, ki so postale mogoče z razmahom senzorike in sposobnostjo komunikacije med skorajda slehernimi napravami, smo ustanovili **IoT Demo Center**[2]. V njegovem okrilju smo izvedli številne zanimive zaključne naloge in izvedli več projektov po naročilu iz gospodarstva in državne uprave. Med zanimivejše sodi platforma **Common**, 2019-20 - *Community Monitoring Platform*, ki omogoča merjenje "utripa družbe"prek avtomatskega spremljanja digitalnih medijev [9]. Analiza podatkov ločuje med posameznimi družbenimi podskupinami, kot so *delovno aktivna populacija*, *upokojenci*, *invalidi*, *študenti* ipd. in omogoča avtomatsko zaznavo tem, s katerimi se posamezne družbene podskupine ukvarjajo ter njihov odnos do teh tem. Drugo pomembno platformo smo razvili v okviru projekta *Idejna zasnova in postavitev pilota ekosistema interneta stvari z algoritmičnimi orodji*, naročnik MJU, (2023-24). **IoT platforma**, ki je v okviru projekta nastala, predstavlja splošno rešitev za zajem podatkov v okviru državne uprave, njihov nadzor in upravljanje. V okviru pilotskega projekta je bila v sodelovanju z Direktoratom za stvarno premoženje na MJU njena uporabnost demonstrirana na primeru zbiranja podatkov za potrebe zagotavljanja energetske učinkovitosti stavb.

Zadnji večji zasuk v raziskovalnem kurzu našega laboratorija se je zgodil v letih 2019-2020, ko smo se začeli ukvarjati z **analizo besedil** in sčasoma s široko paleto raziskovalnih tem na področju **jezikovnih** in predvsem **govornih tehnologij** (strojno prevajanje, računalniška prepoznava govora, računalniška sinteza govora). V okviru projekta **RSDO**[3] (Razvoj Slovenščine v digitalnem okolju, MK, 2019-2022) smo razvili model za prepoznavo slovenskega govora, ki je v primerjavi s prejšnjim, edinim javno dostopnim modelom, dosegel bistveno višjo natančnost prepoznave[4]. Pomembno smo izboljšali tudi model za strojno prevajanje za jezikovni par Slovenščina, Angleščina ter razvili nevronski sintetizator za dva moška in en ženski glas[5]. Visoka natančnost modelov prepoznave in prevajalnikov je nakazovala, da so govorne tehnologije končno dozorele tudi za majhne jezike, kot je Slovenščina. Tehnologijo smo zato promovirali in predstavili v različnih okoljih in s pilotskimi projekti pokazali, kaj zmore, glej npr. [4, 5]. Univerza v Ljubljani nam je v želji po večji internacionalizaciji študija leta 2020 zaupala izjemno pomemno nalogo, in sicer razvoj sistema za sprotno prevajanje slovenskih predavanj v tuje jezike [2, 6]. Nastala je rešitev **Tolmač** (kasneje preimenovana v **Online Notes**[6]), ki združuje vse ključne govorne tehnologije, prepoznavo slovenskega jezika, prevajanje iz slovenščine v tuje jezike ter za slepe in slabovidne tudi sintezo besedila. Študenti, ki ne morejo slediti slovenskim predavanj, lahko prek spletne ali mobilne aplikacije spremljajo prevode v živo, kasneje pa lahko posnetke pregledujejo in si urejajo svoje zapiske ter delijo z drugimi študenti. Rešitev je bila pilotno preskušena na šestnajst članicah Univerze v Ljubljani in s šolskim letom 2024/25 prehaja v produkcijsko delovanje.

Zaradi velikega povpraševanja po tovrstnih rešitvah smo leta 2018 z dovoljenjem upravnega odbora UL ustanovili spin-off **Vitasis**[7], ki je danes vodilno podjetje na področju razvoja govornih tehnologij. Rešitve podjetja Vitasis se uporabljajo v zdravstvenih domovih, bolnišnicah, občinah, Državnem zboru, SDH, Telekomu Slovenije in v drugih ustanovah. Govorne in jezikovne tehnologije ostajajo prednostno raziskovalno področje laboratorija tudi v prihodnje, saj smo vpeti v tri večje nacionalne projekte:

- Temeljne raziskave za razvoj govornih virov in tehnologij za slovenski jezik (**MEZZANINE**[8]), ARIS, 2022-2025,
- Prilagodljiva obdelava naravnega jezika s pomočjo velikih jezikovnih modelov (**PoVeJMo**[9]), ARIS, 2023-2025 ter
- Veliki jezikovni modeli za digitalno humanistiko (**LLM4DH**), ARIS, 2024-2026

Sodelujemo tudi v zanimivem projektu **Proteverb**[10] - *Pravni, etični in tehnološki vidiki obdelave besedilnih in govornih virov podatkov za znanstvene, raziskovalne in razvojne namene*, MDP, 2022-2024, katerega cilj je preučiti vse relevantne vidike in pripraviti podlago, ki bo raziskovalni sferi omogočala lažji ter obenem varen dostop do podatkov, ki so lahko ključni za raziskave in razvoj novih tehnoloških rešitev.

Če smo z domačim gospodarstvom ves čas tesno sodelovali, pa je bila naša vključenost v mednarodne projekte (predvsem imam tu v mislih projekte iz EU programov FP6, FP7 in Horizon) v prvih desetih letih obstoja laboratorija precej manjša. Zavedajoč se, da so za pridobivanje in še posebej izvajanje EU projektov potrebna specifična znanja, smo se po 2019 kadrovsko okrepili prav z namenom, da pridobimo kompetence tudi na tem področju. Danes smo s sodelavci laboratorija vključeni v šest evropskih projektov, EBSI-VECTOR (2023-25)[11], BUILDCHAIN (2023-25)[12], TRUSTCHAIN (2023-25)[13], ACES (2023-25)[14], EXTREMEXP (2023-25)[15] in ESSA (2020-24)[16].

[1] https://vitabits.eu/
[2] http://iot.data-lab.si/
[3] https://rsdo.slovenscina.eu/
[4] https://slobench.cjvt.si/
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[13] https://trustchain.ngi.eu/
[14] https://www.aces-edge.eu/
[15] https://extremexp.eu/
[16] https://softwareskills.eu/

2 Pedagoško delo

S pedagoškim delom sem se začel ukvarjati že pred zaposlitvijo na UL FRI, saj sem predaval na računalniških tečajih. Predavanja so mi bila vedno v veselje, če sem se le čutil suveren na področju, ki sem ga predaval. Posledično sem v pripravo na predavanja vedno veliko vlagal. V prvih letih dela na fakulteti sem izvajal števila izobraževanja za gospodarstvo, s povečevanjem pedagoške obremenitve na lastni fakulteti pa sem to sčasoma opustil. Danes sem nosilec treh predmetov, *Razvoj informacijskih sistemov* in *Osnove podatkovn ih baz* na dodiplomskem univerzitetnem študeuiju ter *Iskanje in ekstrakcija podatkov s spleta* na podplomskem študiju.

Kot mentor sem sodeloval pri nekaj sto diplomskih in magistrskih nalogah ter kot mentor usmerjal 10 doktorskih študentov. Slednje mi je bilo vedno v veliko veselje, čeprav je mentoriranje doktorskega študenta vse prej kot enostavna naloga. Danes lahko z zadovoljstvom spremljam njihov razvoj in uspešne kariere: dva sta na pomembnih položajih v gospodarstvu, eden je lansko leto postal redni profesor, še dva pa sta zelo blizu te habilitacijske stopnje.

3 Vodstvene funkcije

Vključevanje v vodstvene strukture je nekaj, čemur se profesor na Univerzi v Ljubljani težko izogne. Tako sem bil prodekan za gospodarske zadeve en mandat in pol, od leta 2013 do 2019, član Senata UL FRI vse od leta 2013, član Upravnega odbora UL FRI od leta 2010 naprej ter od 2019 naprej njegov predsednik, predsednik Komisije za Razvoj informacijskega sistema UL (KRIS) vse od leta 2016 naprej. Laboratorij za podatkovne tehnoloije vodim od njegove ustanovitve leta 2009. Od leta 2016 vodim IoT Demo Center na UL FRI. Vmes sem en mandat vodil Katedro za informatiko. V obeh spin-off podjetji sem nastopal kot prokurist, kar je s stališča UL oziroma UL FRI dovoljeno, saj ne vstopa na področje konkurenčne prepovedi.

4 Dosežki

Med najpomembnejše dosežke v svoji karieri štejem nagrado **Mentor leta**, ki mi jo podelilo Slovensko društvo doktorskih študentov leta 2014. Nagrade sem bil izjemno vesel, saj mi je dala potrditev, da me doktorski študenti spoštujejo in cenijo moja usmerjanja, v kar sem sam pogosto dvomil. Pod mojim mentorstvom je do danes doktoriralo osem študentov, še dva pa sta na tej poti.

Ponosen sem tudi na priznanja, ki sem jih prejel za svoj doprinos na področju **prenosa znanja** iz akademskega okolja v gospodarstvo. Leta 2010 mi je takšno priznanje podelilo Slovensko društvo informatika, leta 2013 pa programski svet mednarodne konference Informacijska družba.

Pomembno mesto med nagradami ima tudi **Zlata plaketa** za izjemne dosežke na pedagoškem in znanstvenem področju, ki mi jo je Univerza v Ljubljani podelila leta 2014.

Med ključne dosežke s ponosom štejem tudi dve **spin-off** podjetji, ki sem ju v svoji karieri pomagal ustanoviti in sta nastali na temelju odličnih raziskovalnih rezultatov moje raziskovalne skupine. Čeprav se z veseljem ukvarjam s temeljnimi raziskavami, mi je še v večje veselje, ko iz raziskav nekaj konkretnega nastane in pripomore k reševanju praktičnih problemov. Pri obeh podjetjih sem bil vključen v njun začetni razvoj in pomagal pri njunem strateškem usmerjanju ter pozicioniranju na trgu.

Nenazadnje, ponosen sem na svoj laboratorij, **Laboratorij za podatkovne tehnologije**, ki kljub velikim izzivom s pridobivanjem kakovostnega kadra ves čas raste in danes šteje 32 raziskovalcev, kar ga tako po številu članov kot finančnih prihodkih uvršča na prvo oziroma drugo mesto na fakulteti.

5 Zaključek

Kot sem zapisal na začetku, sem postal računalničar bolj kot ne po naključju. A to naključje štejem kot srečno, saj danes zagotovo vem, da me računalništvo oziroma konkretneje reševanje izzivov z računalnikom zares veseli. To nedvomno prispeva tudi k drugim vidikom mojega profesionalnega udejstvovanja. V prispevku sem izpostavil nekaj svojih dosežkov, ki mi ta trenutek največ pomenijo. Črto pod svoje življenjsko delo pa bom lahko potegnil šele čez dobrih 13 let. V tem času me zagotovo čaka še veliko izzivov.

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Povzetek

Prispevek osvetli preteklo življenjsko pot Boruta Robiča skozi razna področja matematike, računalništva in glasbe.

Abstract

The article sheds light on Borut Robič's past journey through various areas of mathematics, computer science, and music.

Ključne besede

optimization, algorithm, parallel computing, parallel algorithm mapping, computational complexity, computability

Keywords

optimizacija, algoritem, vzporedno računanje, preslikavanje vzporednih algoritmov, računska zahtevnost, izračunljivost

1 Osnovno

Borut Robič se je rodil 12. julija 1960 v Postojni. Osnovno šolo je do 1972 obiskoval v Idriji in v prostem času v vlogi Vinetouja ali Old Shatterhanda vzdrževal red in pravičnost na tamkajšnjih ulicah. Šolanje je nadaljeval na OŠ Franceta Bevka v Ljubljani. Tam mu je natančna in zahtevna učiteljica Bogomila Hude privzgojila ljubezen do matematike, za kar ji je neskončno hvaležen.

Po vpisu na gimnazijo Bežigrad v Ljubljani, v razred z intenzivnim programom matematike, je njegovo zanimanje za to lepo vedo še naraščalo, zdaj pod vplivom profesorice Sonje Plevnik. Leta 1978 je z odliko maturiral.

Pravijo, da se matematika in glasba dopolnjujeta; res, tudi Borut je sočasno obiskoval in končal nižjo in srednjo glasbeno šolo Franca Šturma v Ljubljani.

2 Študij in izpopolnjevanja

Po kolebanju ali naj na UL FMF študira matematiko ali fiziko je po nasvetu staršev izbral študij elektrotehnike na UL FE. Pravijo tudi, da stara ljubezen ne zarjavi; in res, že v prvem semestru se je odločil, da bo med kasnejšimi študijskimi usmeritvami izbral Računalništvo in informatiko, kjer je bilo videti največ zanimivih, matematično obarvanih predmetov.

Do diplome so nanj strokovno in osebnostno močno vplivali mnogi visokošolski učitelji, posebej Gabrijel Tomšič (matematika), Boštjan Vilfan (algoritmi in podatkovne strukture), Ivan Bratko (algoritmi in podatkovne strukture), Dušan Kodek (računalniške arhitekture). Pod mentorstvom Tomaža Pisanskega je 1984 z odliko diplomiral in za to prejel dekanovo priznanje.

Tega leta se je Borut vpisal na magistrski študij Računalništva in informatike na isti fakulteti. Zdaj so nanj močno vplivali učitelji Boštjan Vilfan (algoritmi, izračunljivost, računska zahtevnost, algebra), Zvonimir Bohte (numerična analiza, končna aritmetika) in Anton Suhadolc (funkcionalna analiza). Leta 1987 je z odliko magistriral pod mentorstvom Boštjana Vilfana z delom *Minimizacija števila procesorjev v podatkovno pretokovni arhitekturi*. To je problem kombinatorične optimizacije v vzporednem računanju, kjer želimo s primernim zadrževanjem pripravljenih ukazov minimizirati število uporabljenih procesorjev, ne da bi se čas izvajanja vzporednega programa podaljšal preko teoretično najmanjšega možnega.

Z doktorskim študijem je Borut nadaljeval 1988 po služenju vojaškega roka. Leta 1993 je doktoriral s področja računalniških znanosti na UL FER pod mentorstvom Boštjana Vilfana z disertacijo *Optimizacija preslikav vzporednih algoritmov na regularna procesorska polja*. Gre za NP-težek optimizacijski problem v vzporednem računanju, kjer želimo poljuben vzporedni program – predstavljen z usmerjenim grafom, katerega točke so ukazi, povezave pa podatkovne odvisnosti med ukazi – preslikati na množico heksagonalno, kot v satovju povezanih procesnih elementov, da bodo komunikacijske poti med preslikanimi ukazi minimalne. Ker je procesnih elementov končno mnogo, lahko s takim preslikavanjem na procesorsko polje naložimo večje vzporedne programe ali pa sočasno več vzporednih programov.

Kot dobitnik podoktorske štipendije Partridge Visiting Fellowship, ki mu jo je podelila Univerza v Cambridgu, je 1996 gostoval na Fitzwilliam Collegeu in University of Cambridge Computer Laboratory. Tu je obravnaval problem usmerjanja podatkov v 2-krožnih omrežjih tj. neusmerjenih grafih $G(n;a;b)$ s točkami $\{0,1,\ldots,n-1\}$ in povezavami $\{i, i+a \pmod n\}$ in $\{i, i+b \pmod n\}$.

3 Raziskovalna in strokovna dejavnost

Leta 1984 se je zaposlil na Institutu Jožef Stefan v Ljubljani, na Odseku za računalništvo in informatiko, leta 1994 na Odseku za računalniške sisteme, od 1997 pa je zaposlen na Fakulteti za računalništvo in informatiko, UL.

Raziskovalno je deloval na področjih optimizacije podatkovno pretokovnega računanja; vzporednega računanja; razvoja in analize algoritmov za probleme kombinatorične optimizacije; teorije računske zahtevnosti in teorije izračunljivosti.

Bil je vodja raziskovalnega programa in vodja ali sodelavec domačih in mednarodnih raziskovalnih projektov, slednjih predvsem z Univerzo v Grenoblu ter njenima institutoma TIMA in LMC-IMAG. Tu je nanj močno vplival Denis Trystram, vodja institutov. Skupne raziskave so se nanašale na preslikavanje vzporednih algoritmov na večprocesorske sisteme raznih topologij.

Na področju teorije izračunljivosti je s konstrukcijo bijektivne preslikave med univerzumoma Σ^* in $\mathbb{N}$ potrdil, da lahko obravnavo odločljivosti, polodločljivosti ali neodločljivosti formalnih jezikov nadomestimo z obravnavo odločljivosti, polodločljivosti ali neodločljivosti množic naravnih števil, in obratno. Ugotovitve, ki veljajo v enem, veljajo tudi v alternativnem univerzumu.

Raziskovalno delo je dokumentiral kot avtor ali soavtor znanstvenih monografij v tujini (4) in doma (2), izvirnih znanstvenih člankov (45) in prispevkov na znanstvenih konferencah (61).

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Navedimo le znanstvene monografije [**1**, **2**, **3**, **4**] v tujini:

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Zadnja monografija je učbenik na Univerzi v Sieni in tudi na Tehnični univerzi v Münchenu. Pri njeni pripravi je z Borutom sodeloval Benjamin Wells z Univerze v San Franciscu, zadnji doktorand Afreda Tarskega.

Kot recenzent je Borut sodeloval pri vrsti tujih znanstvenih revij in uredniških odborov znanstvenih konferenc.

4 Pedagoška in mentorska dejavnost

Prve pedagoške izkušnje je dobil na Srednji šoli za računalništvo v Ljubljani (Vič), kjer je ob zaposlitvi na IJS poučeval računalništvo v š.l. 1984/85. Leta 1985 je sodeloval pri izvajanju programa računalniškega opismenjevanja v Gorenju iz Velenja. V tečaj je bilo zajetih okoli dva tisoč delavcev.

Leta 2004 je bil na Univerzi v Ljubljani izvoljen v naziv redega profesorja za področje računalništva in informatike. Odtlej je na UL FRI predaval predmete na dodiplomskem, magistrskem in doktorskem študiju. Bil je mentor diplomantom (80), magistrom (19) in doktorjem (6) računalništva in informatike.

5 Organizacijska dejavnost

Danes je Borut Robič na UL FRI vodja Laboratorija za algoritmiko, predstojnik Katedre za teoretično računalništvo in zadnjih dvajset let tudi predsednik Akademskega zbora fakultete.

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Marjan Krisper karierna pot in dosežki

Marjan Krisper Career Path and Achivements

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Povzetek

Prispevek govori o karierni poti in dosežkih na področju računalništva in informatike. Predstavljene so njegovo pedagoško delo in razvojno-raziskovalna dejavnost doma in na tujem.

Ključne besede

Marjan Krisper, računalništvo, informatika, pedagoška in razvojno-raziskovalna dejavnost

Abstract

The paper is about Marjan Krispers life path in the field of computing and informatics. His educational and developmental-research activities at home and abroad re intertwined.

Keywords

Marjan Krisper, computer science, informatics, educational and developmental- research acti

1 Karierna pot in dosežki

Na Fakulteti za strojništvo v Ljubljani sem diplomiral leta 1971 in se leta 1972 zaposlil kot raziskovalni asistent. Za asistenta pri predmetih Tehnična kibernetika in Konstruiranje krmilnih sistemov sem bil izvoljen leta 1976.

Magistriral sem v letu 1977. V času zaposlitve na Fakulteti za strojništvo sem delal na razvoju programske opreme za krmiljenje procesov, na razvoju informacijskih sistemov za upravljanje proizvodnje in na drugih aplikacijah poslovne informatike. Programiral sem v Fortranu na IBM 1130, Asemblerju na procesnem računalniku IBM S7, in DEC računalnikih PDP8 in PDP11. Sodeloval sem pri uvajanju NC tehnologije v okviru povezav Fakultete za strojništvo z industrijo.

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Leta 1978 sem bil imenovan za svetovalca predsednika Republiškega komiteja za družbeno planiranje in informacijski

sistem, kjer sem delal na razvoju organizacijske in tehnološke baze Družbenega sistema informiranja (DSI), programu modernizacije državne uprave z informacijsko tehnologijo, načrtovanju razvoja javnega omrežja za prenos podatkov, na pripravi kriterijev za izbiro računalniške opreme ipd. Bil sem predsednik oz. član strokovnih komisij v republiški upravi za izbiro in uvajanje računalniške opreme oz. za modernizacijo državne uprave.

Ob ustanovitvi Centra za družbeni sistem informiranja in informatiko v okviru republiške uprave sem bil imenovan za pomočnika direktorja, kjer sem nadaljeval delo na navedenih področjih. V letu 1981 sem bil habilitiran za višjega predavatelja in predaval na ,VEKŠ Univerze v Mariboru na dodiplomskem in podiplomskem študiju predmete iz področja poslovne informatike.

V Komisiji za smernice študija računalništva in informatike sem bil kot predstavnik vlade, ki jo je vodil prof. dr. Jernej Virant. Izdelali smo smernice za 4-letni program s tremi profili: logika in sistemi (kasneje računalniški sistemi), programska oprema in informatika. Tako je na Fakulteti za elektrotehniko [FE] nastal program s temi smermi, ki so veljale vse do bolonjske reforme. Sam sem bil zadolžen za oblikovanje programa informatike.

Leta 1982 sem bil prvič habilitiran za docenta na Fakulteti za elektrotehniko v Ljubljani za predmete iz področja informatike oz. informacijskih sistemov: Sistemska informacijska analiza, Razvoj informacijskih sistemov, Osnove informatike, Osnove informacijskih sistemov, Družbeni sistem informiranja.
Doktoriral sem na Centru za multidisciplinarne študije Univerze v Beogradu na temo: Ekspertni sistem za merjenje, spremljanje in napovedovanje družbenega razvoja.

Leta 2007 sem bil prvič izvoljen v naziv izredni profesor. V okviru starega programa dodiplomskega študija sem predaval predmete: Informacijski sistemi, Razvoj informacijskih sistemov, Planiranje in vodenje informacijskih sistemov in Informacijska družba. V okviru podiplomskega študija sem predaval predmete: Informacijski sistemi, Teorija informacijskih sistemov in Planiranje in obvladovanje informatike v poslovnih sistemih.

Na Ekonomski fakulteti , sem v okviru podiplomskega študija, predaval predmet Proizvodni informacijski sistemi. Po upokojitvi sem v letih 2021 in 2022 predaval na Univerzi na Primorskem, FAMNIT, predmet Management informacijskih tehnologij.

Od ustanovitve Fakultete za računalništvo in informatiko leta 1996 , do leta 2014 sem bil predstojnik katedre za informatiko. Moja raziskovalna področja so Informacijski sistemi, Razvoj informacijskih sistemov, Strateško planiranje informatike, Prenova poslovnih procesov in informacijskih sistemov ter Poslovno informacijska arhitektura. Od ustanovitve do upokojitve sem bil predstojnik laboratorija za informatiko.

Sodeloval sem z gospodarskimi in drugimi organizacijami in vladnimi inštitucijami na projektih razvoja informacijskih sistemov, strateškega planiranja, prav tako pa tudi na raziskavah dolgoročnega razvoja tehnologije oz. strategije tehnološkega razvoja.

Vodil sem številne informacijske projekte, tako za javno upravo ter državne organe kot tudi za večja slovenska podjetja. Že v osemdesetih letih (dediščina mojega dela v državni upravi) smo delali za javni sektor (izbira sistema za upravljanje z bazami podatkov za državno upravo), v 90 letih pa izdelali številne strateške dokumente, predvsem za večja slovenska podjetja (Petrol, PTT, Slovenske železnice, Mobitel, Telekom, Klinični center, prenova in vzpostavitev Centralnega registra prebivalstva)
Bil sem vodilni avtor metodologije EMRIS (Enotna metodologija razvoja informacijskih sistemov), ki je bila dolga leta temeljna metodološka usmeritev vseh informacijskih projektov v javni upravi. Prav tako sem sodeloval v strokovnih telesih v državni upravi na področjih informatike, tehnološkega razvoja in družbenega razvoja, med drugem sem bil član programskega sveta za projekte e – uprave (2000- 2004) Vodil sem delovno skupino za izdelavo Strategije razvoja e-uprave RS za obdobje 2000-2004.

Na področju mednarodnega sodelovanja sem z Laboratorijem za informatiko vzpostavil številne stike, predvsem z Merick School of Business Univerze v Baltimoru, z Univerzo Aix - Marseille, Univerzo v Celovcu, kjer sem imel tudi vabljena predavanja. Bil sem tudi predstavnik Slovenije v upravnem odboru COST A3 projekta Management and New Technology. Leta 1986 sem bil na krajši špecializaciji na London School of Economics and Political Science.

V letu 2005 sem postal predstavnik Slovenije v IFIP TC8 (Informacijski sistemi). Leta 2005 sem bil izvoljen za predsednika AIS (Association of Information Systems) oddelka za Slovenijo z začetkom mandata v letu 2006.

V letih 2004, 2006, 2009 in 2010 sem uspešno kandidiral na razpisu ARRS za mentorja mladim raziskovalcem in s tem postal mentor štirim mladim raziskovalcem.
Bil sem član več znanstvenih in strokovnih združenj, med drugim ustanovitveni član AIS (Association of Information Systems) svetovne zveze univerzitetnih učiteljev informacijskih sistemov, ter Slovenskega društva informatika, Društva za umetno inteligenco, IEEE in PMI (Project management institute).

2 Priznanja

Zaradi pomembnega prispevka k uvajanju sodobnih konceptov gradnje informacijskih sistemov v prakso sem leta 2000 od Slovenskega društva INFORMATIKA dobil posebno priznanje. V letu 2017 sem dobil prestižno priznanje Michie - Turing za življenjsko delo pri razvoju informacijske družbe.

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Dosežki kandidata Devida Palčiča

Achievemens of the candidate Devid Palčič

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POVZETEK

Devid Palčič verjetno ni najbolj tipičen predstavnik skupnosti računalništva in informatike, saj se v svojem profesionalnem življenju ukvarja predvsem z avtomatizacijo, kar pomeni da računalnike uporablja za to, da vplivajo na fizičen svet. Avtomatizacijo navadno povezujemo z industrijo (»industrijska avtomatizacija) in tudi Devid je avtomatizacijo najprej apliciral v stroje in procese, vendar je kmalu ugotovil, da lahko iste principe uporabi drugje, pravzaprav kjerkoli.

Tako so računalniki zasedli stavbe, energetiko, mesta, infrastrukturo in še marsikaj. Pri tem jim je Devid Palčič izdatno pomagal.

KLJUČNE BESEDE

Avtomatizacija, IOT, več ciljna optimizacija, umetna inteligenca.

ABSTRACT

Devid Palčič is probably not the most typical representative of the computing and information technology community, as in his professional life he primarily deals with automation, which means he uses computers to influence the physical world. Automation is usually associated with industry ("industrial automation"), and Devid initially applied automation to machines and processes. However, he soon realized that the same principles could be used elsewhere, in fact, anywhere.

Thus, computers have taken over buildings, energy, cities, infrastructure, and much more. In this, Devid Palčič has significantly contributed.

KEYWORDS

Automation, IOT, multi-objective optimization, AI.

1 ZAČETKI

Devid Palčič se je z računalništvom »okužil« na informativnem dnevu za vpis v srednjo šolo, ko se je kot prva generacija »Usmerjenega Izobraževanja« vpisoval na Srednjo Pedagoško in Naravoslovno šolo Koper[i]-SPNMŠ. To je bil TRS-80[ii], ki ga je dijakom dal na voljo kar profesor Aljoša Žerjal. Programski jezik Basic in kasneje tudi Assembler, oziroma kar strojni jezik za procesor Zilog Z-80 so bili tako zanimivi, da se je manjša skupina dijakov borila za čas preživet za tipkovnico. Obdobje srednje šole je bilo polno novih znanj ter prvih dosežkov, kot so uspeh v tekmovanju v izdelavi računalniških igric.

Je pa čas srednje šole pokazal, da se da z računalniki tudi zaslužiti. Skupina dijakov SPNMŠ je sodelovala pri takrat eksotičnih storitvah. Obdelovali so podatke šolskih tekmovanj, izobraževali dijake in starejše ter se spogledovali s podporo računovodstvu, ki je tedaj bilo preprosto: peš.

Delo ni ostalo neopaženo. Ko je bila v Jugoslaviji fizikalna olimpijada, je IBM posodil svoj najnovejši dosežek: IBM PC Junior[1]. Celotna obdelava podatkov je bila izvedena na teh računalnikih in to tako dobro, da se je IBM odločil računalnike podariti: to so bili prvi računalniki tega tipa v Vzhodni Evropi.

V približno tistem času, je Devid Palčič izdelal svoj prvi računalnik. To je bil računalnik Galaksija[iii] narejen po načrtih objavljenih v reviji, kar je dalo

[1] IBM PCjr - Wikipedia

dovolj izkušenj in znanja za načrtovanje drugega računalnika, ki pa je že bil nov, unikaten izdelek, ki je znal krmiliti stroj za sestavljanje kabelskih čevljev. S tem je Devid avtomatiziral stroj svojega očeta in mu povečal produktivnost.

Odločitev za študij elektrotehnike, točneje avtomatike in še natančneje robotike, je tako bila logična.

Študij je bil čisti užitek, diploma pri prof. Bajdu[iv] pa tudi. Diploma je bila praktična in v njenem okviru je bil robot Yaskawa prvič predelan tako, da je bilo krmiljenje izvedeno po poziciji in sili, kar je bilo uporabljeno za ščetkanje okvirja mopeda Tomos Avtomatic.

2 RAZVOJNO DELO

Devid Palčič se je zaposlil v podjetju Tomos Koper, kjer so prevladovali strojniški poklici, inženirji elektrotehnike so bili redki. Takšen je bil tudi pristop k avtomatizaciji: veliko strojniških rešitev, nekaj relejne logike, zelo malo ali nič računalnikov.

Devid je uvedel Programabilne krmilnike (PLC), uporabniške vmesnike in povezavo na osebne računalnike, ki seveda niso uporabljali SCADA in podobnih sistemov, tako da je bila programska oprema napisana v programskih jezikih, kot so C in Delphi.

V slabih dveh letih je ekipa enajstih ljudi, ki jih je vodil Devid Palčič, hkrati pa je bil edini inženir elektrotehnike, zasnovala in izdelala osem zahtevnih strojev in proizvodnih linij. Najzahtevnejša je bila linija za kemično obdelavo motornih valjev, kjer so bili integrirani PLC, servo-motorji in osebni računalnik za upravljanje, poročanje in parametrizacijo.

Rešitev so opazili v podjetju Hitachi in predlagali sodelovanje, vendar je takrat Tomos že bil v velikih težavah, tako da ni imel interesa z nove izzive, zato se je ekipa sporazumno razšla, Devid pa je ustanovil podjetje Robotina[v] d.o.o. in ga usmeril v sistemsko integracijo na področju industrijske avtomatizacije.

3 PODJETNIŠKI ZAČETKI

Pisalo se je leto 1990 in slovenska industrija je potrebovala rešitve, do katerih ni imela dostopa. Avtomatizacija je bila nujna, vendar ni bila dosegljiva, tako da bilo obdobje zaznamovano z nadgradnjami, dopolnitvami in izboljšavami. Na obstoječe in nove naprave se je dograjevala avtomatizacija, posamični stroji so se združevali v linije, računalniki pa so prevzemali vse večjo vlogo.

Devid je v tem obdobju dejansko usmeril podjetje v sistemsko integracijo, pri tem pa je uporabljal izdelke svetovnih proizvajalcev PLC in druge opreme, še najbolj Hitachi.

Hitachi je bil odličen, vendar ni ponujal vseh potrebnih modulov, Tako, da so v Robotini razvili prvi izdelek – najprej seveda zase. Modul RT-60, ki je omogočal neposreden priklop Pt-100 temperaturnih senzorjev na PLC Hitachi, so takoj sprejeli drugi uporabniki tega PLC-ja v Evropi in drugje po svetu. Uporabljene so bile rešitve, za katere se je izkazalo, da jih drugi ne, kar je rezultiralo v večji točnosti in ponovljivosti, tako da ga je na koncu začel kupovati tudi Hitachi.

Že prvi izdelek je bil razvit na osnovi usmeritve, ki jo je uvedel Devid: »če uporabiš računalnik, izkoristi njegove prednosti, namesto, da poskušaš računalnik uporabiti na tak način, kot bi delal avtomatiko brez računalnika«.

Sledilo je še več podobnih izdelkov najintenzivneje pa je bilo sodelovanje takrat, ko je Robotina za Hitachi predelala frekvenčne pretvornike v IP-54 zaščito, ob tem pa razvila še več vmesnikov in drugih rešitev.

Poslovanje podjetja je raslo, osvajali so nove trge, hkrati pa so ugotovili, da izdelek, kot ga želijo ne obstaja.

Padla je odločitev: »gremo razvit svoj PLC«.

4 CYBRO

Zahteve za nov PLC, ki se je kasneje izkazal za novo krmilno platformo, je Devid zapisal zelo enostavno: majhen distribuiran krmilnik, ki bo imel pametne module (vsak s svojim procesorjem), te moduli bodo lahko blizu ali pa narazen, dodajanje modulov ne sme zmanjšati hitrosti, moduli so lahko v razdelilni omari ali kjerkoli. K temu je dodal še zahtevo, da je možno izdelati sistem za avtomatsko generiranje aplikativne programske kode in da je rešitev primerna za industrijo ter stavbe.

Naloga je bila izjemno zahtevna. Celotna ekipa je vložila vse svoje znanje in prišla do prvega prototipa, ki pa ni izpolnil zahtev, tako da je bilo za uporaben izdelek potrebno še korenito spremeniti posamične rešitve.

Prva res uporabna generacija izdelkov je bila CYBRO-2. Na tržišču je bila uspešna več kot 18 let, leta 2019 pa jo je nadomestila nova, sodobna platforma Cybro-3.

5 NAPREDNE REŠITVE

Avtomatizacija je reševala probleme v industriji, hkrati pa se je Robotina vse bolj usmerjala tudi na druga področja, kot so stavbe, mesta in energetika. Intenziven razvoj je pripeljal do velikih razvojno raziskovalnih projektov, ko je sodelovala z inštituti, univerzami in drugimi partnerji. Pri tem je prišlo do sodelovanja z Institutom »Jožef Stefan«[vi], s oddelkom, ki ga je vodil prof. Matjaž Gams in skupaj je bila razvita rešitev za več ciljno optimizacijo (multi objective optimization) ki je bila uporabljena v več rešitvah. Sodelavec je na tem področju tudi opravil doktorat.

Devid Palčič je zasnoval več kot 100 izdelkov, sodeloval pri več patentih in volil številne raziskovalne in razvojne projekte, fokus v prihodnosti pa je obvladovanje celotne verige od avtomatizacije, računalništva na robu, pa naprednih digitalnih storitev, ki vključujejo strojno učenje in umetno inteligenco.

6 SODELOVANJE

Devid je prepričan, da je sodelovanje ključ do napredka za vse. Znanje je edina dobrina, ki se z deljenjem povečuje, zato aktivno sodeluje pri aktivnostih za katere verjame, da lahko prinesejo napredek osebam, podjetjem in družbi.

Sodeloval je pri projektu NEDO, ko je Japonska tehnološka agencija v Sloveniji skupaj s slovensko industrijo izvedla izjemno demonstracijo pametnih omrežij. Sodeloval je pri oblikovanju več SRIP-ov in tehnološke mreže, kjer je tudi član upravnih odborov. Je dolgoletni član upravnega odbora združenja za Inženiring GZS, bil pa je tudi član »Smart City Council«. Prejel je več nagrad, med drugim Nagrado GZS za izjemne gospodarske dosežke.

Ker verjame, da je potrebno znanje širiti in da nas lahko samo znanje ter inovativnost usmerita v prihodnost, Devid že od začetka predava priložnosti in izzive pametnih omrežij na Akademiji Gradbenih Investicij (AGI)[vii]. Tam poudarja pomen digitalne pretvorbe in IoT za vsa področja investicij in življenja.

Na koncu, tehnologije ki prihajajo, oziroma so že tu, so tako pomembne, da jih moramo spoznati, širiti, hkrati pa pomagati razbiti kak tabu. Zato je potrebno razširiti znanje in zavedanje, tako se mora računalništvo, informatika, IoT, umetna inteligenca in druge tehnologije razširiti in postati široko uporabljene v vseh segmentih družbe.

Devid in Robotina so dokazali, da lahko tudi male in inovativne ekipe zmagujejo in sodelujejo z najboljšimi. Če bomo s to prakso še koga okužili, bomo vsi uspešnejši.

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Moja pot skozi 44 let dela na področju računalništva in informatike

My journey through 44 years of work in computer science and information technology

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Povzetek

V prispevku je prikazanih mojih 44 let delovanja na področju računalništva in informatike. Predstavil bom svoje pedagoško, strokovno in raziskovalno delo.

Ključne besede

Milan Ojsteršek, paralelno procesiranje, heterogeni računalniški sistemi, spletne tehnologije, procesiranje naravnega jezika, nacionalna infrastruktura odprte znanosti, interoperabilnost, akademska integriteta.

Abstract

This paper highlights my 44 years of work in the field of computer science and information technology. I will present my teaching, professional and research work.

Keywords

Milan Ojsteršek, parallel processing, heterogeneous computing systems, web technologies, natural language processing, national openscience infrastructure, interoperability, academic integrity.

1 Prvih štirinajst let dela na področju računalništva in informatike

Z računalniškim programiranjem sem se spoznal leta 1980 v prvem letniku študija elektrotehnike na Visoki tehniški šoli v Mariboru. Programirali smo v programskem jeziku FORTRAN. Uporabljali smo luknjane kartice, ki smo jih dajali v zaporedno obdelavo preko čitalnika kartic na IBM 1130. Programiranje me je takoj začelo zanimati, zato sem v tretjem letniku nekaj časa sodeloval v laboratoriju prof. dr. Bogomirja Horvata pri programiranju mikroračunalniškega krmilnika, ki je uporabljal procesor Motorola 6800. V četrtem letniku sem izbral izbirni predmet Sistemsko programiranje, pri katerem sem se naučil programirati v programskem jeziku Pascal.

V okviru moje diplomske naloge sem izdelal simulator podatkovno vodenega računalnika. Za diplomsko nalogo sem prejel Kidričevo nagrado za študente. Oktobra 1984 sem se kot raziskovalec-stažist zaposlil v Laboratoriju za računalniške arhitekture in jezike, ki ga je vodil prof. dr. Viljem Žumer. Še dve leti sem v okviru raziskovalnega projekta nadgrajeval simulator podatkovno vodenega računalnika in objavil nekaj člankov, ki so bili vezani na arhitekturo in programske jezike za podatkovno vodene računalnike. Kasneje sem to arhitekturo nadgradil v paralelni računalniški sistem, ki je bil neobčutljiv na odpovedi posameznih procesnih enot in vozlišč v večstopenjskih medprocesorskih mrežah.

V obdobju od 1986 do 1988 sem sodeloval pri projektu izgradnje mikroračunalniškega krmilnika za Metalno v Mariboru. Na tem projektu smo programirali simulator in interpreter namenskega programskega jezika IMCL, ki je bil uporabljen za programiranje industrijskih mikroračunalniških krmilnikov. V tem času smo s kolegi iz laboratorija dobili idejo za izdelavo paralelnega podatkovno vodenega računalnika, ki deluje v realnem času. Izdelali smo prevajalnik za lastni podatkovno voden jezik DFCL in simulator podatkovno vodenega računalnika, ki deluje v realnem času. Rezultat mojega raziskovalnega dela na tem področju je bilo nekaj mednarodnih objav in magistrska naloga z naslovom "Model makro podatkovno vodenega računalnika, primernega za delo v realnem času", ki sem jo zagovarjal leta 1991.

V obdobju od 1987 do 1989 sem sodeloval v projektu Parsys, ki smo ga izvajali za podjetje Iskra Delta. V tem projektu smo gradili paralelni računalniški sistem za jugoslovansko vojsko. Na žalost je jugoslovanska vojska sredi leta 1989 zaradi predvidenega razpada Jugoslavije ukinila financiranje projekta. Sem pa v okviru tega projekta in v projektu za Metalno v Mariboru dobil ideje za svoje delo na področju določanja razčlenjenosti vozlišč programskih grafov in njihovega razvrščanja v enote večprocesorskega računalnika. Junija 1994 sem zagovarjal doktorsko disertacijo z naslovom "Določitev razčlenjenosti vozlišč programskega grafa in njihovo razvrščanje

⋆ Moja pot skozi 44 let dela na področju računalništva in informatike
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v enote večprocesorskega računalnika". S paralelnim procesiranjem sem se raziskovalno ukvarjal še po zagovoru doktorske disertacije, vendar zaradi neobstoječe industrije na področju razvoja takšnih sistemov, na žalost rezultatov nisem mogel prenesti v prakso. To je bil tudi glavni razlog, da sem se začel ukvarjati z raziskovalnimi področji, katerih rezultate znanstveno raziskovalnega dela je bilo lažje prenašati v prakso.

Ker se je skozi 44 let mojega dela nabralo veliko referenc, jih v članku zaradi omejitve števila strani, ne bom navajal posebej, pač pa sem dal povezavo na mojo bibliografijo, ki zajema dela od 1984 do 2024 in je zavedena v COBISSu [1].

2 Od razvoja aplikacij za internet do informatizacije javne uprave

Leta 1995 je takratno ministrstvo, ki je bilo pristojno za znanost, objavilo razpis za financiranje centrov znanja. Namen centrov znanja je bil prenos znanstveno-raziskovalnih rezultatov v prakso. Na tem razpisu so izbrali tudi Center za heterogeno procesiranje, ki sem ga vodil. Za ta center smo tri leta prejemali financiranje, ki smo ga večinoma porabili za plačilo študentskega dela. Center je izvajal tudi projekte, ki so bili vezani na izdelavo različnih spletnih aplikacij. Leta 1996 smo razvili aplikacijo za spletno rezervacijo mariborskih hotelov. Nato smo za Mestno občino Maribor izdelali »Mariborski informacijski sistem«. Za podjetje Sweetcom smo izdelali aplikacijo za oglaševanje rabljenih vozil preko spleta, za podjetje Dodoma pa spletno aplikacijo za oglaševanje nepremičnin preko spleta. Za Mariborsko razvojno agencijo smo v izdelali spletno aplikacijo za gospodarski informacijski sistem za Podravje. V letih 1998 in 1999 sem tudi sodeloval pri specifikaciji turističnega informacijskega sistema za TIC Ljubljana in Zavod za turizem v Mariboru. Za njih smo razvili spletno aplikacijo za vodenje statistike zasedenosti turističnih objektov in aplikacijo za oglaševanje prireditev v Sloveniji.

V okviru Centra za heterogeno procesiranje sem navezal stike z računalniškimi podjetji Microsoft, Oracle, Marand, NIL in Lancom, ki so nam pomagala z nasveti, programsko opremo in izobraževanji na področju novih tehnologij. Sodelavci Centra za heterogeno procesiranje in študenti, ki so sodelovali pri delu centra, so pridobili certifikate na področju razvojnih orodij in sistemske administracije programske opreme podjetja Microsoft. Ko smo pridobili ustrezne certifikate, je Center za heterogeno procesiranje postal prva izobraževalna inštitucija na svetu, ki je pridobila naziv Microsoft Certified Partner. S pridobitvijo tega naziva smo postali upravičeni do vse Microsoftove programske opreme, njihovih izobraževalnih materialov in udeležbe na Microsoftovih dogodkih doma in v tujini. Znanje, ki smo ga pridobili, smo v okviru predavanj in vaj, posredovali našim študentom.

Od leta 1998 do 2010 sem vodil računalniški center na UM-FERI. Med pomembnejše projekte, ki smo jih v računalniškem centru v tem času izvedli, sodi vsekakor obnova računalniških učilnic, obnova računalniškega omrežja fakultete, izdelava spletnega portala fakultete, izdelava portala za podporo izobraževanju na daljavo in sistema za interno komuniciranje na fakulteti. Med prvimi v Sloveniji smo uvedli enotno identiteto študentov in zaposlenih na UM-FERI, brezžično omrežje, Eduroam in IP telefonijo. Na UM-FERI smo imeli med prvimi v Sloveniji gigabitni ethernet. CISCO je navajal našo fakulteto kot referenco na področju vzpostavitve gigabitnega etherneta na izobraževalnih inštitucijah. Ena od nalog, ki sem jih skupaj z mojimi sodelavci izvedel, je bila tudi izdelava specifikacij za informacijski sistem Univerze v Mariboru (1999 – 2000). Od 2011 do 2014 sem na Univerzi v Mariboru sodeloval v projektih R&D Industry (EU MED, 2011 – 2013) in CITEK (EU MED, 2013 – 2014), v katerih sem vodil razvoj informacijskega sistema za podporo raziskovalnemu delu na vključenih inštitucijah.

Leta 1999 so na Inštitutu za računalništvo, UM-FERI ustanovili Laboratorij za heterogene računalniške sisteme (LHRS), ki ga vodim še danes. Podrobnejši opis nekaterih projektov LHRS, ki bodo omenjeni v nadaljevanju ter nekaterih, ki jih zaradi pomankanja prostora nisem mogel opisati, najdete na https://lhrs.feri.um.si/projekti/. Opise nekaterih programskih rešitev LHRS najdete na https://lhrs.feri.um.si/predstavitev-dela/nase-resitve/.

V okviru LHRS smo začeli izvajati večje projekte. Eden takšnih projektov je bil projekt za podjetje Mobitel (1999), v okviru katerega smo izdelali programsko opremo, ki je omogočala prikaz digitalnih vsebin na infoterminalih, na velikih video zaslonih, mobilnih telefonih, ki so omogočali protokol WAP, na teletekstu in na internetu. Iz tega projekta smo se veliko naučili. Rezultat projekta je bila programska oprema za portal, ki smo jo kasneje naprej razvijali in jo je uporabljalo več kot 50 slovenskih občin, nekatere izobraževalne inštitucije ter nekaj podjetij. Leta 2000, ko smo razvili našo prvo verzijo portalne infrastrukture, še ni bilo na voljo podobnih spletnih aplikacij.

Leta 2000 smo za Kmetijski zavod v Mariboru izdelali aplikacijo za vodenje kontrole ekološkega kmetovanja, ki jo je leta 2004 prevzelo Ministrstvo za kmetijstvo, gozdarstvo in prehrano. Aplikacijo še danes v okviru LHRS vzdržujemo in nadgrajujemo. Ta aplikacija je pomembna, ker smo za pohitritev njenega razvoja razvili ogrodje Blacksmith, ki nam je omogočilo objektno-relacijske preslikave, neodvisno načrtovanje in upravljanje vsebine, navzkrižno sklicevanje med objekti, dedovanje, večjezično podporo, neodvisnost od sistema za upravljanje podatkovnih zbirk in integracijo spletnih storitev. Glavna prednost tega ogrodja je bil krajši čas razvoja porazdeljenih storitev ter bolj razumljiva koda programskih rešitev.

Iz tega obdobja bi omenil sodelovanje pri izdelavi strategije uvajanja elektronskega poslovanja v lokalne skupnosti (2003), izdelavo strateškega načrta informatizacije Mestne občine Maribor (2005), in akcijski načrt izdelave zalednega informacijskega sistema za lokalne skupnosti (2006). Skupaj s podjetjem 3Port smo od 2003 do 2005 razvili nekaj spletnih aplikacij za podporo delovanju lokalnih skupnosti (e-obveščanje občana o njegovih zadevah, e-pobude…).

Od leta 2000 naprej smo v Laboratoriju za heterogene računalniške sisteme razvijali portal za podporo izobraževanju na daljavo, ki smo ga najprej preizkusili na UM-FERI, nato pa smo ga uvedli na celotni Univerzi v Mariboru. V tem času še niso obstajali odprtokodni sistemi za upravljanje z učnimi vsebinami, zato smo na podlagi zahtev učiteljev in asistentov iz Univerze v Mariboru podprli procese upravljanja in podajanja učnih vsebin ter preverjanja znanja. Razvoj programske opreme je bil delno financiran preko različnih Interreg projektov, delno pa ga je financirala Univerza v Mariboru. Bil sem tudi eden od avtorjev nacionalne strategije na področju e-izobraževanja od 2006 do 2010. Sodeloval sem tudi pri projektu izdelave e-gradiv za

srednje računalniške šole (2010-2011), ki ga je koordinirala Srednja elektro-računalniška šola v Mariboru. Izdelal sem učna gradiva za predmete »Upravljanje s programirljivimi napravami«, »Načrtovanje in razvoj programskih aplikacij« in »Načrtovanje in razvoj spletnih aplikacij«.

3 Od digitalnih knjižnic, procesiranja besedil v slovenskem jeziku do detekcije plagiatov

Leta 2004 smo v okviru projekta, financiranega iz Ciljnega raziskovalnega programa, začeli z razvojem Digitalne knjižnice Ministrstva za obrambo (v nadaljevanju DKMORS). Programsko opremo za to digitalno knjižnico vzdržujemo in nadgrajujemo še danes. Projekt je pomemben zato, ker smo na podlagi pridobljenega znanja razvili Digitalno knjižnico Univerze v Mariboru (v nadaljevanju DKUM), katere programska oprema je osnova za repozitorije Nacionalne infrastrukture odprte znanosti. Prav tako smo morali v okviru DKMORS razviti boljši iskalnik, ki je bil primernejši za iskanje po podatkih in besedilih v slovenskem jeziku. Za ta namen smo razvili lastno programsko ogrodje Textproc za obdelavo besedil v slovenskem jeziku (2007 – 2008). Ogrodje omogoča povezovanje različnih opravil za procesiranje besedil (npr. razčlenjevanje vsebine, oblikoslovno označevanje, razreševanje sklicev, pomensko označevanje, delno avtomatsko dopolnjevanje pomenskega slovarja, določanje imenskih entitet, določanje relacij med imenskimi entitetami...). To ogrodje smo uporabili na področju razvoja aplikacij za odgovarjanje na vprašanja v slovenskem jeziku, pri razvoju priporočilnega sistema za priporočanje vsebin iz repozitorijev, sistema za ekstrakcijo znanja iz besedil in sistema za preverjanje podobnosti vsebin. V okviru projekta ESO mreža (2008) smo skupaj s podjetjem 3-Port razvili aplikacijo za odgovarjanje na vprašanja iz področja občinske uprave. Aplikacija je odgovarjala na podlagi podatkov iz podatkovnih zbirk, na podlagi zbirke pogosto zastavljenih vprašanj, zbirke žaljivih vprašanj, posebnih vprašanj in fraz ter na podlagi iskanja po dokumentih. V projektu ESO mreža 2 (2009-2011) smo nadgradili sistem za odgovarjanje na vprašanja še z opisom znanja o domenskem področju s pomočjo ontologij in s pomenskim opisom spletnih storitev. Kot primer uporabe programske rešitve za odgovarjanje na vprašanja z opisom znanja o domenskem področju, smo skupaj s podjetjem 3-Port izdelali aplikacijo za izračun komunalnega prispevka v občini Piran. V okviru projekta “Metal Knowledge Network-Knowledge management and semantic search for metal industry in Slovenia and Austria” (2011 – 2013) smo izdelali infrastrukturo, ki omogoča pomensko iskanje in pomensko označevanje strukturiranih in nestrukturiranih vsebin iz področja kovinsko-predelovalne industrije. V okviru projekta smo izdelali pomenski iskalnik, ki omogoča pomenski opis tabel in pomensko indeksiranje podatkov iz podatkovnih baz informacijskih sistemov ter pomensko obdelavo tekstovnih dokumentov.

Pomemben projekt, ki smo ga začeli leta 2017 in se še nadaljuje, je »Slovenščina na dlani«. Projekt izvajamo skupaj s Filozofsko fakulteto UM, Pedagoško fakulteto UM in kolegi iz Laboratorija za digitalno procesiranje signalov UM-FERI. LHRS je zadolžen za izdelavo in vzdrževanje programske rešitve. V okviru projekta smo izdelali interaktivno učno e-okolje, namenjeno bogatitvi pouka slovenskega jezika, povečanju motivacije za učenje slovenščine, pridobivanju dodatnih jezikovno-digitalnih kompetenc ter izboljšanju zmožnosti tvorjenja in razumevanja besedil. Osrednja ciljna skupina so osnovnošolci od šestega razreda in srednješolci – torej uporabniki, ki so sposobni tvorjenja daljših besedil, a s primanjkljaji v jezikovnem izražanju in razumevanju zlasti neumetnostnih besedil. Naši cilji so bili pripraviti korpus aktualnih obsegovno in vsebinsko raznovrstnih besedil, povezanih z interesi ciljne skupine; na osnovi korpusnega gradiva izdelati trajnostna samostojno delujoča e-orodja za avtomatsko tvorjenje in pregledovanje vaj ter orodja smiselno podpreti s celovitimi slovarsko-slovničnimi in jezikovnonormativnimi opisi. Posebno pozornost smo namenili zapostavljenemu prikazu idiomatičnih jezikovnih prvin ter izkoristili potencial za njihov atraktiven jezikovni opis. Okolje vsebuje bazo znanja, iz katere se lahko učenci in dijaki naučijo pravopisa, slovnice, uporabe frazemov in pregovorov ter razumevanja in tvorjenja besedil. E-okolje omogoča reševanje nalog iz področja slovnice, pravopisa, frazemov in pregovorov ter razumevanja besedil. Pri pouku slovenščine ga uporablja več kot 300 osnovnih in srednjih šol.

Na področju procesiranja besedil v naravnem jeziku sem skupaj s sodelavci Laboratorija za heterogene računalniške sisteme sodeloval še v projektih Spletni portal Franček (2017 – 2021), Slovenska znanstvena besedila (2016 – 2019) in Razvoj slovenščine v digitalnem okolju (2020 – 2023). V okviru Slovenskih znanstvenih besedil smo s sodelavci LHRS izdelali Korpus akademske slovenščine (KAS) in pomenski označevalnik strokovnih terminov v znanstvenih besedilih. V okviru projekta Razvoj slovenščine v digitalnem okolju smo izdelali orodje za avtomatsko ekstrakcijo relacij za gradnjo semantične mreže, orodje za avtomatsko odgovarjanje na vprašanja, orodje za luščenje strokovne terminologije ter sodelovali pri razvoju terminološkega portala.

Za konec tega poglavja bi omenil še aplikacijo, ki jo danes uporablja večina slovenskih višješolskih in visokošolskih izobraževalnih inštitucij. Gre za program, ki smo ga razvili za potrebe Univerze v Mariboru, ki je želela preverjati podobnost zaključnih del študentov. Kasneje smo za Univerzo v Mariboru izdelali tudi vtičnik, ki omogoča preverjanje podobnosti oddanih nalog študentov v sistemu za upravljanje z učnimi vsebinami Moodle. Za namen preverjanja podobnosti vsebin so sicer obstajale komercialne rešitve, ki pa niso bile prilagojene za analizo besedil v slovenskem jeziku. Z našim programom so odkrili nekaj odmevnih plagiatov v Sloveniji, ki so bili predstavljeni v medijih. Namen programa je predvsem naučiti študente ali druge uporabnike, da se plagiatorstvo ne izplača in da je zanje veliko boljše, če sami napišejo besedilo, pravilno navedejo uporabljene vire in jih ustrezno citirajo.

Vodim ali sem vodil mednarodne projekte iz področja akademske integritete, ki obravnavajo plagiatorstvo in kršenje akademske integritete. Ti projekti so ENAI (2016 – 2019), FAITH (2022 – 2025) in PUPP (2021 – 2028, 35 partnerjev iz Kanade, ZDA in Evrope). Sem član več delovnih skupin in član nadzornega odbora European network of academic integrity.

4 Moje pedagoško delo

Leta 1986 sem bil habilitiran v naziv asistent. Izvajal sem vaje pri predmetih "Programiranje I", "Programski jeziki I", "Programski jeziki II", "Principi programskih jezikov",

"Sistemsko programiranje", "Organizacija in arhitektura računalniških sistemov I", "Osnove računalniške organizacije", "Izbrani algoritmi" in "Osnove računalništva". V okviru predmetov, ki so bili vezani na programske jezike sem študente učil programirati v takrat aktualnih programskih jezikih (FORTRAN, Pascal, C++, COBOL, ADA, Smaltalk, LISP, Prolog).

Po zagovoru doktorske disertacije sem bil habilitiran v naziv docent. Najprej sem začel s predavanji na višješolskem študiju. Ko smo leta 1996 na Fakulteti za elektrotehniko, računalništvo in informatiko, Univerze v Mariboru (UM-FERI) začeli z izvajanjem novih študijskih programov, sem predaval ”Programiranje 1”, ”Osnove računalniške arhitekture”, ”Osnove računalniške organizacije”, ”Paralelne računalniške sisteme”, ”Porazdeljene računalniške sisteme” in ”Razvoj aplikacij za internet”. Izbirni predmet ”Razvoj aplikacij za internet” je bil leta 1996 precejšnja novost v Sloveniji, saj se še na drugih inštitucijah in tudi na UM-FERI niso zavedali, da bo internet ključno spremenil naš način življenja.

Leta 2009 se je na UM-FERI začel izvajati bolonjski študijski program. Na različnih študijskih programih sem predaval ”Uvod v svetovni splet”, “Arhitekturo in organizacijo računalnika”, “Računalniška omrežja”, “Razvoj aplikacij za internet”, “Osnove svetovnega spleta”, “Mrežno usmerjeno računanje”, “Spletno programiranje”, “Spletne tehnologije” ter “Pomensko in storitveno usmerjen splet”.

Nekaj tisoč študentov je poslušalo ali sodelovalo pri vajah pri mojih predmetih. Bil sem mentor pri zaključnih delih študija več kot 180 študentom na različnih stopnjah študija. Z nekaterimi imam še danes stike. Nekateri imajo problem, za katerega potrebujejo pomoč in se obrnejo name. Nekateri me srečajo na ulici in obudimo spomine na čas, ko so študirali. Lep občutek je, da sem tudi jaz prispeval k temu, da imamo danes toliko dobrih strokovnjakov na področju računalništva in informatike.

5 Od nacionalne infrastrukture odprtega dostopa do EOSC interoperabilnostnega okvirja

Slovenske univerze so leta 2013 s sofinanciranjem Evropskega sklada za regionalni razvoj in Ministrstva za izobraževanje, znanost in šport vzpostavile nacionalni portal odprte znanosti ter repozitorije za odprti dostop do zaključnih del študija in rezultatov raziskav raziskovalcev na Univerzah v Ljubljani, Mariboru, Novi Gorici in na Primorskem. Vključili pa smo tudi več drugih virov, ki so ponujali vsebine za raziskovalce in študente. Nacionalni portal openscience.si agregira vsebine iz repozitorijev in drugih virov za potrebe združevalnega iskalnika, priporočilnega sistema in preverjanja podobnosti vsebin. To infrastrukturo smo v letih od 2014 do 2022 dopolnili z repozitorijem za samostojne raziskovalne organizacije in repozitorijem za višješolske in visokošolske inštitucije, nacionalnim strežnikom za dodeljevanje trajnih identifikatorjev in arhivom za velepodatke. Ta arhiv je bil vzpostavljen na superračunalniku Vega v okviru projekta HPC RIVR (EU skladi, EUROHPCJU, 2018 – 2021), v katerega je bil vključen tudi LHRS. Sodeloval sem pri izdelavi nacionalne strategije odprtega dostopa do znanstvenih objav in raziskovalnih podatkov v Sloveniji od 2015 do 2020, izdelavi uredbe o izvajanju znanstvenoraziskovalnega dela v skladu z načeli odprte znanosti in izdelavi akcijskega načrta razvoja odprte znanosti v Sloveniji od 2023 do 2030. V okviru akcijskega načrta vodim razvoj in vzdrževanje nacionalne infrastrukture odprte znanosti.

Kot član projektne skupine sem sodeloval v EU projektih DAPHNE (H2020, 2020 – 2024) in EuroCC (EUROHPCJU, 2020-2022). V okviru UM vodim evropska projekta GDI (Digital Europe, 2022 – 2026) in EUROCC2 (EUROHPCJU, 2023 – 2025). V projektu European genomic data infrastructure (GDI) vodim vzpostavitev nacionalne infrastrukture genomskih arhivov, ki bo povezana v evropsko genomsko infrastrukturo. Ta infrastruktura je poseben izziv, saj je potrebno zagotoviti ustrezno varnost podatkov, procesiranje podatkov v varnem okolju in varno izmenjavo podatkov z drugimi genomskimi arhivi po Evropi. V projektu EUROCC2 je pet inštitucij v Sloveniji vzpostavilo nacionalno vozlišče EUROHPC. To vozlišče je povezano z ostalimi nacionalnimi vozlišči po Evropi. Znotraj Slovenije skrbimo za izobraževanja na področju uporabe visoko zmogljive računalniške infrastrukture (HPC) in razvoja programskih rešitev za HPC, prenašamo te rešitve v gospodarstvo in javno upravo ter sodelujemo z drugimi deležniki v Sloveniji, v Evropi in širše.

Sodelujem v aktivnostih iniciative European open science cloud (EOSC). Od 2019 do 2021 sem bil član EOSC Interoperability working group. Sodeloval sem v podskupini, ki je izdelala »EOSC interoperability framework«, v katerem so podana osnovna navodila za zagotavljanje interoperabilnosti znotraj EOSCa. Definirali smo tudi referenčno arhitekturo in minimalni nabor metapodatkov za opis FAIR digitalnih objektov. Nato sem od 2021 do 2023 sodeloval v EOSC-A semantic interoperability task force, kjer sem vodil podskupino za preslikave metapodatkovnih shem in določanje minimalnega nabora metapodatkov. Sedaj sem član EOSC-A technical and semantic interopability task force, ki ima mandat od 2024 do 2025. Sem eden od sovodij v CODATA GOSC Data interoperability working group, eden od sovodij RDA metadata IG in član več delovnih skupin v RDA ter član uredniškega odbora COAR vocabularies,

Zahvala

Veliko srečo sem imel, da sem sodeloval z ljudmi, ki so mi zmeraj stali ob strani in me pri mojem delu spodbujali. Posebna zahvala gre prof. dr. Viljemu Žumerju in prof. dr. Petru Kokolu, ki sta me povabila v Laboratorij za računalniške arhitekture in jezike na Visoki tehniški šoli Univerze v Mariboru. Prof. Žumer je bil moj mentor pri diplomski, magistrski in doktorski nalogi. Kadarkoli sem ga potreboval, mi je pomagal z nasveti. Prof. dr. Peter Kokol je bil moj sodelavec v laboratoriju in me je na začetku moje poti uvedel v raziskovalno in pedagoško delo ter me vseskozi spodbujal. Zahvalil bi se tudi vsem mojim sodelavcem, s katerimi sem sodeloval. Poimensko jih ne bom naštel, da ne bi slučajno koga izpustil. Vsi ste mi stali ob strani in mi pomagali na moji profesionalni in osebni poti.

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ChatGPT v zdravstvu
ChatGPT in Medicine

Uredniki / Editors

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PREDGOVOR

Umetna inteligenca, zlasti generativna umetna inteligenca, kot je ChatGPT, je spremenila pravila igre v številnih panogah. Vendar je njen vpliv v medicini še posebej pomemben, saj gre v zdravstvu za več kot le informacije - gre za človeška življenja. Vključitev umetne inteligence lahko bistveno izboljša izide zdravljenja bolnikov, racionalizira delovne procese in izboljša procese odločanja na celotnem področju medicine.

Vloga umetne inteligence presega pomoč strokovnjakom; neposredno vpliva na oskrbo bolnikov. Z virtualnimi posvetovanji, izobraževanjem bolnikov in preverjanjem simptomov lahko ChatGPT izboljša dostop do zdravstvenega varstva za skupine prebivalstva, ki bi se sicer soočale z ovirami zaradi lokacije ali časovnih omejitev. Poleg tega umetna inteligenca z avtomatizacijo rutinskih opravil zmanjšuje upravno breme zdravnikov, tako da lahko več časa posvetijo oskrbi bolnikov in manj papirologiji. To je lahko ključni dejavnik v boju proti izgorelosti zdravnikov, ki je v sodobnem zdravstvu vse večji problem. Čeprav je potencial ChatGPT v zdravstvu vznemirljiv, moramo obravnavati etične in varnostne izzive, ki jih prinaša. Ključna vprašanja so zagotavljanje zasebnosti pacientov, zmanjšanje pristranskosti algoritmov umetne inteligence in ohranjanje natančnosti zdravniških nasvetov. UI mora podpirati - ne pa nadomestiti - človeško presojo, zlasti pri kritičnih medicinskih odločitvah. Zagotavljanje preglednosti, odgovornosti in zasnove teh sistemov s pristopom, pri katerem je v ospredju varnost, je bistvenega pomena za krepitev zaupanja v te tehnologije.

V prihodnosti se bo vloga ChatGPT in podobnih sistemov umetne inteligence verjetno še povečala. Pravkar začenjamo raziskovati njihove aplikacije v personalizirani medicini, kjer bi umetna inteligenca lahko pomagala prilagoditi zdravljenje posameznim pacientom na podlagi genetskih podatkov, podatkov o okolju in življenjskem slogu. Poleg tega lahko umetna inteligenca z analizo trendov v populacijah prispeva k zgodnjemu odkrivanju bolezni, odkrivanju zdravil in globalnim zdravstvenim pobudam.

Ta konferenca je priložnost, da se poglobimo v najsodobnejše raziskave, nastajajoče aplikacije in etične vidike uporabe ChatGPT v medicinski praksi. Skupaj bomo raziskali sedanje zmogljivosti in prihodnje možnosti, hkrati pa se bomo posvetili izzivom, ki jih prinaša vključevanje umetne inteligence na tako občutljivo in tvegano področje.

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predsedniki konference ChatGPT v zdravstvu

FOREWORD

AI, and particularly conversational AI like ChatGPT, has been a game-changer in many industries. However, its impact in medicine is particularly significant because healthcare is about more than just information—it's about human lives. The integration of AI has the potential to dramatically improve patient outcomes, streamline workflows, and enhance decision-making processes across the medical field.

The role of AI extends beyond assisting professionals; it directly impacts patient care. Through virtual consultations, patient education, and symptom checks, ChatGPT can enhance access to healthcare for populations who might otherwise face barriers due to location or time constraints. Additionally, by automating routine tasks, AI reduces the administrative burden on clinicians, allowing them to spend more time on patient care and less on paperwork. This can be a crucial factor in combating physician burnout, a growing issue in modern healthcare. While the potential of ChatGPT in healthcare is exciting, we must address the ethical and safety challenges that come with it. Ensuring patient privacy, minimizing bias in AI algorithms, and maintaining the accuracy of medical advice are key concerns. AI should support—not replace—human judgment, particularly in critical medical decisions. Ensuring that these systems are transparent, accountable, and designed with a safety-first approach is essential to building trust in these technologies.

Looking forward, the role of ChatGPT and similar AI systems will likely expand. We are just beginning to explore its applications in personalized medicine, where AI could help tailor treatments to individual patients based on genetic, environmental, and lifestyle data. Additionally, AI can contribute to early detection of diseases, drug discovery, and global health initiatives by analyzing trends across populations.

This conference is an opportunity for us to delve into the cutting-edge research, emerging applications, and ethical considerations surrounding the use of ChatGPT in medical practice. Together, we will explore both the current capabilities and the future possibilities, while also addressing the challenges that come with integrating AI into such a sensitive and high-stakes field.

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Automatic Reviewing of Conference Papers in Healthcare and Other Sciences Using ChatGPT

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ABSTRACT

The emergence of artificial intelligence (AI) has significantly impacted various fields, including the peer review process in scientific research. ChatGPT, a large language model developed by OpenAI, has shown potential in automating and enhancing the review of conference healthcare papers. Our HealthReview AI tool can process and analyze large volumes of text rapidly, providing feedback and insights that streamline the peer review process, reduce human workload, and increase efficiency. This paper presents a web application developed using the Flask framework that enables users to upload PDF files containing research papers and utilizes ChatGPT to generate reviews for each paper. The methodology, results and potential implications of this application are discussed, highlighting both the advantages and the challenges of integrating AI into the academic review process.[1]

KEYWORDS

Artificial Intelligence, ChatGPT, Peer Review, Healthcare, Scientific Research, Flask Framework, PDF Processing, Academic Writing, Conference Papers

POVZETEK

Pojav umetne inteligence (UI) je pomembno vplival na različna področja, vključno s postopkom strokovnega pregleda v akademskih in znanstvenih raziskavah. ChatGPT, velik jezikovni model, ki ga je razvil OpenAI, je pokazal potencial za avtomatizacijo in izboljšanje pregleda medicinskih konferenčnih prispevkov. To orodje UI lahko hitro obdela in analizira velike količine besedil ter zagotovi povratne informacije in vpoglede, ki poenostavijo postopek strokovnega pregleda, zmanjšajo delovno obremenitev in povečajo učinkovitost. Ta članek predstavlja spletno aplikacijo HealthReview, razvito s pomočjo ogrodja Flask, ki uporabnikom omogoča nalaganje datotek PDF, ki vsebujejo raziskovalne prispevke, in uporablja ChatGPT za generiranje pregledov za vsak prispevek. Obravnavane so metodologija, rezultati in možni vplivi te aplikacije, ki poudarjajo tako prednosti kot izzive integracije UI v akademski pregledni postopek.

KLJUČNE BESEDE

Umetna inteligenca, ChatGPT, strokovni pregled, zdravstvo, znanstvene raziskave, Flask ogrodje, obdelava PDF, akademsko pisanje, konferenčni prispevki

1 Introduction

The integration of artificial intelligence (AI) across various domains is significantly transforming complex processes, including the peer review of conference papers in healthcare and other sciences. Among AI tools, ChatGPT, developed by OpenAI, stands out for its potential to automate and enhance the review process. Its ability to quickly analyze large volumes of text and provide insightful feedback could streamline peer reviews, reduce human workload, and enhance overall efficiency.

Recent studies highlight the diverse applications of ChatGPT in healthcare education, research, and practice. For example, it has been shown to improve scientific writing, analyze datasets, and aid drug discovery [1, 2, 3]. Additionally, its role in generating paraphrased content and literature reviews indicates the potential to expedite academic tasks, although concerns about originality and accuracy persist [4, 5].

ChatGPT's integration into medical literature reviews has been explored, demonstrating its ability to synthesize medical knowledge, though ethical and accuracy issues require further research [6, 7]. Beyond healthcare, ChatGPT enhances research efficiency across various scientific fields. It effectively generates Boolean queries for systematic reviews and supports rapid literature searches [8]. The AI's potential to streamline peer reviews and address biases, is also evident, though managing issues like bias, plagiarism, and inaccuracies remain crucial to maintaining academic integrity [9, 10, 11]. In our opinion, tools like ChatGPT offer significant opportunities to enhance the peer review process. However, careful deployment is necessary to ensure ethical considerations, accuracy, and the preservation of academic integrity. This paper explores these

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aspects and presents insights into effectively integrating ChatGPT into the peer review process designed with our system HealthReview. The paper consists of Section 1 Introduction, section 2 Methodology where the system is presented. Results are demonstrated in Section 3, and the paper concludes with a discussion.

2 Methodology

When tested, GPT-4o was already able to reply to all basic questions, e.g. “Is grammar in that text correct”. Therefore, the first task was to create a list of commands to perform the sequence of the review, chosen for the Information Society conference (is.ijs.si). The second task was to fine-tune the process since several output issues were not as desired. The third task was to include additional knowledge, and that was executed by including the Insieme knowledge base as the core medical information. In this way, the HealthReview performance achieved reasonable levels.

The Insieme platform was selected for integration with GPT [12]. This platform features a user-friendly interface that enables users to efficiently access valuable healthcare information from a centralized website, either via manual search or through the Insieme search function. Insieme serves as the successor to the national Electronic and Mobile Health (eHealth) initiative, a project that was characterized by collaboration among 15 partners. Furthermore, the platform's development has been significantly shaped by insights derived from the analysis of various EU healthcare platforms, particularly those that specialize in elderly care. Insieme not only builds upon the foundation laid by these prior initiatives but also aims to set a new standard in the accessibility and usability of healthcare information, thereby providing a more integrated and cohesive experience for its users. Additional medical knowledge therefore comes from the Insieme database that was created from a national electronic and mobile project for smart cities. Including the Insieme platform into the GPS is described elsewhere and is not part of this paper. The HealthReview web application is developed in Python using the Flask framework. Flask is a lightweight web framework for the Python programming language, used for building fast and stable web applications [13]. This application allows users to upload one or several PDF files containing multiple research papers, processes these files to extract the individual papers, and then employs ChatGPT to generate reviews for each paper.

The application is initialized and configured to use an upload folder named 'uploads'. This folder is created if it does not exist to ensure that uploaded files have a designated storage location. To maintain file security, the application restricts uploads to PDF files by specifying an allowed file extension set.The user interface of the application consists of an HTML form rendered by the index route. This form allows users to upload their PDF files through a file input and submit button. Client-side JavaScript enhances user experience by displaying the selected file name and showing a loading indicator upon form submission. Upon file upload via the /submit route, the PDF is securely saved in the upload folder. The file function ensures that only files with a .pdf extension are accepted. Once the file is stored, the papers_strArr function extracts the text of individual papers from the PDF. This function searches for specific markers like "ABSTRACT" and "Author index" to identify the boundaries of each paper. Text is extracted from each page and grouped into separate papers based on these markers. If no papers are detected, an error message is returned. Otherwise, the program proceeds to each extracted paper.

The API Call function facilitates the interaction with the ChatGPT model. It sends the text of each paper to the ChatGPT API, along with a predefined prompt, and retrieves the model's generated review. These reviews are stored in a global dictionary RESULTS with unique identifiers for each paper.

The */paper/<paper_id>* route enables users to view the generated reviews. When a specific paper ID is requested, the corresponding review content is fetched from the RESULTS dictionary and displayed using the paper.html template. Navigation links allow users to browse through the list of papers and view their respective reviews.

HTML templates, including form.html and paper.html, provide the user interface for uploading files, displaying instructions, and viewing individual paper reviews. The form.html template includes the file upload form and instructions for use, while the paper.html template displays individual paper reviews and includes navigation for switching between different papers. This program integrates Flask for web functionality, PDFMiner for PDF text extraction, and OpenAI's ChatGPT-4o for generating paper reviews. This combination offers a streamlined and efficient method for reviewing conference papers, potentially enhancing the speed and consistency of the review process, which is crucial in managing the increasing volume of research submissions. HealthReview accepts input in the form of any language and similarly outputs replies in any language supported by ChatGPT-4o.

3 Results

The developed web application HealthReview was tested using a dataset of conference papers to evaluate its performance and efficiency in generating reviews. An example of the application’s output is shown below.

Title: Anonymous in this paper
Authors: Anonymous
Abstract:
The article focuses on physical inactivity, which increases the risk of chronic diseases, especially cardiovascular diseases, among the adult population as well as among children and

youth. Based on data from the Institute for Health Metrics and Evaluation, the article reports relative risks of cardiovascular disease by age group, gender, and country. In doing so, we focus on the comparison between Slovenia and the world average. Based on the analysis, we conclude that cardiovascular diseases impact people in different age segments; as such they become one of the important risk factors through aging. Also, physical activity importantly influences behavioral, nutrition, and other factors, which contribute to cardiovascular diseases. For that reason, it is very important to systematically analyze and monitor these factors to contribute to better guidelines and measures of policymakers.

Overall evaluation: 1 - Accept with minor changes
(All options: 2 - Accept as is | 1 - Accept with minor changes | 0 - Accept with major changes | -2 - Reject)
The paper provides valuable insights into the relationship between physical inactivity and cardiovascular diseases, particularly in different age segments. However, some minor improvements could elevate the presentation and clarity of the findings.
Overall quality: 7/10.
The scientific quality is solid, but minor methodological limitations and the need for more comprehensive data analysis slightly reduce its impact.
Presentation: 3 – Routine
(All options: 5 - Crystal-clear and particularly attractive | 4 - Clear and attractive | 3 - Routine | 2 - Not very clear and/or attractive | 1 - Unclear and/or particularly unattractive.)
The presentation is well-structured but lacks visual aids and a more engaging writing style.
Language modifications: Minor grammatical mistakes. The paper includes some minor grammatical mistakes that should be fixed before publication.
Proposed modifications: Correct "prerana" to "prehrana" in the "REZULTATI" section. Ensure consistency in the use of terms such as "risk factors" and "prevalence" across sections.
Improve the translation and readability of some sentences for better clarity.
Consider adding graphical representations of data to enhance interpretability.
Suggestion: Use tools like Grammarly or GPTs.
Reviewer's confidence: 4 – High
(All options: 5 - Expert | 4 - High | 3 - Medium | 2 - Low | 1 - None)
Excellence: 3 - Definite but modest methodological novelty and/or good application
(All options: 5 - Important methodological novelty | 4 - Definite methodological novelty | 3 - Definite but modest methodological novelty and/or good application | 2 - Debatable methodological novelty and/or acceptable application | 1 - No methodological novelty and poor application)
Impact: 3 - Used/useful and moderately mature
(All options: 5 - Highly impactful application and/or very widely used, at least moderately mature | 4 - Important application and/or widely used, at least moderately mature | 3 - Used/useful and moderately mature | 2 - Used/useful in limited cases and/or immature | 1 - No practical use)

The HealthReview web application successfully generated reviews for multiple conference papers. Table 1 represents a summary of the evaluations for the conference section. The paper number is a serial number assigned to each paper in the conference dataset. Examples of the meanings of other fields are listed in this section.

4 Discussion

The results of our study demonstrate the promising potential of integrating AI, specifically ChatGPT, into the peer review process for healthcare and medical conference papers. The application that was developed effectively generated insightful reviews, which were evaluated against traditional human-generated reviews for quality and consistency. While the overall performance of the AI-based review system was favorable, several considerations and implications warrant further discussion. First, the ability of ChatGPT to process and analyze large volumes of text rapidly offers a significant advantage in terms of efficiency. This is particularly beneficial in the context of increasing research output and the growing burden on peer reviewers. However, while the AI-generated reviews were generally accurate and aligned with human assessments, there were instances where the feedback provided by ChatGPT lacked depth, particularly in areas requiring domain-specific expertise. This highlights a limitation of current AI technologies, where the ingenuity, flexibility and expertise of human reviewers are still crucial.

It is not clear to what extent the automatic reviewing system applies to all domains, not only healthcare. In any case, when adopting a specific form of review, the instructions as part of the prompt programming should be modified. In practical terms, it should also be noticed that the API GPT call is not free of charge.

Additionally, the application of AI in the peer review process raises ethical concerns, particularly around the potential for bias, the risk of plagiarism, and the integrity of the review process. Although ChatGPT can streamline the review process, these tools must be used as supplements rather than replacements for human reviewers. Maintaining a balance between AI efficiency and human oversight is critical to preserving the integrity and quality of academic peer reviews. Moreover, the reliance on AI for academic tasks necessitates continuous monitoring and updates to the AI models to ensure accuracy, relevance, and fairness. Future developments should focus on enhancing the contextual understanding of AI tools like ChatGPT to better mimic the critical thinking and analytical capabilities of human reviewers.

Table 1: Summary of Reviews

Paper number	Overall evaluation	Overall quality	Presentation	Language (grammatical mistakes)
1	2/4	6/10	2/5	Quite some
2	3/4	7/10	3/5	Minor
3	3/4	7/10	3/5	Some
4	3/4	7/10	3/5	Quite some
5	3/4	7/10	3/5	Some
6	3/4	7/10	3/5	Minor
7	3/4	8/10	3/5	Minor
8	3/4	8/10	3/5	Some
9	3/4	7/10	3/5	Minor
10	3/4	7/10	3/5	Minor
11	3/4	8/10	4/5	Some
12	3/4	7/10	3/5	Minor
13	4/4	9/10	4/5	Minor

In conclusion, the inclusion of HealthReview, i.e. an additional automated review layer introduces several advantages, such as increased objectivity and the potential to generate supplementary suggestions, further enriching the review process. AI tools like ChatGPT offer substantial potential to enhance the peer review process. However, their successful integration requires careful implementation and continuous evaluation to effectively address inherent challenges and ensure that these tools make a meaningful contribution to academic research. In any case, the automatic review by HealthReview or any other review tool should be marked in a way explicitly denoting the source and type of the reviewing tool.

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Leveraging Federated Learning for Secure Transfer and Deployment of ML Models in Healthcare*

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Abstract

Federated learning (FL) represents a pivotal advancement in applying Machine Learning (ML) in healthcare. It addresses the challenges of data privacy and security by facilitating model transferability across institutions. This paper explores the effective employment of FL to enhance the deployment of large language models (LLMs) in healthcare settings while maintaining stringent privacy standards. Through a detailed examination of the challenges in applying LLMs to the healthcare domain, including privacy, security, regulatory constraints, and training data quality, we present a federated learning architecture tailored for LLMs in healthcare. This architecture outlines the roles and responsibilities of participating entities, providing a framework for secure collaboration. We further analyze privacy-preserving techniques such as differential privacy and secure aggregation in the context of federated LLMs for healthcare, offering insights into their practical implementation.

Our findings suggest that federated learning can significantly enhance the capabilities of LLMs in healthcare while preserving patient privacy. In addition, we also identify persistent challenges in areas such as computational and communicational efficiency, lack of benchmarks and tailored FL aggregation algorithms applied to LLMs, model performance, and ethical concerns in participant selection. By critically evaluating the proposed approach and highlighting its potential benefits and limitations in real-world healthcare settings, this work provides a foundation for future research in secure and privacy-preserving ML deployment in healthcare.

Keywords

Federated Learning, Large Language Models, Data Privacy, Healthcare ML, Privacy Preservation, Model Transferability

1 Introduction

The advancements in hardware and software technologies, hyper-connectivity, and the fourth industrial revolution lead to the creation of mass amounts of health-related data. Machine learning and AI, in general, are the biggest winners from this endless pool of structured and unstructured data, as these technologies thrive on large datasets to identify patterns and make predictions. The novel adaptable, predictive approach to generating insights, decision support, and assistance in tasks that have long been considered solely reserved for human expertise is based on this paradigm's capabilities to recognize patterns from the data without being explicitly programmed.

Conventional machine learning implies that the data owner communicates with a specific central server with significant computational power. The central server consumes data from different sources and applies training techniques and algorithms to devise an effective model. ML requires large amounts of data to satisfy the expectations for the model's performance.

Large-language models (LLMs), as representative of ML advancements, have been a particular point of interest in recent years. They have already proven their applicability and massive potential in multiple fields [30]. LLMs are designed to understand, generate, and interact with human-like text and can understand context, making them suitable for performing a wide range of complex language-related tasks. They are trained in two main phases. First, the model learns general knowledge about language patterns in the pre-training phase. Then, it can be fine-tuned to execute downstream tasks to specialize its expertise in a specific domain [28].

However, like other machine learning models researched and implemented, this paradigm is data-hungry, meaning that it inherently requires massive training data to achieve the expected performance [10]. Thus, LLMs are designed to perform better with an increase in training data volume and computational power.

Various unfortunate scenarios related to the misuse of private and personal data cast a shadow on AI's capabilities, underscoring the growing concerns about data privacy, specifically in the phases when the models are trained. [13]. The year 2016 is particularly significant for two key developments aiming to overcome these challenges. The first is the attempt to regulate personal data collection, processing, and storing by introducing the General Data Protection Regulation (GDPR) in Europe [12]. The second key development was the introduction of Federated Learning (FL) by Google researchers, which provided a groundbreaking scientific approach to addressing data privacy and security concerns in ML [16].

This paper aims to discuss the possibility of satisfying the needs of both data owners and ML experts by leveraging the concept of federated learning. On the one hand, data owners can be supported to participate in collaborative training in a privacy-preserving manner when their data is insufficient to craft a high-

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performance model, such as LLM. On the other hand, ML experts can develop and advance their approaches by utilizing large volumes of real-life institutional data and access to diverse scenarios, which are essential for building a robust model.

Being aimed at investigating the FL potential for application in the health domain, the insights presented in this work offer support in finding a more robust, secure, and effective use of AI that does not require technical proficiency of the medical experts, ultimately contributing to improved patient care and data protection.

The remainder of this paper is organized as follows: Sections 2 and 3 introduce FL and LLMs, and their relevance to healthcare; section 4 presents our proposed FL architecture for LLMs in healthcare, detailing the system components and their roles; section 5 discusses challenges in implementing LLMs in healthcare using FL; and section 6 explores privacy-preserving techniques for integration with our FL architecture.

2 LLM-based Healthcare Applications

LLMs are usually trained on high-quality public data, but their performance is often limited when tasked with specialized or narrower-spectrum tasks. With specific expertise in mind, such as healthcare, different approaches should be considered to build that corpus. Healthcare institutions can use their local datasets, leading to less efficient LLM, or they can join other collaborative efforts to make high-quality training data facing the inevitable challenges of privacy and regulations.

LLMs are attractive in the healthcare area because of their capability to simplify the interaction with an intelligent system without needing technical expertise. Lack of technological proficiency of medical experts can decrease the adoption of a specific software solution and can be marked as overly complex. The core principles of the LLMs allow users to interact with their domain rules, persistent knowledge, and past experiences without the need to rely on their computer literacy. One of the enormous benefits of utilizing LLMs in potential areas of medical workflows relies on the output, which is in an understandable form of natural language. The ease of use of natural language to provide instructions and ask for decision support bridges the gap between the domain experts and the utilization of an intelligent computer system. Furthermore, much of the data that persists within healthcare institutions is in unstructured formats, such as clinical notes, conversations, diagnoses, prescriptions, and research articles. LLMs are particularly effective at processing and using these natural language texts. In that way, the transparency is increased, and the expert can examine the reasoning behind the answers provided straightforwardly.

In the past several years, we have already witnessed the potential of LLMs in healthcare in many areas, such as interpreting images from a specific medical domain, summarizing reports and medical history, identifying patterns in electronic health records (EHR), and offering support for decision-making processes. The use of natural language can also influence patient engagement processes [16].

Even though exceptional remarks on providing suitable LLMs for healthcare are already in place and the community is verifying the theoretical and conceptual findings, the decision of one healthcare institution to utilize such a system can face a lot of hesitation. Most of the training data for the LLMs comes from publicly available sources, lacking the nuances that bring the real-life data isolated in the infrastructure of a single healthcare institution. Additionally, each institution has many characteristics that make it unique in how it works. Workflows, dictionaries, specific characteristics of the population it serves, or particular domain attributes can result in difficulties for off-the-shelf LLMs in providing the correct output to the instruction given. This calls for the institutions to further tailor and tune the capabilities of the LLM. Although state-of-the-art LLMs allow for such modifications and fine-tunings and making this process feasible, this comes with a heavy involvement and effort by the institution representatives and with extensive computational resources. Finally, even if one institution is capable of making efforts to adapt a generalized LLM for its use, it faces the inevitable obstacle of data insufficiency. In general, a single institution either cannot provide enough data to receive proper, correct output for the downstream task or is incapable of solving instruction of so-called new events or conditions.

A healthcare institution would need support in multiple areas to make the process easier to follow and adopt. As a result, processes related to finding a suitable LLM model, maintaining it, and keeping it up to date should be outsourced to a separate body owning the expertise. To effectively adapt LLMs in the healthcare domain, collaboration among institutions in compliance with the industry regulations should be established to build a rich training corpus.

3 FL Principles Relevant to Healthcare Data Privacy and Security

In healthcare, data is often distributed across multiple institutions, each possessing unique and valuable patient information. Traditional approaches to AI model training require centralizing this data, which poses significant privacy and security risks. Federated learning provides a solution by enabling collaborative model training without exchanging raw data. Instead, each institution trains the model locally and shares only aggregated updates with a central server. This method ensures that sensitive patient data remains within the institution, facilitating the transfer and deployment of AI models across different settings without compromising data security. FL is an iterative process, and each communication round aims to improve the model's performance. A typical FL scenario consists of two main phases in each round: local training of the model done on the participant side and aggregation of updates, which aims to create the most accurate consensus model.

There are three main types of FL based on how the data is distributed across participants. In horizontal federated learning, the datasets share the same feature space but differ in the samples they contain. Vertical federated learning, on the other hand, involves datasets with the same samples but different features. Lastly, federated transfer learning encompasses datasets that vary in both their feature and sample spaces [8].

FL in healthcare is predominantly covered in theoretical research, with many studies exploring its potential, such as for improved personalized treatment and public health monitoring. However, there are real-life applications, such as in radiology, where FL enables collaborative training on medical images like MRIs and X-rays without sharing patient data [23].

In the context of machine learning (ML) applications involving healthcare data, there are three critical vulnerability points that require attention: the data itself, the training of ML models, and the communication and transfer of data. Each area carries specific challenges and risks that must be mitigated to ensure the privacy, security, and efficacy of ML systems in healthcare. Health-related data is inherently complex, with characteristics such as high dimensionality, variance over time, heterogeneity, difficult interoperability, sparsity, and isolation [4]. Protecting the privacy of patients' personal and sensitive health information is crucial. Due to the sensitive nature of healthcare data, security breaches can lead to severe consequences, including identity theft, fraud, and violation of patient confidentiality.

Healthcare data often comes from various sources, such as hospitals, clinics, wearable devices, and electronic health records (EHRs). This data is typically non-independent, identically distributed (non-iid), unbalanced, and fragmented across different systems. Additionally, data may be sparse or isolated, making it challenging to build comprehensive patient profiles or conduct large-scale analyses.

Federated learning offers a promising approach to overcoming these challenges by allowing ML models to be trained across multiple decentralised data sources while keeping data local. This technique improves data privacy and security by not requiring raw data to be transferred to a central location. In an FL environment, each data controller defines its governance processes and privacy policies. This includes setting conditions for data access, training, and validation phases [3, 7, 19].

Communication between institutions, especially in healthcare, must adhere to strict regulatory requirements, such as the Health Insurance Portability and Accountability Act (HIPAA) in the U.S. and GDPR in Europe. Thus, privacy-preserving mechanisms should be implemented "by design" and "by default" to ensure that sensitive patient information is processed securely. A compliant ML system requires secure data transfer mechanisms, consent management, and audit trails. The FL setting can offer advancement in this area by letting institutions keep sensitive information, prevent unnecessary data transfers and processing that could violate regulatory requirements, and minimize the risk of data breaches [27].

Training ML models with healthcare data presents unique challenges, including addressing data bias, limited sample sizes, and ensuring model performance. Healthcare data may be biased due to demographic imbalances, socio-economic factors, or varying levels of care access across populations.

Training of ML models with diverse datasets enhances their generalizability and robustness. By incorporating data from various sources and populations, models can better adapt to new and unforeseen health events, improving their predictive power and reliability. Federated learning, in particular, enables the use of diverse datasets while maintaining privacy, thus improving overall model performance [21, 17].

4 FL Architecture for LLM-Based Healthcare Applications

Figure 1 depicts the three major components of a typical FL architecture. The participants involved in our cross-silo FL setting are the healthcare institutions, the manager (e.g., aggregation server or global server), and the communication-computation layer, which aggregates local updates and orchestrates communication phases in the ecosystem. Each component has its own responsibilities, which are essential for the model to satisfy the preset expectations.

Leveraging FL in utilizing LLMs adds a layer of complexity and implies different approaches based on the level of decentralization that needs to be achieved [29]. FL can help in both the pre-training and fine-tuning phases of LLM, and it is up to the requirements' specific characteristics and the parties involved computational power to choose the right strategy [2, 11]. We will cover the different approaches while examining the three major architecture components.

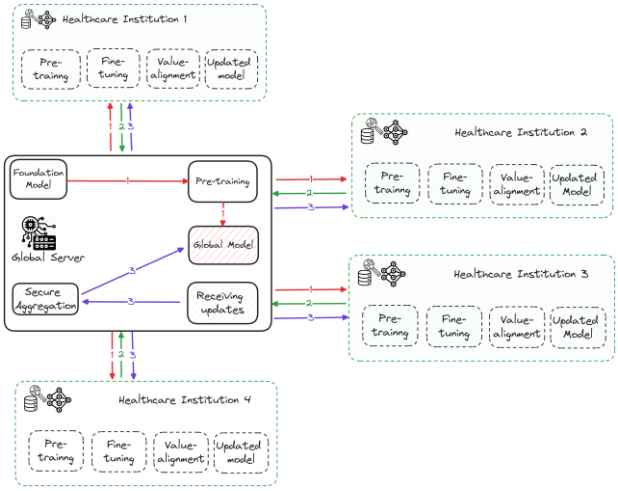

Figure 1: Typical FL Architecture that can be deployed for LLM-based applications

4.1 Global Server

The global server plays a central role, and due to the lack of properly established taxonomy and standards, this component in the literature is also considered as the manager or creator of the whole ecosystem. It is often referred to as the "manager" or "aggregation server" tasked with overseeing the entire collaboration and ensuring its smooth functioning. In healthcare, the manager can be a single healthcare institution that holds a lot of data and wants to leverage the FL setting to collaborate with other institutions, either to complete the missing domains and dimensions (by utilizing Vertical FL) or to enrich and expand the feature set in the same dimension (Horizontal FL). The global server's responsibilities can be broken down into several distinct areas: strategy for choosing a foundation model, strategy for exploiting data distribution and the client selection.

The foundation model, also called the base model, forms the initial point of the LLM training in the FL setting. It represents a starting point for institutions to leverage the pre-training process with their own data or fine-tune it to perform specific downstream tasks since foundation models are usually trained on publicly available datasets. The pre-training process is computationally and time-consuming, meaning that the global server must find the most suitable scenario for satisfying requirements.

There are two main kinds of pre-training models: one based on the BERT model and the other on the GPT model. Both perform differently for different tasks and scenarios [5, 22]. Many attempts are made to use publicly available literature specific to the medical domain and create ready LLM models for usage, such as BioBert, which show superior performance than general pre-trained models [15].

One approach is to select a suitable foundation model based on the options examined before or to initialize FL pre-training, where each party will contribute to the pre-training of the foundation LLM model. The latter approach requires the institutions to have expertise and sufficient computational power in their infrastructure to complete the assignment. Another consideration is the model's size and complexity, which will influence the following steps if not chosen according to the participant's IT infrastructure.

Federated Learning can work differently depending on how data is spread and distributed across entities. In horizontal FL, each institution has data with similar features (for example, multiple hospitals with similar patient data). In vertical FL, institutions have different features for the same set of patients (for example, one entity has clinical data, and another has genetic data). Transfer learning can also be used when the model needs to generalize across different datasets [20]. The global server is responsible for choosing the appropriate strategy based on the data distribution and the desired outcomes.

Client selection in FL refers to choosing which institutions to participate in each training round. The global server must ensure that diverse institutions contribute to model updates without overloading the communication system. Institutions with more data or better computational resources might participate more frequently. Still, the system should be flexible enough to rotate clients or dynamically adjust client participation based on resource availability.

4.2 Participants

The entities participating in this collaboration technique are also tasked with significant responsibilities. In the medical domain, these institutions own huge structured or unstructured datasets and are willing to participate in a distributed training process. Their responsibilities can be broken down into the pre-training process, fine-tuning, value alignment, and strategy for local updates.

If the FL-specific training approach is adopted, as discussed previously in the strategy for choosing the foundation model, then each institution may pre-train the selected model on its data and ensure that the initial model updates sent to the global server are more relevant and valuable. This capability in an FL setting can depend significantly on the institution's computational power, and even though possible and theoretically feasible, it can require a lot of additional expertise for the healthcare institution to engage in this kind of activity.

Fine-tuning is crucial in adopting an LLM in the healthcare domain. The approach of LLM fine-tuning is to make downstream tasks required by the domain be instructed with human feedback [18]. Each institution should provide input-output pairs where instructions are explicitly offered to solve some already defined downstream tasks. These datasets are designed to give the model an idea of what kind of output is expected. The expectation is that the LLM will learn to generalize and can handle novel instructions even though they were not a part of the fine-tuning instruction dataset.

The variety of downstream tasks that LLMs can perform in the healthcare domain is often the critical reason institutions engage with this concept. Based on a benchmark for generalist biomedical AI, some of the most frequently performed medical-relevant tasks suitable for the LLM domain are question answering, visual question answering (for example, based on radiology or pathology images), report summarization and generation, and medical image and medical documents classification [26]. Additionally, relation extraction in combination with named entity recognition can be added to the list of medical-relevant tasks. This is helpful in the medical domain to extract medical terms such as diseases, conditions, procedures, and symptoms from unstructured data and find suitable interpretations and connections in the unstructured data pool.

Thanks to the LLaMA, each institution can make significant attempts to build its domain-specific instruction set and contribute to global instruction tuning in the FL setting. With the FL paradigm, each downstream task can be trained on multiple datasets instead of a single dataset, giving more suitable responses and outputs [25].

In the FL setting, the value-alignment step occurs on the participant's side during local training. Its purpose is to ensure that the model's objectives are aligned with each institution's values and goals. This step is particularly crucial in the medical field, where ethical guidelines and patient care standards are of the utmost importance.

Technically, value-alignment is solved similarly to instruction tuning, with each participant's preference dataset containing combinations of instruction, preferred, and misreferred responses.

In FL, participants typically have far fewer computational resources than centralized cloud servers and fine-tuning all parameters of LLMs can be an obstacle. Parameter-efficient tuning techniques, such as Lora, are used to address this limitation [6]. Instead of updating the entire pre-trained model weights to obtain local updates, participants modify only specific parameters and send them back to the global server for aggregation.

4.3 Communication-Computation Layer

As presented above, the global server is responsible for managing the whole ecosystem, and one of the most complex tasks is related to the communication-computation layer. The global server should manage the aggregation process of local model updates and ensure that the global LLM and updates are securely transmitted across the system.

Choosing the suitable FL algorithm for combining all findings and improvements made by each participant in the form of parameter weights is a step that has attracted many researchers and experts. One of the first and most used algorithms is Federated Averaging (FedAvg), but more sophisticated approaches may be necessary in different scenarios [16]. The model's performance relies significantly on how model updates are aggregated. Even though the only data transmitted through the network in an FL setting are the model and its updates, the communication layer is responsible for ensuring that the transfer is done securely and continuously. The communication layer

component must develop a strategy for creating a pipeline from a live data connection to the model and inference to transmitting new model parameters via secure channels to the aggregating server. Size and complexity of the model must be considered as well, since they can cause a bottleneck.

In addition, the communication layer also ensures that the data transfer is seamless and uninterrupted. This component is tasked with developing a robust strategy to create an efficient pipeline, from managing real-time data connections to facilitating model utilization and transmitting updated model parameters securely to the central aggregation server. A key consideration for the communication layer is the size and complexity of the used model. Large models with huge parameter lists can introduce significant bottlenecks during transmission, especially when dealing with limited bandwidth or less powerful devices. As such, the communication layer must be adept at handling these challenges, ensuring that updates are transferred efficiently without compromising the speed or security of the system.

5 Hype, Vision and Challenges

Implementing LLMs in healthcare using FL presents a set of intertwined challenges when viewed through the lenses of privacy and security. There is a foundational challenge between the need for diverse and high-quality data generated by institutions in the specific domain and the importance of protecting sensitive information. FL enables availability and access to a broader spectrum of data sources while maintaining privacy. Still, the inability to directly act upon raw data can impact the convergence of the model and model performance. Data transfer needs in FL, even though minimized to just model updates, still introduce a risk for security attacks. This risk increases with the communication overhead caused by distributing complex and large LLMs.

By introducing a central figure in the architecture in the name of the global aggregation server, the FL setting in LLM opens up a single point of failure in the ecosystem. Adversarial attacks can be performed, compromising model integrity, which could lead to data breaches and incorrect outputs.

FL is still a young and immature topic in the context of LLM. One of the biggest challenges is the lack of benchmarks and comprehensive reviews that can examine the solution's success based on different tasks, architectures, the number of clients, network bandwidth, computational resources, etc. These reviews and benchmarks can further expose security and privacy-preserving issues and initiate proper risk mitigation strategies. Multiple algorithms exist in the literature for aggregating local updates, but no specific algorithm is proposed or adapted for LLMs.

The analysis of the three major components in the previous section pointed out the responsibilities, approaches, and strategies that need to be considered in order to collaboratively design and implement training, and utilize LLM properly. The analysis emphasized that training LLMs in a federated learning setting requires a thoughtful, tailored approach to address the unique challenges. Additionally, there are various approaches to take, depending on factors such as participant resources, data distribution, model size and complexity, data transfer, etc. This section will further examine the challenges of implementing such LLM training in the FL setting. Fine-tuning LLMs in FL is a time-consuming and computationally expensive task [6].

The client selection process, in which the ecosystem manager decides which participants should be involved, can raise many ethical concerns, such as fairness. The purpose of the collaboration is to make the LLM more robust. Still, some participants' data volume and computational power can squeeze out institutions that are not on that level but still can add to the diversity and offer unique cultural, ethical, and contextual values. While FL addresses many privacy concerns by design, it also introduces new security considerations that must be carefully managed. Successfully navigating these challenges requires a detailed approach that balances privacy protection, security enhancement, and the pursuit of practical and robust LLM in healthcare.

6 Privacy-Preserving Techniques

The deployment LLMs in the healthcare field through FL promises advancements in preparing models to react to given domain-specific downstream tasks. The FL can enhance LLMs' effectiveness and proper application while safeguarding patient confidentiality and ensuring regulatory compliance, providing medical professionals greater confidence in adopting these tools.

However, while FL enables collaborative learning without direct data sharing, it's not immune to privacy threats. With this approach, raw data remains local, but the model updates shared during training can still leak information. In addition, LLMs trained with healthcare data could memorize and potentially regenerate sensitive patient information. A privacy breach in this context can cause severe consequences, including exposure to medical history, compromising patient confidentiality, and misuse of sensitive health information [1].

During this collaborative process, the model or its updates could become targets for various attacks. For instance, model inversion attacks performed on the global model might allow the reconstruction of individual patient records. Similarly, membership inference attacks could reveal the presence of specific institutions or patient data in the training, potentially exposing the entire medical history. Malicious participants in the process could poison the model by introducing biases or backdoors, potentially leading to improper results generated by the LLMs [9, 24].

To counter these risks and threats, researchers and practitioners evaluate the effects of several privacy-preserving techniques, such as secure aggregation and differential privacy. Secure aggregation, a cryptographic protocol, allows the central server to observe aggregated results without accessing individual model updates. This approach maintains accuracy but adds significant communication costs. Differential privacy, on the other hand, adds calibrated noise to data or model parameters, offering statistical privacy guarantees. While effective against inference attacks, it may reduce model accuracy and require additional workload in the parameter-tuning process [14]. The choice of privacy-preserving techniques must be made with a thorough understanding of the specific use case, the sensitivity of the data involved, and the potential impacts of privacy breaches. The tailored approach should calibrate the trade-off between model performance and data protection. More robust privacy protection might require limiting the model’s access to

much-needed data for LLMs to offer a proper answer to a specific task, degrading the model performance and increasing the computational and communicational overhead. As research in this field progresses, finding the right balance between privacy, system performance, and efficiency will be crucial for deploying LLMs in healthcare using FL.

7 Conclusion

This paper has explored the potential of FL in enhancing the deployment of LLMs in healthcare settings. By enabling privacy-preserving collaboration, FL allows healthcare institutions to collectively train and improve LLMs without compromising sensitive patient data. This approach not only addresses fundamental privacy concerns but also enhances model performance by leveraging diverse datasets across institutions, potentially improving the generalizability and robustness of LLMs in healthcare applications. To facilitate the implementation of healthcare LLM with FL, we examined a tailored architectural framework that outlines the roles and responsibilities of participating entities. In addition, challenges and consideration of risks and threats were reviewed, especially in combination with privacy-preserving techniques.

Looking ahead, several areas require further research and development. Optimization of computational and communication efficiency for LLMs, development of standardized benchmarks, establishment of ethical frameworks for participant selection, and exploration of advanced privacy-preserving techniques are crucial for future work.

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Use and Limitations of ChatGPT in Mental Health Disorders

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Abstract / Povzetek

ChatGPT is one of the most advanced and rapidly evolving large language model-based chatbots. It excels in everything from handling simple questions to performing complex medical examinations. While current technology cannot replace the expertise and judgment of skilled psychiatrists, it can assist in early detection of mental problems, patient evaluations, differential diagnoses, psychotherapy and in planning and conducting medical research. Ensuring privacy and adhering to professional, ethical, and legal standards is crucial when processing training data. This is especially important in mental health settings, where disclosing sensitive personal information increases the risk of data misuse and the potential for harmful advice. Current uses of ChatGPT in mental health care are constrained by its design as a general chatbot, rather than a specialized psychiatric tool. Despite this, the model proves useful for handling routine psychiatric and administrative tasks. As GPT technology evolves, it holds significant promise for psychiatry, including integration into diagnostics, psychotherapy, and early detection of mental health issues. To deploy these advancements responsibly and effectively, it is crucial to develop and refine professional ethical standards and practice guidelines.

Keywords / Ključne besede

Keywords mental health disorders, large language models, deep learning, ChatGPT

Introduction

ChatGPT has emerged as one of the most advanced and rapidly evolving large language model-based chatbot systems. Its extensive capabilities, ranging from responding to basic inquiries to performing well in complex medical examinations, have garnered significant attention from the global scientific and research communities, prompting ongoing discourse regarding its potential applications across diverse domain [1]

The discourse surrounding the potential applications of ChatGPT in mental health disorders remains relatively underexplored. This work seeks to offer a quick overview of the current state of ChatGPT implementations within the mental health domain, while also projecting future advancements in digital mental health care through the integration and development of ChatGPT technology.

Current use of ChatGPT for mental health disorders

In managing mental health disorders, human contact is especially crucial compared to other medical fields, as it is accompanied by understanding and empathy. This is why, in the most vital aspects of psychiatric work, human relationships remain central [2]. While ChatGPT's practical applications in the field of mental health are limited because it specializes in language generation, it can still support certain routine tasks within the field. Although evaluations, diagnoses, psychotherapy, and patient assessments are mainly conducted by human therapists, ongoing trials are exploring how ChatGPT might be utilized in mental health services. Several platforms, like ChatBeacon, or Koko, are already available on the market, claiming to offer mental health assistance powered by ChatGPT [3,4]. For instance, Koko is a peer-support platform that provides crowdsourced cognitive therapy. It's experimenting with using GPT-3 to generate bot-written responses to users while they wait for peer responses. Koko is an online mental health intervention that has reached nearly two million people, mostly adolescents. The platform started as a clinical trial at MIT and is based on the concept of crowdsourced cognitive therapy. Users are taught to help each other think more hopefully about the world. Unlike traditional peer support platforms, all interactions on our service are supported and augmented by AI.

Applied to the classification of psychiatric disorders.

Recent advancements in deep learning, the foundational algorithm of GPT, have significantly impacted the field of mental health disorders. This technology has been applied to classify psychiatric disorders using neuroimaging data [5], develop models based on electroencephalograms [6], and utilize a range of patient characteristics for diagnosing and predicting mental disorders [7]. These deep learning models have shown good diagnostic accuracy (AUC 0.74- 0.81) suggesting the possibility of combining genetics and registry data to predict both mental disorder diagnosis and disorder progression in a clinically relevant, cross-diagnostic setting prior to clinical

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assessment. The main limitation of this model is that it is restricted to learning from historical data and should be continuously assessed and evaluated by trained clinicians and never stand alone in the decision-making

Utilized to alleviate the burdens associated with clinical documentation, communication, and research tasks.

Also, new technologies can assist clinicians by allowing them to focus more on direct patient care and alleviate the high clinical workload and bureaucratic tasks- such as handling admissions and managing paperwork- that have been linked to burnout in earlier research [8]. ChatGPT can assist in processing clinical case transcripts, generating summaries, completing medical record documentation, and efficiently preparing discharge summaries. It can also help facilitate communication between clinicians of different specialties when consultations are needed, aiding in an integrative approach [9].

While current technology cannot replace the expertise and judgment of skilled psychiatrists, it can assist in generating differential diagnoses based on relevant signs and symptoms. ChatGPT is recognized for its substantial potential to assist experts with clinical and laboratory diagnoses, as well as in planning and conducting medical research [10].

Applied in psychotherapy to enhance therapeutic processes

Chatbots can be also beneficial in psychotherapy. The therapist's emotions and the emotional alignment between therapist and client are crucial factors influencing the process and outcomes of therapy [11]. A study conducted during the COVID-19 pandemic showed that technology can offer an effective method, providing at least a first level counseling support structure [12]. This implies that GPT models may potentially develop cognitive empathy over time, making it possible for ChatGPT to achieve a notable level of accuracy in identifying users' emotions [13], nevertheless it is important to make systematic testing to ensure a non-superficial comparison between human and artificial intelligences [14]. Namely, ChatGPT currently lacks the capability to accurately assess personality traits, a task that demands extensive training and expertise from psychiatrists. AI researchers are diligently pursuing technical advancements to improve the precision of personality detection [15].

A study designed to assess the accuracy and appropriateness of psychodynamic formulations generated by ChatGPT found that the model produced suitable results even without additional psychoanalytic information. It also demonstrated a strong ability to generate psychodynamic formulations consistent with various psychoanalytic theories when given appropriate instructions. [16].

The research underscores that ChatGPT is not intended to substitute psychiatrists or psychologists but rather to function as an initial resource and a first line of support for those dealing with mental distress. When used wisely and within appropriate limits, ChatGPT can be an effective tool in supporting mental health services. [17]. However, it is essential to process training data in a manner that ensures privacy protection and adheres to all professional, ethical, and legal standards. Given that individuals may be at increased risk of data misuse when disclosing sensitive personal and family information during mental health treatment [18].

Employed for the prevention and early detection of mental health issues

The role of AI in the prevention and early detection of mental problems can also be very significant. Patients frequently turn to ChatGPT to seek information about their symptoms, possible diagnoses, and treatment options. ChatGPT performs better than Google Search in delivering general medical knowledge but scores lower when it comes to providing medical recommendations [19]. A recent study highlighted early success for an AI model that can detect cognitive distortions in text messages with accuracy comparable to that of clinically trained human raters [20]. GPT's ability to recognize mental health warning signs in routine conversations or text-based telemedicine interactions has the potential to improve early and effective intervention strategies when necessary.

Risks and limitations ChatGPT use for mental health disorders

Despite its strengths and potential, the use of AI technologies in psychiatric clinical practice carries several risks. A significant concern is the phenomenon of "artificial hallucinations" where the conversational model may confidently produce text that is factually incorrect, nonsensical, or misleading [18].

Recent systematic review that included 118 articles identified some limitations regarding the potential of ChatGPT in patient care and medical research, noted that the solutions provided by ChatGPT are often insufficient and contradictory, raising concerns about their originality, privacy, accuracy, and legality [10]. It is well established that ChatGPT may generate inaccurate facts and references when summarizing previous research, and the quality of its responses often hinges on how the questions are phrased [21].

Even with the advanced GPT-4 model, there is still a risk of providing harmful advice. The absence of clinical reasoning and experience in ChatGPT can lead to the omission of important clinical details in patient summaries and medical records. Thus, the most prudent approach is to employ AI systems as supplementary tools for mental health professionals, ensuring they are used under close supervision to uphold the safety and quality of patient care. [22]

Conclusion

The recent introduction of GPT-4 has significantly enhanced the capabilities of the GPT system. Current implementations of ChatGPT within mental health care are limited by its inherent design as a chatbot, rather than as a specialized AI tool specifically tailored for psychiatric use. Nonetheless, this sophisticated language model demonstrates significant utility in addressing various routine psychiatric and administrative functions.

As this technology evolves and advances, we anticipate substantial potential for future applications of GPT technology in psychiatry, including its integration into diagnostic processes, the provision of psychotherapy within clinical environments, and the rapid identification of early warning signs for mental health disorders. Crucially, the development and refinement of professional ethical standards and practice guidelines are imperative for the responsible and effective

deployment of these transformative GPT technologies in the mental health sector.

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Testing ChatGPT's Performance on Medical Diagnostic Tasks

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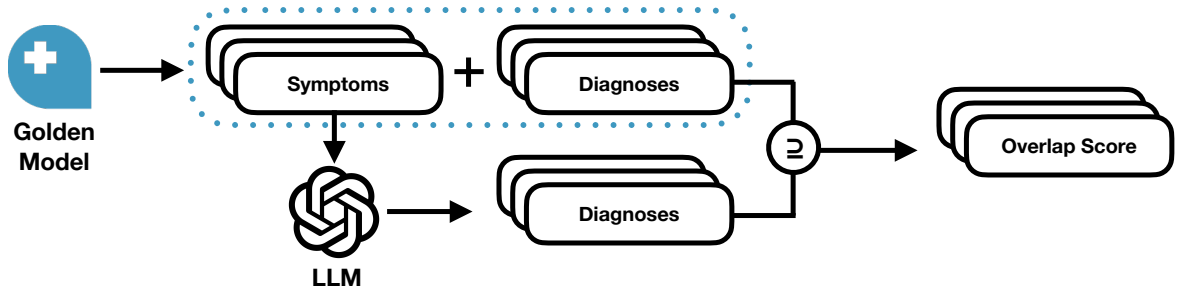

Figure 1: Semi-Automatic Evaluation of an LLM on Medical Diagnostics Using a Medical Expert System as a Golden Model.

Abstract

Large Language Models and chat interfaces like ChatGPT have become increasingly important recently, receiving a lot of attention even from the general public. People use these tools not only to summarize or translate text but also to answer questions, including medical ones. For the latter, giving reliable feedback is of utmost importance, which is hard to assess. Therefore, we focus on validating the feedback of ChatGPT and propose a testing procedure utilizing other medical sources to determine the quality of feedback for more straightforward medical diagnostic tasks. This paper outlines the problem, discusses available sources, and introduces the validation method. Moreover, we present the first results obtained when applying the testing framework to ChatGPT.

Keywords

Large Language Models, ChatGPT, NetDoktor, Testing, Validation

1 Introduction

Large Language Models (LLMs) are omnipresent in today's society, as they are used by a wide audience for a growing number of tasks. This study sheds light on one area of application in particular, which is asking for medical diagnoses. Assessing one's health and medical diagnostics are complex tasks, that fall into the domain of medical experts. However, since the dawn of search engines and medical websites, like NetDoktor [13], people have turned to the internet for getting health advice. Previously, users searching for answers had to consult multiple online resources, compare page contents, and evaluate whether their set of symptoms matched what they found. Nowadays it is seemingly easy to find answers in one spot as LLM-powered chatbots, like ChatGPT [8], are happy to respond with a diagnosis. This, of course, implies much risk of harm or misinterpretation. After all, the very reason many users - being non-experts - turn to chatbots is that they cannot assess symptoms themselves. Clusmann et al. [5] further point out that there is a lack of mechanisms to guarantee that the LLM's output is correct. All of this makes it important to test such systems on a practical level, which is close to the use cases of non-experts. As for its popularity, our evaluation focuses on ChatGPT [8], which is powered by OpenAI's most recent model, GPT-4o [9, 10]. The task of medical diagnostics shares many traits with the natural language processing (NLP) task of question answering (QA). Namely, this task tests for medical knowledge as well as basic reasoning facing medical language. MedQA [6] is a popular benchmark in literature, which is tailored to the medical domain. In recent years, open-domain LLMs such as GPT-3.5 [3], GPT-4 [9], and LLaMA-2 [16] as well as domain-specific LLMs like Med-PaLM 2 [15], Meditron [4] and Med-Gemini [14] have been evaluated on medical QA. The United States Medical Licensing Examination (USMLE) part of MedQA is used particularly often as a performance indicator in this domain. Table 1 shows reported scores of the mentioned LLMs and demonstrates GPT-4's and MedGemini's superiority, with GPT-4 performing marginally worse despite being an open-domain model.

Table 1: LLMs Evaluated on Medical Question Answering. Accuracy Results on the United States Medical Licensing Examination (USMLE) Part of MedQA [6], as Reported in [7, 14, 4, 15].

Model	Domain-Specific	MedQA USMLE
Med-Gemini	Yes	91.1
GPT-4	No	90.2
Med-PaLM 2	Yes	86.5
Meditron	Yes	75.8
LLaMA-2	No	63.8
GPT-3.5	No	60.2

*Both authors contributed equally to this research.

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Alongside ChatGPT's popularity, these results are a major reason why this paper focuses on GPT-4o in particular. This work contributes by introducing a semi-automated validation procedure for medical diagnostics performed with LLMs using an expert system as a golden model (compare to Figure 1). Specifically, we evaluate the performance of ChatGPT powered by GPT-4o with a focus on symptom descriptions in German and compare it to NetDoktor's Symptom-Checker [13], which is curated by medical professionals. Our setup is guided by the following questions regarding prompting ChatGPT:

- Does ChatGPT provide equivalent diagnoses when presented with the same symptoms as NetDoktor?
- Does the output quality - as measured by the overlap - change when asked for a specific amount of "most likely" diagnoses?
- Does the output increase in quality when ChatGPT is queried in English instead of German?

2 Validation Methodology

For the purpose of introducing our methodology, we use myocardial infarction (i.e. heart attack) as a guiding example. According to Statisik Austria's annual report, cardiovascular diseases, which include heart attacks, are the most common cause of death in Austria. The symptoms of a myocardial infarction include:

- Feeling of tightness or constriction
- Feeling of anxiety/panic attacks
- Sudden severe shortness of breath, unconsciousness, or severe dizziness
- Nausea and vomiting
- Blood pressure and pulse drop

These symptoms are now linked to an imaginary person's sex and age to form a persona whom for we want to retrieve diagnoses. Our exemplary set of symptoms shall be linked to an adult man and can be identified by ID 1 in all tables and plots. Besides this exemplary persona, where we first fixed a disease, all other sets of symptoms are picked at random. This can be done due to our assumption of a golden model, which we use as our baseline.

2.1 Golden Model

We use NetDoktor's "Symptom-Checker" [13] as a baseline for our evaluation. Symptom-Checker is a freely accessible, medical expert system for retrieving likely diagnoses corresponding to a person's symptoms. The system can be interacted with via a questionnaire but is only available in German. Parts of the questionnaire are static, such as questions regarding sex, age, and selecting the general area of one's body where symptoms occur most prominently, while others are adapting to the previously asked questions. The dynamically changing questions are always asked expecting an answer from the set: "Yes", "No" and "Skip". According to NetDoktor, the system is continuously validated by medical professionals and is based on the medical database AMBOSS [1] and follows the medical guidelines of professional societies [2]. We assume this expert system to be our golden model, as it comprises curated knowledge of high quality and is fully deterministic. The latter makes it possible, to generate a decision tree from a person's (or persona's) interaction with the system, that is reproducible across multiple calls [1]. Figure 2 shows the tree generated from the interaction of our exemplary persona having a heart attack. The tree is to be read from top to bottom, starting with the first question as the root node. It should be noted, that the very first question "Um wen geht es?" (i.e. "Who is it about?"), was always answered by "jemand anderen" (i.e. "somebody else") for this study. Rectangles represent questions and the ellipses represent the respective possible answers to choose from. The node at the second to last level, which is denoted by "Mögliche Erkrankungen" (i.e. "possible diseases") symbolizes the retrieval of diagnoses from the database, while the leaf nodes on the bottom level signify the results of the query. In this exemplary case, the questions were answered to correspond to the symptoms of a heart attack for demonstration. However, we can also use Symptom-Checker to automatically and randomly traverse the questionnaire's tree-like structure to retrieve sets of symptoms and corresponding diagnoses. This allows for a scaleable framework for comparing other methods against a strong and valid baseline. Sets of symptoms and corresponding "golden" diagnoses are extracted from such a tree as follows: Firstly, for each path from the root node to the bottom level nodes (i.e. the diagnoses), questions-answer-pairs are stored in a JSON data structure. Each full path represents one set of symptoms. Secondly, each set of symptoms is summarized in a textual representation in German taking special care not to lose or add information. This is then translated from German to English. The first rows of Tables 3 and 4 contain the textual descriptions of our example in German and English, respectively. Lastly, the diagnoses provided by the golden model are extracted from the bottom layer (i.e. the leaf nodes) of the tree, which is always a set of three diagnoses. These sets of diagnoses are referred to as NetDoktor diagnoses for the remainder of this paper.

[1] As long as the underlying knowledge base does not change.

2.2 Evaluation Metric

The main evaluation metric used in this work is the overlap of diagnoses as compared to NetDoktor. A set of diagnoses is considered as being good if it contains a large overlap with the golden model diagnoses of NetDoktor. Since the NetDoktor baseline always yields three diagnoses, the highest overlap any other system can achieve is 3/3. Thus, the score ranges from 0/3 to 3/3. We explicitly do not normalize, although we want to compare sets of diagnoses with varying cardinalities. The reason for this is that yielding more diagnoses should not be penalized (as they might be worth considering, as well), and yielding fewer should not lead to a better score automatically.

2.3 Equivalence of Diagnoses

This study compares systems designed for direct interaction with humans. These systems' output is presented to the users in natural language. A key feature of medical language is its interchangeable use of semantically equivalent terminology originating from different languages such as Latin, German, or English. Additionally, when talking to patients, medical personnel often have to use simplified terminology, which includes the use of colloquial synonyms, hypernyms, and hyponyms. Hence, the semantic equivalence of diagnoses must be considered to ensure the comparability of different systems.

- Synonyms are terms, which can be used interchangeably with one another.
- Hypernyms are superordinate or umbrella terms of a term.
- Hyponyms are describing subordinate terms (i.e. more specific) or another term.

Table 2 lists diagnoses that are treated as equivalents for this study.

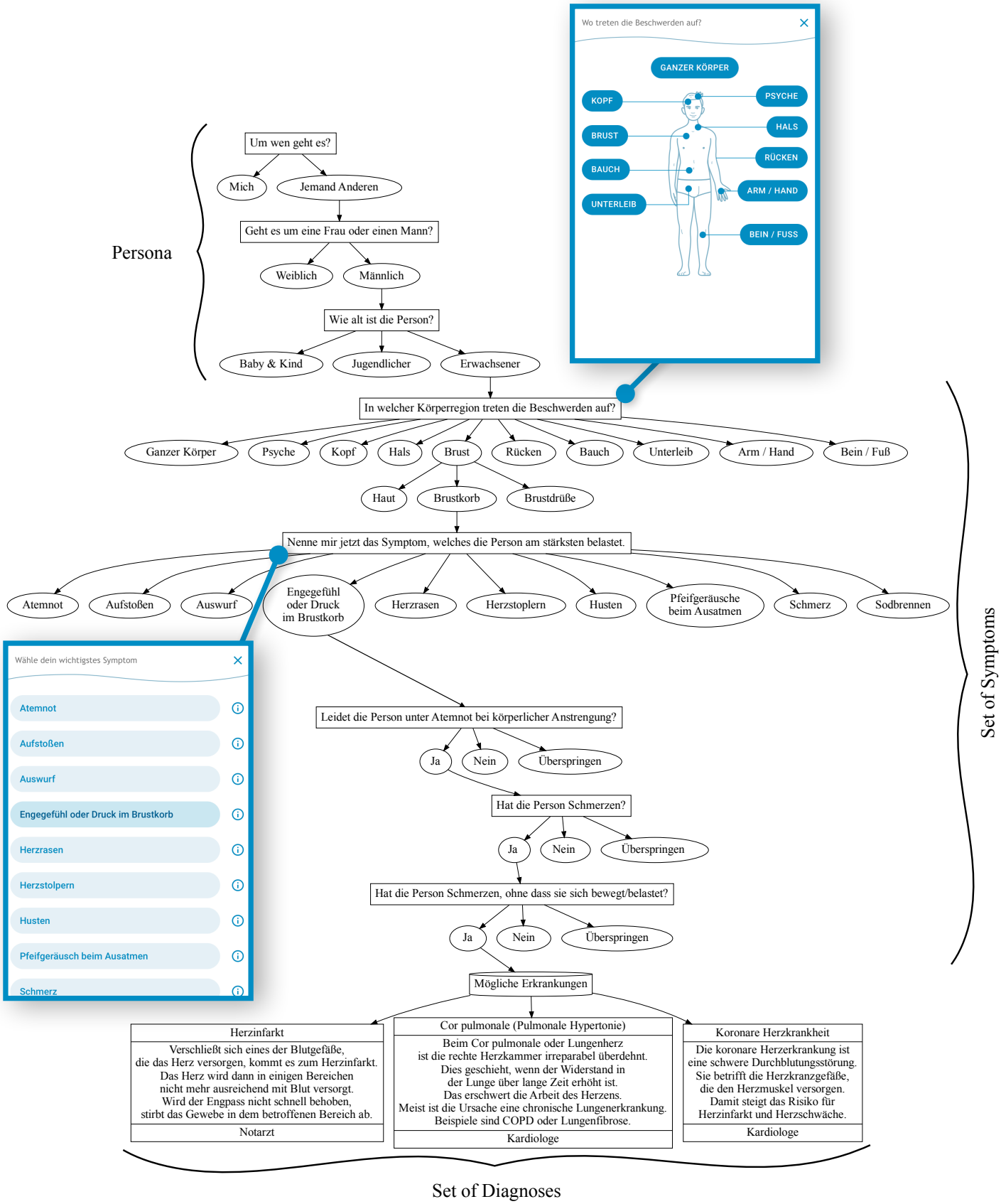


Figure 2: Golden Model: Exemplary Decision Tree Based on NetDoktor's Symptom-Checker Questionnaire [13] Filled-Out for a Persona Having a Heart Attack. Blue Boxes are Screenshots from Symptom-Checker Corresponding to Nodes in the Tree. We Set a Persona and Automatically Extract A) a Set of Symptoms and B) a Set of Diagnoses for Each Path From the Root Node to the Leaf Nodes on the Bottom-Most Level.

Table 2: Equivalent Diagnoses: Synonyms, Hypernyms, Hyponyms & Translations

Diagnosis	Equivalence (as Occurring in ChatGPT Output)
Herzinfarkt	Myokardinfarkt
	Akutes Koronarsyndrom
	Myocardial Infarction
	Heart Attack
Reiter-Syndrom	Reaktive Arthritis
	Morbus Reiter
	Reactive Arthritis
	Reiter's Syndrome
Kawasaki-Syndrom	Kawasaki Disease
	Kawasaki Syndrome
Blinddarmentzündung	Appendizitis
Vorhofflimmern	Herzrhythmusstörungen
Glutenunverträglichkeit	Zöliakie
Bakterielle Pharyngitis	Mild Bacterial Conjunctivitis with Pharyngitis
Krätze	Scabies
Erkältung	Virale Infekte
Pfeiffer-Drüsenfieber	Pfeiffersches Drüsenfieber
	Mononukleose
Blasenentzündung	Zystitis
	Harnwegsinfektion
	Urinary tract infection
Gürtelrose	Herpes Zoster
Mastopathie	Fibrozystische Mastopathie
Lipom	Lipoma

2.4 Sets of Symptoms & Personas

For this evaluation, we retrieved 12 sets of symptoms from NetDoktor - 6 for females and 6 for males, and for each sex, we used all of NetDoktor's 3 age categories (baby/child, adolescent, adult) twice. In addition, we used the exemplary set of symptoms for an adult man having a heart attack, as discussed in the previous section. This yields the 13 sets of symptoms listed in Tables 3 and 4. In Figure 2, the parts of the questionnaire are marked, which correspond to the persona and the set of symptoms respectively. In the following, both terms are used interchangeably.

2.5 Model, Prompts & Diagnose Retrieval

For all of our experiments, we used GPT-4o [9, 10] through ChatGPT [8]. More specifically, we used version GPT-4o-2024-08-06, which has been released in August 2024. We evaluate the same model in German and English and denote this with a trailing "[DE]" for German and "[EN]" for English for the respective results. We extended this convention to our golden model NetDoktor as well. The full list of prompts used can be found in the next section, Section 3. All LLM results were retrieved in a zero-shot methodology, without samples or additional context besides the prompt itself. Every symptom description is sent within a new chat to isolate individual queries. However, we cannot guarantee that we are indeed interacting with a "blank slate" as ChatGPT and GPT-4o are both black boxes and our user profile might interfere with the output.

Table 3: Sets of Symptoms per ID [DE]

ID	Description of Symptoms in German
1	Ein erwachsener Mann verspürt ein Engegefühl im Brustkorb. Er hat Schmerzen, auch wenn er sich nicht bewegt oder belastet. Außerdem leidet er unter Atemnot, wenn er sich anstrengt.
2	Ein Bub hat gerötete Augen und Fieber. Außerdem hat er Schmerzen beim Wasserlassen.
3	Ein kleiner Junge hat starke Bauchschmerzen, die bei Druck schlimmer werden. Es wurde auch festgestellt, dass er allgemein druckempfindlich ist.
4	Ein jugendlicher Junge verspürt ein Engegefühl oder Druck im Brustkorb. Er bemerkt, dass sein Herz sehr schnell schlägt und unregelmäßig arbeitet. Er fühlt sich oft müde und weniger leistungsfähig.
5	Ein jugendlicher Junge hat an Gewicht verloren und leidet unter anhaltender Müdigkeit. Er hat regelmäßig Durchfall, der besonders voluminös und übelriechend ist.
6	Ein erwachsener Mann hat eine Rachenentzündung und bemerkt gerötete Augen. Es gibt jedoch kein Fieber oder geschwollene Lymphknoten.
7	Ein erwachsener Mann hat entzündliche Hautveränderungen am Unterschenkel, die stark jucken, insbesondere nachts. Es wurde kein Zusammenhang mit Allergien festgestellt.
8	Ein kleines Mädchen hat seit einiger Zeit ihren Appetit verloren, fühlt sich ungewöhnlich müde und hat ungewollt an Gewicht verloren. Es wird auch über verminderten Urinfluss berichtet.
9	Ein kleines Mädchen hat Fieber, eine Rachenentzündung und geschwollene Lymphknoten. Sie fühlt sich abgeschlagen und schwitzt besonders nachts stark.
10	Eine jugendliche Mädchen hat Blut im Urin und Schmerzen beim Wasserlassen. Der Harndrang ist häufig, aber es wird nur eine geringe Urinmenge ausgeschieden. Zudem verspürt sie ein Brennen beim Wasserlassen.
11	Ein jugendliches Mädchen klagt über ausstrahlende Schmerzen im Nackenbereich und hat einen Hautausschlag mit kleinen Bläschen.
12	Eine erwachsene Frau hat Spannungsgefühle in der Brust und tastet schmerzlose Knoten. Die Haut ist nicht gerötet.
13	Eine erwachsene Frau verspürt Druckempfindlichkeit im Oberbauch, die Haut wölbt sich vor und die Region ist geschwollen.

3 Experimental Evaluation

Figure 1 depicts our experimental setup: NetDoktor is used as a golden model to automatically derive sets of symptoms and corresponding diagnoses as exemplified in Figure 2. The extracted symptoms are then used as input to the LLM GPT-4o via ChatGPT. ChatGPT diagnoses are then compared to NetDoktor diagnoses to compute an overlap score. Figure 4 gives an overview of our evaluation results. For each set of symptoms, NetDoktor results are shown, followed by four diagnosis strategies utilizing ChatGPT. The grey bars denote the cardinality of every resulting set of diagnoses. Blue overlays are used to show the overlap between NetDoktor diagnoses and ChatGPT diagnoses. These overlays correspond to the values in Table 5, which comprises the occurrences of overlaps in each category from 0/3 to 3/3. In addition to the 13 sets of symptoms, Figure 4 and Table 5 include averages computed over all sets for easier comparison of the prompts/-diagnosis retrieval methods. In the following, you can find the used prompts/methodologies corresponding to the depicted bars:

A **NetDoktor [DE]:** Diagnoses from NetDoktor were retrieved via the Symptom-Checker questionnaire as is documented in Subsection 2.1. This is our golden model and

Table 4: Sets of Symptoms per ID [EN]

ID	Description of Symptoms in English
1	An adult man feels a tightness in his chest. He experiences pain even when he is not moving or exerting himself. Additionally, he suffers from shortness of breath when he exerts himself.
2	A boy has red eyes and a fever. He also has pain when urinating.
3	A little boy has severe abdominal pain, which worsens with pressure. It was also found that he is generally sensitive to pressure.
4	A teenage boy feels a tightness or pressure in his chest. He notices that his heart beats very fast and irregularly. He often feels tired and less capable.
5	A teenage boy has lost weight and suffers from persistent fatigue. He has regular diarrhea that is particularly voluminous and foul-smelling.
6	An adult man has a throat infection and notices red eyes. However, there is no fever or swollen lymph nodes.
7	An adult man has inflammatory skin changes on his lower leg that itch intensely, especially at night. No connection with allergies was found.
8	A little girl has lost her appetite for some time, feels unusually tired, and has unintentionally lost weight. Reduced urine output is also reported.
9	A little girl has a fever, a throat infection, and swollen lymph nodes. She feels weak and sweats heavily, especially at night.
10	A teenage girl has blood in her urine and pain when urinating. The urge to urinate is frequent, but only a small amount of urine is passed. She also feels a burning sensation when urinating.
11	A teenage girl complains of radiating pain in the neck area and has a rash with small blisters.
12	An adult woman has a feeling of tension in her breast and can feel painless lumps. The skin is not reddened.
13	An adult woman feels tenderness in the upper abdomen, the skin bulges, and the area is swollen.

overlaps with its diagnoses are marked in blue, in Figure 4. The questionnaire and results are in German.

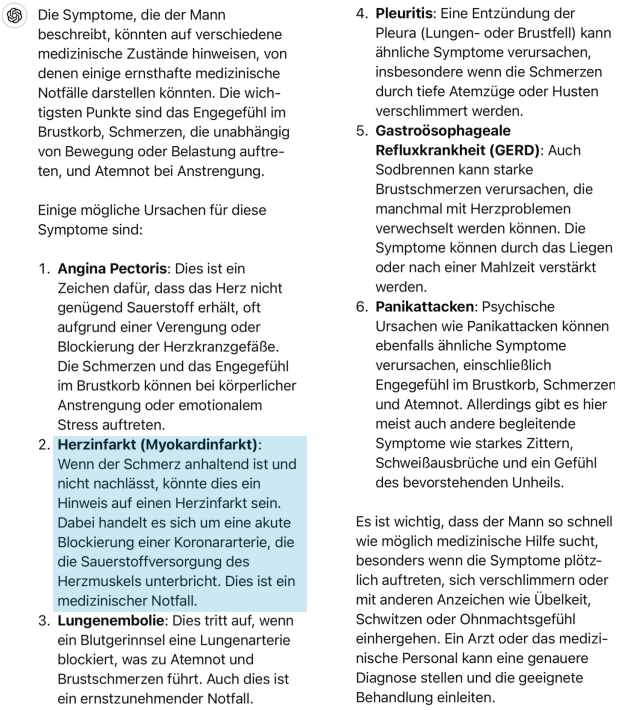
B **ChatGPT [DE]:** Ad-hoc query sent to ChatGPT using the symptom descriptions in German from Table 3 as is.

C **ChatGPT [DE] "3 Most Likely":** More elaborate query sent to ChatGPT using the symptom descriptions in German from Table 3, additionally requesting the "3 most likely" diagnoses.

D **ChatGPT [DE] "10 Most Likely":** More elaborate query sent to ChatGPT using the symptom descriptions in German from Table 3, additionally requesting the "10 most likely" diagnoses.

E **ChatGPT [EN]:** Ad-hoc query sent to ChatGPT using the symptom descriptions in English from Table 4 as is.

Out of convenience, the letters introduced in this list are used when referring to a specific prompt in the following paragraphs. The main takeaway from this evaluation is that none of the used prompts achieves a complete overlap of 3/3 with NetDoktor for any of the personas. Prompt B, achieves the highest score, with 0.92/3 i.e. 31%. For our small test set of 13 sets of symptoms, these results constitute from 2/3 for two, and 1/3 for seven sets of symptoms. The same prompting strategy in English, denoted by E, yields worse results, having overlaps of 2/3 for one, and 1/3 for three sets of symptoms. The two prompts giving ChatGPT the task of answering with the "n most likely" diagnoses are equally not performing as well as the simple prompt in German: C achieves 1/3 for 9 sets of symptoms and D yields 2/3 for three and 1/3 for five sets of symptoms. This means that prompt D,



Die Symptome, die der Mann beschreibt, könnten auf verschiedene medizinische Zustände hinweisen, von denen einige ernsthafte medizinische Notfälle darstellen könnten. Die wichtigsten Punkte sind das Engegefühl im Brustkorb, Schmerzen, die unabhängig von Bewegung oder Belastung auftreten, und Atemnot bei Anstrengung.

Einige mögliche Ursachen für diese Symptome sind:

1. **Angina Pectoris**: Dies ist ein Zeichen dafür, dass das Herz nicht genügend Sauerstoff erhält, oft aufgrund einer Verengung oder Blockierung der Herzkranzgefäße. Die Schmerzen und das Engegefühl im Brustkorb können bei körperlicher Anstrengung oder emotionalem Stress auftreten.
2. **Herzinfarkt (Myokardinfarkt)**: Wenn der Schmerz anhaltend ist und nicht nachlässt, könnte dies ein Hinweis auf einen Herzinfarkt sein. Dabei handelt es sich um eine akute Blockierung einer Koronararterie, die die Sauerstoffversorgung des Herzmuskels unterbricht. Dies ist ein medizinischer Notfall.
3. **Lungenembolie**: Dies tritt auf, wenn ein Blutgerinnsel eine Lungenarterie blockiert, was zu Atemnot und Brustschmerzen führt. Auch dies ist ein ernstzunehmender Notfall.
4. **Pleuritis**: Eine Entzündung der Pleura (Lungen- oder Brustfell) kann ähnliche Symptome verursachen, insbesondere wenn die Schmerzen durch tiefe Atemzüge oder Husten verschlimmert werden.
5. **Gastroösophageale Refluxkrankheit (GERD)**: Auch Sodbrennen kann starke Brustschmerzen verursachen, die manchmal mit Herzproblemen verwechselt werden können. Die Symptome können durch das Liegen oder nach einer Mahlzeit verstärkt werden.
6. **Panikattacken**: Psychische Ursachen wie Panikattacken können ebenfalls ähnliche Symptome verursachen, einschließlich Engegefühl im Brustkorb, Schmerzen und Atemnot. Allerdings gibt es hier meist auch andere begleitende Symptome wie starkes Zittern, Schweißausbrüche und ein Gefühl des bevorstehenden Unheils.

Es ist wichtig, dass der Mann so schnell wie möglich medizinische Hilfe sucht, besonders wenn die Symptome plötzlich auftreten, sich verschlimmern oder mit anderen Anzeichen wie Übelkeit, Schwitzen oder Ohnmachtsgefühl einhergehen. Ein Arzt oder das medizinische Personal kann eine genauere Diagnose stellen und die geeignete Behandlung einleiten.

Figure 3: ChatGPT Output for ID 1, Using Prompt B. Overlap with NetDoktor Marked in Blue. Compare to Figure 2.

asking for the "10 most likely" diagnoses is the runner-up with an average of 0.85/3 i.e. 28%. Surprisingly, the simple prompt in English, E, performs poorest, which contradicts our hypothesis of English prompts performing better.

Table 5: Overlaps of Diagnoses with NetDoktor per Prompt

Score	Diagnosis Retrieval Method				
	A	B	C	D	E
3/3	13	0	0	0	0
2/3	0	2	0	3	1
1/3	0	8	9	5	3
0/3	0	3	4	5	9
Avg.	3/3	0.92/3	0.69/3	0.85/3	0.38/3
Avg.[%]	100%	31%	23%	28%	13%

Apart from the overlaps, other interesting observations can be made on closer inspection of the results: ChatGPT seems to rigorously follow the instruction to generate n diagnoses and as such, yields consistently 3 diagnoses for prompt C and 10 diagnoses for prompt D. However, it can be doubted that "most likely" is interpreted in a scientifically backed manner, as ChatGPT often does not include even one of the NetDoktor diagnoses and not once all of them. Equally interesting is the inclusion of the necessity to consult a doctor in one form or the other at the end of every result we received, which is likely due to being "hard-coded" for legal reasons on the part of OpenAI. This can also be seen in Figure 3. Although ChatGPT and GPT-4o are black boxes and LLMs are non-deterministic, we try to document our reported results as well as possible for replication. You can find all of our

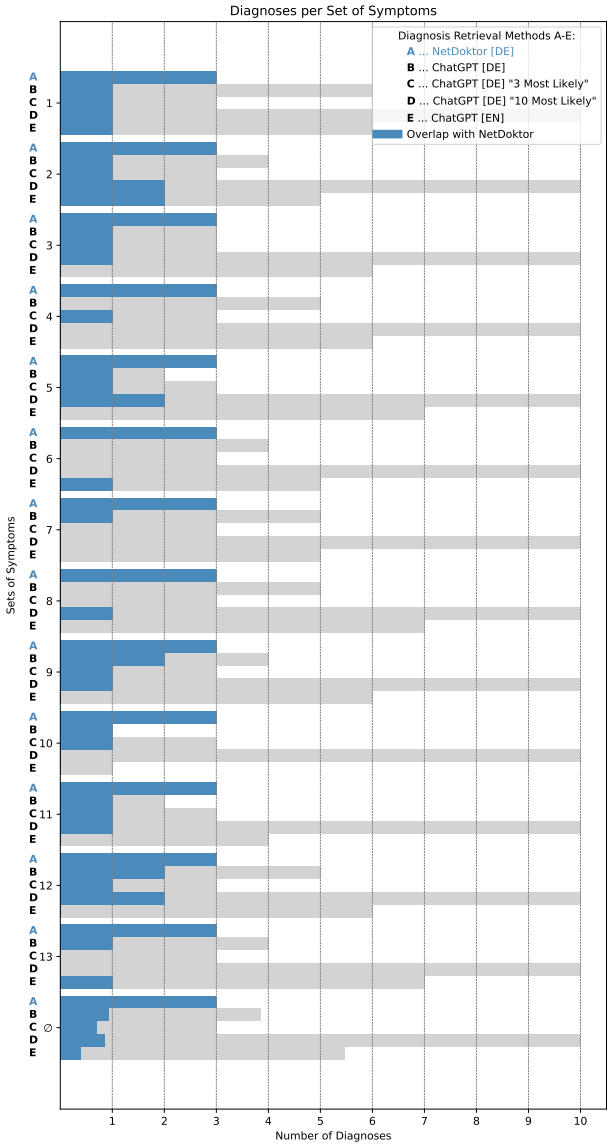


Figure 4: Comparison of Diagnoses for Symptoms Seen in Table 3

experimental results as a replication package under the provided URL [2].

4 Conclusions

In summary, ChatGPT diagnoses only partially match the diagnoses retrieved from our golden model NetDoktor. ChatGPT diagnoses are mostly well-structured and are seemingly valid but fail to include all NetDoktor diagnoses in any of the tested cases. This holds for all tested prompts and across all tested symptoms. The highest overlap, on average, could be achieved with the simplest prompt in German, giving only a description of the symptoms for a persona. When asked for a specific amount of "most likely" diagnoses, ChatGPT always delivered exactly the asked-for number of diagnoses. However, this does not benefit the quality of the output as measured by the overlap metric. Neither does an interaction in English change the output quality for the better. In our tests, ChatGPT always includes a notice to consult a doctor. Human assessment of the diagnoses cannot be fully bypassed by the proposed evaluation methodology. This is due to the immanent presence of semantic equivalence and the necessary medical knowledge to find those equivalences. Although such a task is automatable via LLMs as well, the authors of this paper underline the potential implications for undermining the quality of an evaluation, when fully automated. While our evaluation reports results achieved using ChatGPT and GPT-4o, the proposed methodologies transcend to other LLMs as well. As part of future work, we want to repeat our experiments at a larger scale to achieve representative results. Additionally, we want to consider stability metrics, as seen in [11]. Another interesting direction can be further analysis of the relationship between prompt (engineering) and the retrieval of matching diagnoses as well as their stability. Finally, it would be interesting to compile a corpus of medical symptoms corresponding to diagnoses including named entities and logical abstractions to perform evaluations as seen in [12] on the medical domain.

[2]https://zenodo.org/doi/10.5281/zenodo.13765345

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HomeDOCtor App: Integrating Medical Knowledge into GPT for Personal Health Counseling

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Abstract

The escalating workload demands on healthcare professionals are leading to systemic overload, resulting in a decline in the efficiency of public health services. This situation necessitates the development of solutions that can alleviate the burden on physicians while ensuring comprehensive patient care. Recent advancements in generative artificial intelligence, particularly in the field of medicine, have demonstrated that large language models (LLMs) can outperform doctors in specific tasks, highlighting their potential as valuable tools for reducing the strain on healthcare providers. This study focuses on the development of the HomeDOCtor application, which integrates additional validated medical knowledge into the GPT-4o LLM. The objective of this application and the enhanced LLM is to offer users reliable access to a medical chatbot capable of providing accurate and timely responses to health-related inquiries. The chatbot's behavior has been meticulously tested and refined in collaboration with a team of physicians. The findings of this research offer insights into the development of such systems and explore their potential application within the Slovenian healthcare system.

Keywords

large language models, GPT-4o, vector embeddings, vector databases, natural language processing, prompt engineering

1 Introduction

There are worldwide growing problems in the health sector due to an ageing population and a shortage of health experts [13, 17]. The field of Natural Language Processing (NLP) has recently seen an increase in the number of LLMs being customised for different domains [2]. Increasingly, we are also seeing their integration into the field of medicine, which is one of the core domains of today's society [14, 22, 11, 20]. Currently, OpenAI's GPT-4o is considered to be the most powerful LLM, which also performs best in the area of health questionnaires and other related tasks [16, 12, 1, 5].

Because of their advanced ability to understand natural language text, there are many potential applications [8, 3]. Patients can talk to the GPT, describe their symptoms in detail, include documents to past treatments and then get a friendly response in seconds. This is particularly useful when the patient is unable to access their personal doctor or simply wants to get feedback before taking further action. LLMs are trained on a huge amount of data, but there is the possibility of hallucination, especially in less researched areas and specific issues [19]. As a result, it makes sense to think about augmenting the existing LLM with verifiable resources that can help to improve it. One of the most important issues regarding the use of LLMs relates to the aspect of secure use of health data. When using commercial LLMs, the data is passed to them and the user should be informed with appropriate disclaimers about the use and processing of the data they have entered. In an ideal situation, we would use our own LLM, running on a local server, and have full control over the implementation, but this raises different issues. Creating your own LLM is a time-consuming and costly process, so our research focused on extending the best LLM currently on the market, GPT-4o.

In our case, we focused on the Slovenian healthcare sector and the adaptation of the LLM to the needs of the average user. The aim was to develop an application (HomeDOCtor) that would allow all Slovenian citizens to get medical help 24/7 without the need to contact a personal doctor. As a result, performance testing is crucial, as even the smallest errors can lead to serious consequences [8].

The core research hypothesis posits that the system, enhanced with additional modules integrated into a GPT, will provide more effective medical advice to the general Slovenian population compared to existing GPTs.

In section 2 we present all the datasets used to extend the LLM. Section 3 systematically describes the approach and technologies used to develop the software solution. Section 4 shows the results of the developed solution and an example of a user conversation with the improved LLM. Section 5 describes how performance was tested and how doctors helped to guide LLM to get the desired outcome. Section 6 presents concluding thoughts and possible improvements.

2 Datasets

To improve the knowledge of the existing ChatGPT-4o, data from verified sources was obtained. The addition of new data allows the GPT to answer questions using its existing knowledge, as well as to address a broader range of questions that require specialized knowledge. In this case, it is about integrating information on Slovenian healthcare [4].

2.1 Insieme Platform

The Insieme platform is the core building block of the dataset used [9]. The platform integrates hand-crafted expert-based knowledge that is accessible to users on all devices and contains basic information on Slovenian healthcare.

The information is organised hierarchically by medical specialty. By clicking (or visiting) on one of the branches, the user is redirected to a sub-page that provides an overview of the diseases and other services that belong to the selected field of medicine.

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https://doi.org/https://doi.org/10.70314/is.2024.chtm.8

Each of the diseases is accompanied by a set of key data that allows the user to get everything they need in one place. This includes:

- basic information about the diagnosis,
- professional help (list of clinics in Slovenia),
- apps (where the user can upload their pictures, ask for opinion, etc.),
- associations in Slovenia,
- articles,
- forums,
- video content, and
- image content.

Figure 1 shows an example of one of the pages illustrating the display of the information for skin cancer.

All data have been compiled in collaboration with doctors and are therefore suitable for use as a primary source for the extension of the LLM. The aim is to enable users of the platform to quickly obtain information on Slovenian healthcare that they can understand.

2.2 Other resources

The Med.Over.Net Health Forum was used as one of the two remaining data sources. The forum is divided into different branches of medicine where users can create new conversations and ask questions within them. Each of the sub-forums has an assigned moderator (a doctor) who carefully reviews and answers the questions. All other forum users can also join the conversation. All data from the online forum was extracted using web scraping, whereby all extracted data was stored in a single PDF file.

The second source is the Home Doctor Encyclopaedia (The Home Doctor - Practical Medicine for Every Household), which is in the field of practical home medicine. It contains useful tips on how people can help themselves by applying helpful advice without the need to visit a doctor.

In the future, consideration will be given to adding new resources, in particular a better medical book suitable for Slovenian healthcare. For now, we have focused on the three data sources mentioned above.

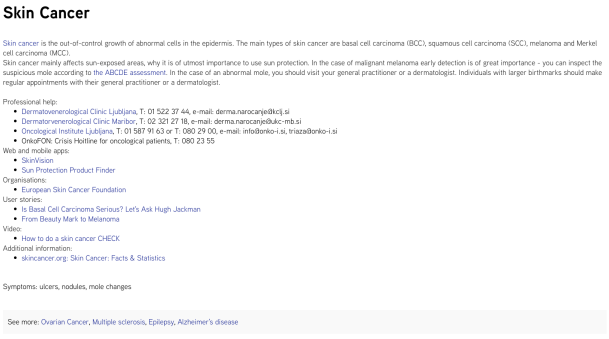

Figure 1: Image of the skin cancer disease subpage on the Insieme web platform.

3 Methodology

This section presents the design of a system that extends the LLM GPT-4 with acquired knowledge resources and outlines the architecture of the developed application.

3.1 Fine-tuning

One solution is fine-tuning, which allows a pre-trained LLM to add external data sources to a LLM that already has its own existing knowledge [10]. The idea is that instead of creating an LLM from scratch, an existing LLM is used and further adapted to the user's operational needs. Fine-tuning typically works on the principle of supervised learning, where the LLM needs to be given examples of the input and the expected output. With additional learning, the LLM is able to use the new data. This directly influences the change of parameters (weights) in the model and its performance. The problem arises in that, due to the large amount of parameters in modern LLMs, the whole learning process may be impractical due to the cost of training an outsourced LLM. Additionally, any incorporated data is static, meaning that the learning process must be repeated whenever adding new data. As a result, fine-tuning is not the best solution in cases where we know that the data will change, and we will be constantly adding new data.

3.2 Storing data

The data obtained by web scraping was stored in a vector database, which allows efficient management of the vector data [21].

The raw data obtained (e.g. PDF and Markdown files) are unsuitable for direct use with LLMs as they cannot be directly managed by the LLM. While documents can be added as attachments in the web interfaces of platforms such as ChatGPT (OpenAI's web LLM access), this is only useful in the context of a single conversation. In our case, we would like the LLM to have permanent access to information sources without the need for manual addition of documents by the user.

3.2.1 Vector embeddings. Each of the documents is converted into vector embeddings, which allow the text to be presented in a numerical notation that can be understood by a computer [6]. From this notation, the computer can understand the meaning of the text and determine the meaning between the words in the input. This is useful in many NLP tasks, e.g. search engines, sentiment analysis, recommendation systems and so on. We use vector embeddings to be able to extract information relevant to the corresponding question based on user input.

Modern LLMs have a limitation in the form of a context window, which determines how much text they can process within a single user input. Because of this limitation, we need to be careful what additional information is sent to the LLM, as we could quickly exceed the context window by sending all data sources. E.g. if the user's question is about skin cancer, we only want to get information about that specific disease. As a consequence, we have divided the text into chunks, where each chunk contains data for only one of the diseases. Similar care has been taken with the encyclopaedia and the Med.Over.Net online forum. Meaningful paragraphs have been grouped together to form one chunk of text. Thus, only the key chunk that is most likely to contain the answer to the question asked will be provided to the LLM.

For each of the chunks, a vector embedding has to be created using an appropriate model (e.g. text-embedding-ada-002 from OpenAI). The vector databases (e.g. Redis) have to be used to store the resulting vector embeddings properly.

3.2.2 Vector databases. The vector database allows the storage of unstructured data and fast retrieval due to efficient indexing of the data. In our case, we use them to store individual chunks and their associated vector embeddings [7].

Over all stored chunks, vector search is enabled, which means that the chunks whose vector embeddings most closely match the query vector are returned. The query vector represents the user input, which is converted into vector format. Cosine similarity, Euclidean distance, inner product and other metrics can be used to measure similarity between vectors.

The configuration used to retrieve the chunks can be modified: e.g. specifying the required similarity threshold and the number of chunks retrieved.

3.3 RAG

An alternative solution is Retrieval-Augmented Generation (RAG), where the LLM calls an external database containing all our data when the user provides a question [15]. Relevant data is retrieved from there and passed directly to the LLM, which uses this data in the generation of the answer. In this case, the basic architecture of the LLM used remains completely unchanged, as it accesses a separate building block to retrieve the data. It is a cheaper solution that allows dynamic data extraction. Data can be deleted, modified and newly added to the database at any time.

The Retriever is responsible for retrieving relevant pieces of text from the vector database. The user question is converted into vector embedding, and then the most similar chunks are retrieved to help guide the LLM to the correct answer. A merged query is then created containing the original user question, the extracted chunks of text and any other system instructions given. In the final step, the LLM generation produces an answer based on the query, which is passed to the user.

Compared to fine-tuning, RAG allows the system to change continuously (adding new knowledge sources), makes the operation more understandable (we can check which pieces of text have been passed to the LLM) and reduces the possibility of hallucination (verified pieces of text from the selected domain are added). The style of writing the answers cannot be changed directly, as the parameters of the original model remain completely unchanged, but we can help by writing system instructions. System instructions further guide the operation of the chatbot and play a very important role in achieving a user-friendly behaviour of the system.

All of these features make RAG a suitable choice for enriching the work of an existing LLM with validated information in the chosen field.

The schematic design of the RAG system can be seen in the figure 2 below.

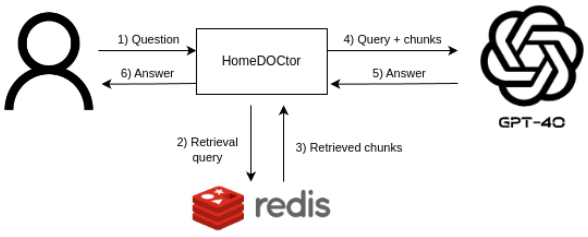

Figure 2: Demonstration of how the RAG system works.

3.4 Application architecture and used technologies

A brief overview of the technologies used to develop the software solution is presented below.

3.4.1 Flutter. The Flutter framework was used to develop the front-end part of the system. The reason for using it is that it allows us to develop applications that work on all platforms by writing unified code in the Dart programming language. It then gets compiled into code for the dedicated platform. This way, the application works on web browsers as well as in the form of a mobile application. Otherwise, we would have to use multiple programming languages to ensure support on multiple devices, which would slow down development.

3.4.2 Redis. The Redis database was used to store all additional knowledge resources. It is a NoSQL database that stores data in key-value format and also works as a vector database. The data is stored in memory, which helps significantly with data retrieval and overall application responsiveness.

3.4.3 LangChain. The LangChain framework offers a number of functionalities that facilitate the development of applications that involve working with LLMs [18]. It allows us to easily connect to a vector database, retrieve documents, call arbitrary LLMs, modify system instructions and so on.

3.4.4 FastAPI. The FastAPI framework allows the creation of RESTful APIs that can be accessed by the HomeDOCtor application. It uses Uvicorn for the server implementation and allows processing of requests received from users. These requests are related to the processing of the received questions and the execution of all the necessary tasks to obtain the appropriate response from the LLM.

3.4.5 Docker. The entire application was packaged in a Docker container to facilitate development and deployment to the server. All the necessary configuration is included in the container, which runs on the system without the need to install the rest of the programming libraries and tools.

3.4.6 Firebase. The Firebase platform offers a number of useful functionalities such as user authentication, application usage analytics, cloud storage and a real-time database (NoSQL cloud database, which in our case is used to store the necessary user data).

4 Results

The HomeDOCtor app allows users to access a chatbot that is constantly available to answer their questions. Users can access the app on their browsers or via a mobile app. The user interface allows users to view the history of the conversation, ask questions, include their own documents as an attachment (e.g. PDF documents of previous exams), get a PDF summary of the conversation and additional information in three side windows. By clicking on the "End session" button at the bottom of the screen, all data is deleted, and the user is redirected to the main page where they can start a new conversation with the chatbot.

Initially, HomeDOCtor determines what kind of conversation is being had. In the case of a simple chat, no additional information is displayed. However, if the system detects that the conversation is about the user's health, additional information is displayed in three side windows. This additional information is dynamically updated according to the progress of the user's

conversation with the chatbot. The first window gives a list of possible medical conditions, the second window gives advice on how the user could help himself, and the third window tells whether a visit to the doctor would be necessary. This way, the user can receive a comprehensive overview of the conversation so far and get an opinion that adapts to the course of the conversation.

Figure 3 below shows the user interface of the HomeDOCtor application. We can see the user's conversation with the chatbot in Slovenian and the display of additional information in the three side windows along the right edge. When answering questions, GPT-4o uses its existing knowledge, incorporating as often as possible additional sources of knowledge (especially from the Insieme platform).

Using the app, users get instant help from a chatbot. The chatbot first tries to collect sufficient data before proceeding to further advice. In the course of the treatment, the user is advised on different forms of help (websites, questionnaires, forums, apps, visits to pharmacies, etc.). A visit to the doctor is only advised in urgent cases, when HomeDOCtor considers that the situation is too complicated or further medical treatment is needed.

Figure 3: An example of a user talking to the HomeDOCtor chatbot. Additional information is visible on the side.

An example of a conversation from a user who consulted the developed chatbot is shown below. We can see the user's questions and all the corresponding answers.

- *User:* I have a slight headache and a bit of a sore throat today.
- *HomeDOCtor:* I understand. Let's gather some more information to better assist you.
  1. How long have you been experiencing these symptoms?
  2. Do you have any other symptoms, such as fever, cough, or body aches?
- *User:* I've been feeling this way for about two days now. It started with just a mild sore throat, and the headache came yesterday.
- *HomeDOCtor:* Thanks for the information.
  1. How severe are your headache and sore throat on a scale from 1 to 10?
  2. Have you noticed any other symptoms, like nasal congestion, fatigue, or body aches?
- *User:* I'd say my headache is about a 4 out of 10. It's more of a dull ache, not too intense, but definitely noticeable. The sore throat is a bit worse, probably a 6 out of 10.
- *HomeDOCtor:* Thank you for the details.
  1. Have you taken any over-the-counter medications or home remedies for relief? If so, have they helped?
  2. Is there anything that seems to make your symptoms better or worse, such as certain foods, drinks, or activities?
- *User:* I tried drinking some warm tea with honey, which soothed my throat for a while. My headache seems to get a bit worse when I'm looking at screens for too long.
- *HomeDOCtor:* Thank you for the additional information. It sounds like you might be experiencing symptoms of a common cold or another mild infection. Here are a few recommendations:
  1. Rest and Hydration: Ensure you get plenty of rest and stay well-hydrated.
  2. Warm Teas: Continue drinking warm teas with honey to soothe your throat.
  3. Limit Screen Time: Try to reduce your screen time to help with your headache.
  4. Steam Inhalation: Consider steam inhalation to relieve any nasal congestion you might have.
  For additional relief, you can visit a pharmacy for over-the-counter options. You can find more information about medications at https://mediately.co/si and http://www.cbz.si.
  If your symptoms worsen or persist for more than a week, it's advisable to consult a healthcare professional.
- *User:* Thank you for the advice. Where could I get more information?
- *HomeDOCtor:* You're welcome! For more information on common conditions and treatments, you can check these resources:
  1. Med.Over.net: https://med.over.net
  2. Ars Pharme - Zdravstveni nasveti: https://www.arspharmae.com
  3. Triglav Zdravstveni Nasveti: http://www.triglavzdravje.si
  If you need more personalized advice, consider visiting a pharmacist or consulting with a healthcare professional.

5 Evaluation

The full operation of the HomeDOCtor app and chatbot was carried out by the authors and medical experts. After consulting with doctors and identifying the key performance points, iterative and collaborative development followed, gradually introducing changes and improving the performance of the chatbot.

Doctors have contributed significantly to improving the app through rigorous testing, ensuring that the user can get the best possible results to their questions. We have been careful to address situations where a doctor's visit is not necessary. In many cases, non-urgent situations only add to the workload of doctors. In our system, we have tried to avoid this as much as possible by trying to refer the user to other resources that would be good and useful enough for them, and only as a last resort recommending a visit to the doctor. Of course, a visit to the doctor should not always be avoided, so it is crucial that the system is able to correctly identify scenarios where this is really necessary. These are mainly cases where additional diagnostics are needed, which are difficult for the LLM to perform on its own. Doctors have been particularly helpful in the project by further adapting the system instructions, which detail how to deal with all scenarios.

We compared HomeDOCtor with other large language models on the market, but focused the most on comparing it with the regular GPT-4o model, which our system uses for its basic operation. The main differences are in the flow of the conversation, as HomeDOCtor is customised by the system instructions to follow specific scenarios and ask questions that are key for

providing further advice. Thus, by simulating a conversation of a user who starts the conversation by listing symptoms, a comparison between the two systems can be made. According to the clinicians' evaluations, HomeDOCtor appeared to be better at asking sub-questions and guiding the user through the treatment. A further important difference can be seen in the display of videos and images, as HomeDOCtor can display them right within the app, whereas GPT-4o creates fictional images or often provides links to non-existent videos. HomeDOCtor also often gives practical advice on how users can help themselves at home and carefully evaluates when it is really necessary to redirect the user to professional help.

Testing of the system has demonstrated the added value of the included knowledge sources, though formal validation tests are still pending. Nevertheless, the scientific hypothesis that superior performance can be achieved compared to the original GPT is increasingly supported by the evidence. Through iterative testing by all participants, the system has now reached a level of maturity suitable for deployment in a production environment. Test users will be able to provide feedback and suggest corrections via a form, which will further refine the chatbot to better meet the needs and preferences of the average user in Slovenia. This will display the data sources used to the test users, who will be able to indicate whether they believe that the relevant documents have been extracted from the vector database.

6 Conclusion

In this study, we have shown how verified information can be incorporated into one of the existing LLMs. It was an extension of GPT-4o, which currently achieves the best results, and has been further adapted to the needs of Slovenian public health in the context of the development of the HomeDOCtor application.

Comprehensive testing has been carried out with a team of doctors, which has helped to ensure that users are provided with relevant and understandable information. HomeDOCtor initially gathers information by asking questions, and only then advises on further action. External resources and self-help methods are prioritised, as the intention is that referral to a doctor should only be made in urgent situations.

Possible improvements are in the use of one of the open source LLMs, which would negate the need for external access to OpenAI's LLMs. Currently, in order to run the HomeDOCtor application, an API call is sent for each question asked, for which a fee is paid to OpenAI. This is also problematic from a data protection point of view as it involves working with confidential user data which should not be passed on (altough you are default opt-out for OpenAI API). Currently, this is taken care of with disclaimers and warnings that the user has to agree to before using the application. At the same time, the use of open source models would bring additional problems, as the appropriate infrastructure would have to be established. Open source models also typically perform worse than e.g. GPT-4o. As a result, we have chosen to use GPT-4o, as we cannot afford worse outcomes due to the criticality of the medical domain.

HomeDOCtor could also be adapted to meet the healthcare needs of countries abroad, but this would require ensuring that the relevant data is obtained in accordance with their national guidelines and security laws. The behaviour of the chatbot could remain largely the same, as GPT-4o can by itself convert between many languages. The key component would thus be to obtain all the necessary country-specific information that we want to make available to users (information on clinics, apps, articles, video content in that language).

In the future, work will be carried out on improving the chatbot, taking into account the opinions of external users, who in this case are also our target group. This research has shown that generative artificial intelligence has a great potential application in the field of medicine and could make a significant contribution to relieving the burden on the healthcare system.

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Standards for Use of LLM in Medical Diagnosis

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Abstract

Artificial intelligence, particularly large language models (LLMs), is increasingly being recognized for its potential to revolutionize medical diagnosis by mimicking human cognitive functions in clinical decisionmaking. Despite promising developments, such as the ability to pass medical exams and assist in complex diagnostic processes, LLMs still face significant hurdles, including issues with accuracy, bias, and safety. This paper critically consider evaluation of LLMs performance across various criteria to ensure they meet the required standards for clinical use. Several dimensions of evaluations such as accuracy, calibration, and robustness are used. While LLMs and generative AI more broadly show real potential for healthcare, these tools are not ready yet. The medical community and developers need to develop more rigorous evaluation, analyze across specialties, train on real-world data, and explore more useful types of GenAI beyond current models. But ultimately, we believe these tools can help in improving both physician workload and patient outcomes. We urgently need to set up evaluation loops for LLMs where models are built, implemented, and then continuously evaluated via user feedback.

Keywords

large language models, artificial intelligence, clinical AI implementation, AI in clinical practice, AI safety in healthcare

1 Introduction

Artificial intelligence (AI) by its definition, and in the broadest of terms, represents intelligence exhibited by computer systems. The main goal of AI is to enable computers and machines to mimic human cognitive function. In other words, it aims to simulate human learning, comprehension, problem solving and critical decision making. AI approaches human cognition in two distinct ways, the symbolic and the connectionist approach [1]. The symbolic approach aims to replicate human intelligence by analyzing cognition independent of the biological structure of the central nervous system while the connectionist approach aims to create neural networks that imitate the brains's structure. To realize the potential of AI in healthcare, we believe that the systematic approach to evaluation and benchmarking can get us to a place where AI can be a net positive for health systems.

2 LLM's in Medicine

The rapid advancements in AI, particularly in the realm of large language models (LLM's), have transformed various sectors, including healthcare [2,3]. LLM's and Chat GPT in particular has earned much attention in recent years due to its ability to complete tasks previously considered completable by humans alone as in passing United States Medical Licensing Examination [4]. The ability of LLM's to accurately answer questions, provide advice and even triage patients based on clinical input exceeds that of the everyday person. However, the accuracy of these systems to resolve real world medical issues is yet to exceed that of a fully trained physician. Also, a finite percentage of LLM answers to patients had safety errors, and in one instance the advice given to a patient could have been fatal [5]. In order to avoid this error in the future it is essential to assess these models through rigorous comparative benchmarks. One of the most critical aspects of benchmarking medical LLM's is comparing their performance with existing clinical decision support systems (CDSS) and other AI models. Traditional CDSS, often rule-based or statistical, have been used in healthcare for decades to assist clinicians in making evidence-based decisions. By comparing LLMs to these systems, researchers can determine whether the new models offer significant improvements in accuracy, speed, and comprehensiveness [6]. For example, a comparative benchmark might involve evaluating the diagnostic accuracy of an LLM against a well-established CDSS in predicting outcomes for specific conditions, such as sepsis or diabetes. The LLM's ability to incorporate a broader range of data, including unstructured text from electronic health records (EHRs), could be a key factor in outperforming traditional systems [7]. However, it is also crucial to consider scenarios

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where traditional systems might still have an edge, particularly in specialized tasks where they have been finely tuned over many years of clinical use [8]. Outside of primary care, radiology is perhaps the medical branch that has been the most upfront and welcoming to the use of new technology [2,3]. The concept of computer-assisted diagnosis (CAD) is well known. AI's provide substantial aid by labeling abnormal or most often borderline exams or simply by quickly excluding negative exams in computed tomographies, X-rays, magnetic resonance images especially in high volume settings like the emergency room where human resources might be less available. AI-driven diagnostic tests have the potential to overcome several current limitations in the clinical approach to patient care [9]. Namely the clinical review, time to diagnosis, diagnostic accuracy and consistency. In tandem with AI, diagnosticians of all medical branches are capable of improving measures of diagnostic accuracy (mainly sensitivity and specificity) as well as minimizing observer variability in specific patient interpretation. This proves most useful in settings where the clinical diagnosis is in question – such as with complex patient presentation or in patients with long histories and various comorbidities. Currently not many prospective studies and randomized trials exist in medical AI application. Most are not prospective, are at high risk of bias and deviate from existing report standards. Data availability is lacking and human cooperator groups are more often small and inadequate. LLM's, in particularly GPT-3, has shown promise in various clinical applications, ranging from creation of patient notes to helping healthcare providers diagnose rare conditions. However, it is important to recognize the inherent limitations of these systems.

3 Standardized Evaluation Framework for Assessing LLM's Clinical Utility for Future Clinical Practice

Medical diagnosis involves a complex process in which a practitioner uses objective data from a clinical exam, as well as data collected from medical tests along with self-described subjective symptoms to conclude the most likely health problem. This kind of approach relies heavily on the synthesis and individual interpretation of a vast amount of information from various sources. These most often include available patient histories, clinical exam data correlated with current medical literature. In this setting LLM's open up new opportunities for enhancing the diagnostic process. In order to better evaluate the LLMs clinical utility a direct comparison must be made between LLMs and human clinicians. This approach is essential to gauge how well AI models can replicate or even enhance the decision-making process of experienced healthcare professionals. Studies often involve presenting both clinicians and LLMs with the same clinical cases and comparing their diagnoses, treatment recommendations, and reasoning [10]. Human clinician benchmarking can reveal important insights into the strengths and limitations of LLMs. For instance, while LLMs might excel at processing and synthesizing vast amounts of data quickly, they may struggle with nuanced cases that require deep contextual understanding or ethical considerations that a human clinician might naturally account for [11]. Furthermore, these benchmarks can highlight areas where LLMs might support clinicians, such as providing second opinions or identifying potential errors in human judgment, rather than replacing them [12]. Randomized controlled trials (RCTs) are considered the gold standard in clinical research for evaluating the efficacy of innovations. Comparative benchmarking of LLMs can also involve assessing how well these models predict or align with outcomes from RCTs. For example, an LLM could be tested on its ability to recommend treatments for stroke prevention based on patient data, and its recommendations could be compared with those validated by RCTs [7]. However, this approach presents a set of challenges, as RCTs often involve highly controlled environments that might not fully capture the complexities of real-world clinical settings. Currently LLMs are most often tested on small datasets acquired for a specific research study or large public benchmark dataset, both of which are usually collected on a limited number of very similar sites with consistent diagnostic techniques. This does not reflect the substantial differences in manufacturer, quality and clinical practices often found in real-world hospitals. As an example, the UK Biobank, a widely employed public imaging benchmark dataset includes brain magnetic resonance images (MRI) for a total of 100,000 patients and more. It restricts image acquisition to four sites each of which has identical equipment in terms of hardware and software and performs regular quality check to ensure the harmonization of data. In contrast most medical centers, including our own in Serbia, extracts data from clinical archives over a period of 20 years which reflects the much more diverse array of available data in everyday settings. Another point of interest is a lack of consensus on which dimensions of evaluation to consider and prioritize for various healthcare tasks. While accuracy is the most often examined dimension when evaluating LLM performance, other dimensions such as fairness, bias and toxicity, robustness, and deployment considerations need to be considered as well [13]. Therefore, while alignment with RCT outcomes is a strong indicator of an LLMs clinical relevance, it is also important to test these models in more varied and less controlled environments to ensure their robustness [11]. Unlike traditional systems or statistical models that remain relatively static once developed, LLMs can be continuously updated and refined. This raises the question of how implement models that are constantly evolving. Development of standardized benchmarks that can be applied across different versions of a model are essential to address this challenge [14]. These benchmarks help identify areas where LLMs can enhance clinical practice and highlight the potential risks or limitations that need to be addressed [6]. By rigorously comparing LLMs against existing systems, human clinicians, and traditional models, we can ensure that these advanced AI systems are integrated into healthcare in a way that maximizes their benefits while minimizing potential harms [10]. In general, there is a lack of consensus on what to consider and prioritize for various healthcare tasks. Several dimensions of evaluations such as accuracy, calibration, and robustness are used [13]. While accuracy is the most often examined when evaluating LLM performance, other aspects such as fairness, bias and toxicity, robustness, and deployment considerations need to be considered as well. A list of possible aspects are presented on Table 1. Comparative benchmarks can guide the development of future AI models. Insights gained from these evaluations can inform

model improvements, such as enhancing interpretability, reducing bias, or improving performance on specific tasks. As the field of AI in healthcare continues to evolve, comparative benchmarking will remain a crucial tool for ensuring that new models are both safe and effective for clinical use [8].

Table 1. Comparative benchmarks for evaluation of LLG performances in healthcare (adapted and modified from Bedi et al. 2024)

Dimension of Evaluation	Definition	Metric Examples
Accuracy	Measures how close the LLM output is to the true or expected answer	Human evaluated correctness, ROUGE, MEDCON
Calibration and Uncertainty	Measures how uncertain or underconfident an LLM is about its output for a specific task	Human evaluated uncertainty, calibration error, Platt scaled calibration slope
Robustness	Measures the LLMs resilience against adversarial attacks and perturbations like typos	Human evaluated robustness, exact match on LLM input with intentional typos, F1 on LLM input with intentional use of word synonyms
Factuality	Measures how an LLMs output for a specific task originates from a verifiable and citable source. It is important to note that it is possible for a response to be accurate but factually incorrect if it originates from a hallucinated citation	Human evaluated factual consistency, citation recall, citation precision
Comprehensiveness	Measures how well an LLMs output coherently and concisely addresses all aspects of the task and reference provided	Human evaluated comprehensiveness, fluency, UniEval relevance
Fairness, bias and toxiticy	Measures whether an LLMs output is equitable, impartial, and free from harmful stereotypes or biases, ensuring it does not perpetuate injustice or toxicity across diverse groups	Human evaluated toxicity, counterfactual fairness, performance disparities across race
Deployment considerations	Measures the technical and parametric details of an LLM to generate a desired output	Cost, latency, inference runtime

4 Conclusion

Comparative benchmarking is a critical process in the development and deployment of medical large language models. By comparing LLMs to existing clinical decision support systems, human clinicians, traditional statistical models, and outcomes from randomized controlled trials, we can gain a comprehensive understanding of their strengths, limitations, and potential impact on healthcare. As AI continues to play an increasingly prominent role in medicine, rigorous comparative benchmarks will be essential for ensuring that these models deliver on their promise of improving patient care while adhering to the highest standards of safety and effectiveness.

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Using Combinatorial Testing for Prompt Engineering of LLMs in Medicine

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Abstract

Large Language Models (LLMs) like GPT-4o are of growing interest. Interfaces such as ChatGPT invite an ever-growing number of people to ask questions, including health advice, which brings in additional risks for harm. It is well known that tools based on LLMs tend to hallucinate or deliver different answers for the same or similar questions. In both cases, the outcome might be wrong or incomplete, possibly leading to safety issues. In this paper, we investigate the outcome of ChatGPT when we ask similar questions in the medical domain. In particular, we suggest using combinatorial testing to generate variants of questions aimed at identifying wrong or misleading answers. In detail, we discuss the general framework and its parts and present a proof-of-concept utilizing a medical query and ChatGPT.

Keywords

Large Language Models, ChatGPT, Prompt Engineering, Combinatorial Testing, Validation

1 Introduction

The use of LLMs in medicine has been of growing interest. In a recent publication [9], the authors discuss the future of LLMs in medical applications. Although using such a model may lead to improved communication and other advantages, some drawbacks prevent using such models and tools. It is well known that LLMs like ChatGPT [33] have shortcomings like hallucinations [46]. Hallucinations are answers with incorrect claims that do not depend on training data. Such answers, unfortunately, cannot be necessarily identified as wrong and, therefore, might be harmful, especially when dealing with medical questions. There are methods for detecting hallucinations, e.g., see [11]. Hence, verifying and validating tools based on LLMs to ensure a harmless use is of utmost importance.

When using LLMs for queries, the form of the query, i.e., the prompt, is of great importance. Although there has been much work on how to improve writing prompts in various setups, e.g., [28], there is only little scientific work, e.g., [24], providing statistical evidence. However, it is generally agreed that the query's structure has a significant impact on the output of a LLM. Therefore, we need to consider different prompts in any verification and validation procedure.

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In this paper, we contribute to verifying and validating LLMs focusing on the impact of prompts. In particular, we introduce and discuss a methodology based on combinatorial testing [21] for generating various versions of prompts for medical queries. We rely on testing because it is a methodology to straighten the view on finding interactions with a system under test (SUT) that leads to unexpected behavior. Hence, in testing, we want to provide interactions that make a system fail. Combinatorial testing is a test methodology that has proven to be effective in finding test cases, i.e., inputs given to a system, to provoke a failing behavior. In particular, combinatorial testing focuses on interacting parameter values that reveal faults. In previous work, Kuhn and colleagues [22] showed that strictly less than 7 interacting parameters must be considered for many applications.

Besides its effectiveness, combinatorial testing is a good testing methodology for LLMs that consider prompts. For the latter, we need different combinations of textual fragments to show differences in the outcome. Combinatorial testing provides such combinations and also avoids leading to a combinatorial explosion of potential prompts when restricting the number of considered fragment interactions.

We organize the paper as follows: We first introduce the foundations. For this purpose, we discuss related research on testing LLMs, and introduce the basic concepts behind combinatorial testing. Afterward, we introduce the general testing methodology for generating different prompts focusing on the medical domain. In addition, we illustrate the use of the methodology considering one particular medical query. Finally, we conclude the paper.

2 Related Research

In the past several years, considerable efforts have been made to evaluate LLMs. The first indicator is the wide variety of *benchmarks* which have emerged in order to test and compare their performance on various tasks. In [6], the authors compile a selection of 46 popular benchmarks. Among them, we can differentiate between benchmarks used for general language tasks, like Chatbot Arena [7], MT-Bench [49], HELM [25], or MMLU [13] and domain-specific benchmarks, like MATH [14], concentrated on assessing reasoning and problem-solving capabilities of AI models in mathematics, APPS [15] for evaluating code generation, or MultiMedQA [41] with focus on medical examinations, medical research, and consumer healthcare questions.

Further on, depending on the human involvement in the evaluation process, there are two common methods: *human evaluation* and *automatic evaluation*. Human evaluation becomes a natural choice in many non-standard cases, where the automated evaluation metrics are either not suitable or insufficient. For example, in [25], the evaluators analyze summarization and disinformation

scenarios, while in [2] analogical reasoning tasks. Also, Ziems et al. [50] used the annotations from researchers for generation. Although it can provide more comprehensive and accurate feedback than the automatic evaluation, the human evaluation may suffer from a high variance and instability due to cultural and individual biases. On the other hand, the automatic variant benefits from higher standardization. LLM-EVAL [26], for instance, is a unified multidimensional automatic evaluation method for open-domain conversations with LLMs. Jain et al. [18] proposed a self-supervised evaluation framework, and also PandaLM [45] obtained reproducible and automated language model assessment by training an LLM that acts as the 'judge' to assess different models. For more details on the specific key metrics and factors for both evaluation types, we refer the interested reader to [6].

In addition, *domain-specific evaluation* is also critical, as LLMs are often used in specific areas, such as healthcare or finance, that have specific requirements for the models. In the beginning, most evaluation research has been focused on natural language tasks. A popular direction here is, for instance, the sentiment analysis task, which analyzes and interprets the text to identify the emotional inclination. Further on, in the medical field, the application of LLM has recently gained significant attention. According to the literature ([6], [5]), most LLMs evaluations in the medical field focus on medical queries. ChatGPT, in particular, generated relatively accurate information for various medical queries from genetics [10], biomedicine [17], radiation oncology physics [16]. Furthermore, several studies have evaluated the performance and feasibility of ChatGPT in the medical education field. In [31], GPT-3.5 [4] and GPT-4 [34] models were evaluated in terms of their understanding of surgical clinical information and their potential impact on surgical education and training. These findings demonstrate that LLMs can be successfully used in clinical education, still further efforts may be needed to overcome limitations. For more details concerning the evaluation of other applications like social science, natural science, engineering agent applications, education, search and recommendation, and personality testing, we refer the reader to [6].

Another interesting taxonomy from [6] groups the encountered testing approaches into three directions: (1) from the objective calculation (benchmarking) to human-in-the-loop testing, (2) from static to crowd-sourcing test sets and (3) from unified to challenging test sets. While unified settings involve test sets with no preference for any specific task, challenging settings create test sets for specific tasks. Tools like DeepTest[43] use seeds to generate input modifications for testing, CheckList [38] builds test sets based on templates, whereas AdaFilter [36] constructs tests adversarially. Furthermore, despite the growing number of academic projects designed for prompting LLMs [19, 27, 3], just a few of them support systematic evaluation of textual responses [48, 1]. ChainForge [1] is a visual toolkit that offers on-demand hypothesis testing of the behavior of text-generating LLMs on open-domain tasks.

To our knowledge, the use of combinatorial testing (CT), in particular for the testing of LLMs, is reported in a single paper [12]. Based on a given original sentence, the authors derive new sentences by replacing words with synonyms according to a combinatorial test set. Assuming that the semantics of the original sentence are preserved in the derived sentences, a test oracle is created based on existing annotations. In the experimental evaluation from [12], the authors apply generated pairwise sentence test sets from the BoolQ benchmark set [8] against two LLMs (T5 [37] and LLaMa [44]). The results indicate that the accuracy of the responses remains roughly equivalent to those provided for the original test set.

3 Combinatorial Testing

Combinatorial testing aims to generate test cases by considering a system's input model. The input model comprises a set of parameters (or variables) $\{x_1, \ldots, x_n\}$ and a not necessarily different domain d_i for each parameter x_i. The domain itself is a finite set of values a parameter can take. A test case is a n-tuple specifying a value $v_i \in d_i$ for every parameter $x_i \in \{x_1, \ldots, x_n\}$. A test suite is a set of test cases. Usually, we write a test suite as a table where the columns are the parameters, and the rows have their corresponding values.

Given an input model, a complete test suite comprises a row for each possible value-parameter combination. Obviously, the upper bound of rows is of order $O(D^n)$ where D is the maximum size of all domains d_i, $i = 1, \ldots, n$, i.e., $D = \max_{i=1,\ldots,n}(d_i)$. Hence, computing a complete test suite is not feasible for software or systems comprising a larger number of input parameters. Moreover, applying all test cases is not feasible because the system's behavior must also be evaluated. In combinatorial testing, we do not have a test oracle. The focus is only on input generation. Hence, such a test oracle must be added to classify a test case as passing or failing, i.e., indicating whether a test case leads to a correct or wrong output, respectively. It is worth noting that such a test oracle can be automated, and we will discuss this when showing our application for validating LLMs considering medical queries.

Combinatorial testing avoids computing all possible test cases. The idea behind this is to consider not all parameter combinations but only those combinations of values for a fixed number k (smaller than n) of parameters. Hence, a combinatorial test suite covers all combinations of values for any subset of parameters of size k, which is usually substantially smaller. Such a test suite is said to be of strength k or to be a k-wise test suite. If k is 2, then the test suite is a pairwise test suite, and we speak about pairwise testing. Note that in practice, pairwise testing is not good enough (see [22, 23]). For more information on combinatorial testing and its foundations, we refer the interested reader to [30, 21]. There are many algorithms available, including ACTS [47], for computing combinatorial test suites for arbitrary input models and strengths. It is also worth mentioning that combinatorial testing has been successfully used in many application domains, including autonomous driving [20] and security testing [40].

In the following, we illustrate combinatorial testing using a small example. In this example, we assume four parameters a, b, c, d, all of them only taking values from the Boolean domain $\{T, F\}$ standing for true and false. A pairwise combinatorial test suite for this input model comprises 6 test cases:

	a	b	c	d
1	T	T	F	F
2	T	F	T	T
3	F	T	T	F
4	F	F	F	T
5	F	T	F	T
6	T	F	F	F

For any combination of two parameters, e.g., a and c, this table comprises all possible combinations of values. Rows 1, 2, 3, and 4 already cover all four combinations for these two parameters. For parameters b and d, rows 1, 2, 5, and 6 are required to cover all value combinations. It can be easily checked that this holds also

for any other pair of parameters. Note that pairwise testing in this case only requires 6 test cases. Considering all combinations, we would have $2^4 = 16$ test cases. For the remainder of this paper, as we introduce domains extending beyond boolean values, we will use indices when referring to parameter values. For $\{T, F\}$, the indices would be 0 and 1, respectively, and the first row of the table above would be represented as $[0, 0, 1, 1]$.

4 Validation Methodology

Figure 1 gives a high-level overview of our proposed validation methodology. The remainder of this section follows the numbers shown in Figure 1 and discusses the individual elements of our validation pipeline.

The domain of our combinatorial prompt generation pipeline can be seen in Table 1, where parameters are components of a prompt and values are (sub-)phrases. Our prototypical set of parameters comprises a) symptom presentation, which is an introductory sub-phrase to the prompt, b) diagnostic focus, which sets the horizon for which kind of diagnoses are expected, c) an additional hint to consider context information such as age, and d) constraints on how the output should be formulated. Each parameter can assume an indexed value from the given set, and every set of values includes an empty string, which is denoted by "-".

Table 1: Domain: Prompt Components and Values by Index

Parameter (i.e. Prompt Component)	IDX	Value
Symptom Presentation *"Given the following..."*	0	-
	1	list of symptoms
	2	symptoms
	3	high-level overview of symptoms
Diagnostic Focus	0	-
	1	a probable diagnosis
	2	a differential diagnosis
	3	an emergency diagnosis
	4	the three most likely diagnoses
	5	the ten most likely diagnoses
Contextual Information	0	-
	1	based on patient's age and gender
Constraints *"the diagnosis should..."*	0	-
	1	be concise
	2	be detailed including explanations
	3	have less than 100 words

In our prototype implementation, we use pairwise testing for all parameters seen in Table 1. Note that we treat the sets of symptoms separately from the rest of the input parameters: Symptoms are excluded from the pairwise combination as we rather want to combine each set of symptoms with all pairwise combinations of the other parameters. This results in the listed 24 pairwise combinations per set of symptoms. Finally, the output of our combinatorial testing pipeline is textual prompts in natural language that act as test cases for evaluating an LLM. The resulting test suite from pairwise combinations for our exemplary set of symptoms can be seen in the first two columns of Table 3. For our preliminary evaluation, we used GPT-4o [34, 35] exclusively. The model can be accessed either via ChatGPT [33] or the OpenAI API [32]. Having both a chatbot interface and a programmable API enables rapid prompt prototyping as well as executing larger test suites with the same underlying model. That said, it would be easy to swap out the SUT and test another LLM using the same validation methodology.

We use the expert system "Symptom-Checker" [39], which is curated by medical professionals and freely accessible via NetDoktor [29]. Given a set of symptoms, we can automatically retrieve diagnoses by traversing a decision tree and answering yes-no-questions. In addition to "yes" and "no" there is also the option to skip a question when the inquired information is not available. Further questions are asking for age, sex, and main symptoms, as well as the body part that is influenced the most. We compute a score by comparing results (i.e., diagnoses) from our SUT ChatGPT with our Golden Model NetDoktor. This is done semi-automatically by first retrieving the diagnoses in the same format and then assessing their overlap. As NetDoktor always yields three diagnoses, our score ranges from 0/3 (no overlap) to 3/3 (complete overlap). In cases where the SUT yields more or less than three diagnoses, we do not normalize the score. This means that a result comprising only one diagnosis cannot achieve a complete overlap with NetDoktor and thus cannot achieve a better score than 1/3. In turn, a result comprising 10 diagnoses cannot achieve a higher score than 3/3. It must be noted that duplicate diagnoses are only counted once, and semantic equivalence is considered when comparing diagnoses.

5 Medical Use Case

For our use case, we assume the downstream task of retrieving diagnoses from an LLM based on a given set of symptoms. As mentioned earlier in this paper, hallucination is a severe problem when using LLMs. Especially in the medical domain, it is of utmost importance that systems are tested and validated in a structured way, as faulty output might have dire consequences ranging from misinformation to taking the wrong medication. However, LLMs cannot be tested exhaustively due to their non-deterministic nature and other factors, such as computational and monetary costs. Even testing a restricted domain, such as prompt formulation, given a limited set of input parameters, may lead to a combinatorial explosion when testing all possible combinations. For instance, compare the 24 pairwise combinations, as described above, to all possible 192 combinations from the values in Table 1 used with reasonably sized corpus of pathologies, such as DDXPlus [42]: This corpus comprises 134,530 samples (i.e. sets of symptoms) from the real world, which yields 25,829,760 possible test cases as compared to 3,228,720 for pairwise testing. Taking into account cost, we look at 206,134.40$ versus 25,766.80$. Table 2 gives a breakdown of the number of tokens for prompts as well as their cost, assuming the current pricing of GPT-4o, which is 5.00$ and 15.00$ per million input and output tokens, respectively. It has to be mentioned that the input length can be fully controlled, whereas the length of the output can only be guided by the prompt. In this case, we always assumed 475 output tokens, which was the average in our preliminary experiments. The average number of input tokens was 171.1, consisting of 19.1, which are derived from combinations of values seen in Table 1, and 152 coming from our exemplary set of symptoms, discussed in the following Subsection 5.1.

5.1 Example

To further explain our proposed validation methodology, we use the following exemplary description of symptoms:

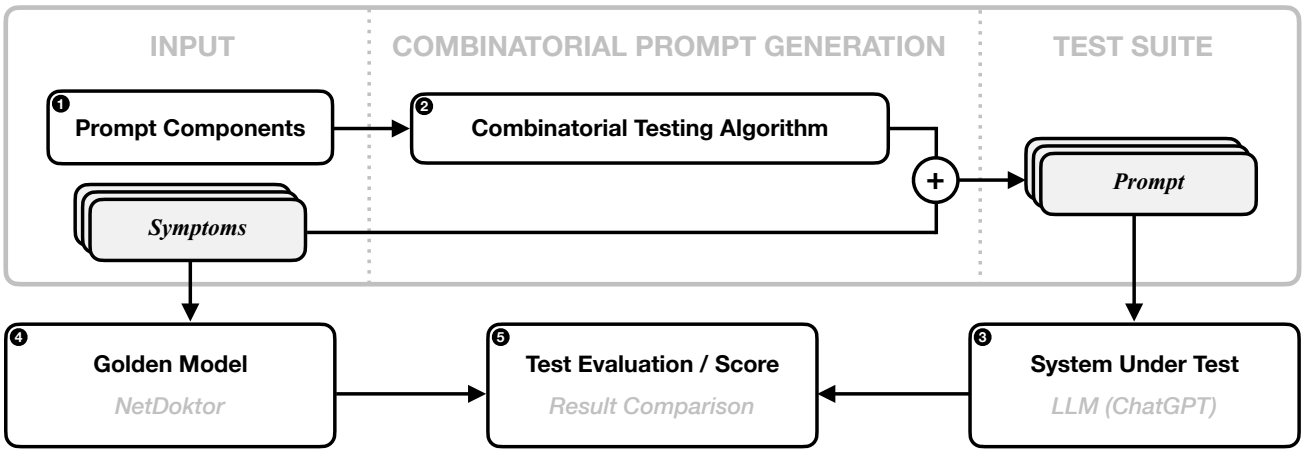

Figure 1: Basic Architecture of Our Validation Methodology.

Table 2: Cost per Size of Medical Corpus

Corpus Size	1	10	100	...	DDXPlus
All Combinations					
Combinations	192	1,920	19,200	...	25,829,760
Input Tokens	0.03M	0.33M	3.29M	...	4,419M
Input Cost [$]	0.16	1.64	16.43	...	22,097.36
Output Tokens	0.09M	0.91M	9.12M	...	12,269M
Output Cost [$]	1.37	13.68	136.80	...	184,037.04
Total Cost [$]	1.53	15.32	153.23	...	206,134.40
Pairwise Combinations					
Combinations	24	240	2,400	...	3,228,720
Input Tokens	0.004M	0.04M	0.41M	...	552M
Input Cost [$]	0.02	0.21	2.05	...	2,762.17
Output Tokens	0.01M	0.11M	1.14M	...	1,533M
Output Cost [$]	0.17	1.71	17.10	...	23,004.63
Total Cost [$]	0.19	1.92	19.15	...	25,766.80

> *An adult woman is experiencing symptoms in the breast gland area. Her most troubling symptom is fluid discharge, and she can feel a firm, painless lump.*

This set of symptom shall be seen as a sample from a corpus of medical pathologies (i.e. sets of symptoms). We use it to test different prompting strategies by combining the values from our domain, seen in Table 1. From this singular sample, we can generate 24 test cases as per our methodology. These test cases are then used to evaluate our SUT based on the output of our golden model. For this set of symptoms, our golden model diagnoses are:

- Breast cancer
- Cyst in the breast
- Mastopathy

Table 3 shows the test result of all 24 test cases. It can be easily spotted that test case 13 was the only prompt achieving a complete overlap with the NetDoktor diagnoses. When fully written-out, prompt 13 corresponding to the combination $[3, 5, 1, 0]$ was:

> *Given the following high-level overview of symptoms, provide the ten most likely diagnoses based on the patient's age and gender.*
> *An adult woman is experiencing symptoms in the breast gland area. Her most troubling symptom is fluid discharge, and she can feel a firm, painless lump.*

Other than the overlap score, there are severe differences in the output depending on the used prompt. Figure 2 illustrates those differences underlined by textual metrics, such as the number of words, while Figure 3 highlights the conciseness of the result as measured by the ratio between the number of words and the number of diagnoses. Most notably, the constraints to asking the LLM to provide concise diagnoses or limiting the number of words to 100 reduce the length drastically. As can be seen in Figure 2, the prompts 3, 4, 7, 8, 11, 12, 16, 17, 20, 22, 23, and 24 all yielded results with less than 200 words. However, prompt 7 exceeds the posed 100 word limit. Furthermore, none of these prompts fully overlapped. When comparing the results for conciseness in particular, Figure 3 shows that the ratio between the number of words and the number of diagnoses is less than 50 for all prompts querying the LLM to provide concise responses (i.e. 3, 4, 16, 17, 23, 24), whereas it is above 60 for all and above 100 for all but one of the prompts asking for a detailed response (i.e. 5, 6, 9, 10, 19).

In an effort to make our work as transparent and reproducible as possible, we provide all prompts and responses of our preliminary study as a replication package [1].

6 Conclusion

This paper highlights the importance of a structured and rigorous validation methodology for LLMs in the medical domain, particularly focusing on prompt engineering. The proposed validation pipeline makes use of pairwise combinatorial testing to systematically evaluate the responses of LLMs like ChatGPT to medical queries. The methodology generates test cases given sets of symptoms and combinations of prompt components. Combinatorial testing ensures that a wide range of prompt variations is tested per set of symptoms without causing a combinatorial

[1] https://zenodo.org/doi/10.5281/zenodo.13765131

Table 3: Overlaps of Diagnoses with Golden Model per Combination for One Exemplary Set of Symptoms. Each Combination Corresponds to One Prompt and Is Denoted by a Code Representing the Indices of the Assumed Values per Prompt Component, as Seen in Table 1. "Mast." stands for " "Mastopathy".

Test Suite		Golden Model Overlap			Score
ID	Combination	Cancer	Cyst	Mast.	
1	[0, 0, 0, 0]	✓	✓		2/3
2	[1, 1, 1, 0]	✓			1/3
3	[2, 2, 1, 1]	✓			2/3
4	[3, 3, 0, 1]	✓			1/3
5	[3, 4, 1, 2]	✓			1/3
6	[2, 5, 0, 2]	✓	✓		2/3
7	[1, 5, 0, 3]	✓	✓		2/3
8	[0, 4, 1, 3]	✓			1/3
9	[0, 3, 1, 2]	✓	✓		2/3
10	[1, 2, 0, 2]	✓	✓		2/3
11	[2, 0, 1, 3]	✓	✓		2/3
12	[3, 1, 0, 3]	✓	✓		2/3
13	**[3, 5, 1, 0]**	✓	✓	✓	**3/3**
14	[2, 4, 0, 0]		✓		1/3
15	[1, 3, 0, 0]	✓			1/3
16	[0, 1, 0, 1]	✓	✓		2/3
17	[1, 0, 0, 1]	✓	✓		2/3
18	[0, 2, 0, 0]	✓	✓		2/3
19	[2, 1, 0, 2]	✓			1/3
20	[3, 2, 0, 3]	✓			2/3
21	[3, 0, 0, 2]	✓	✓		2/3
22	[2, 3, 0, 3]	✓			2/3
23	[0, 5, 0, 1]	✓	✓		2/3
24	[1, 4, 0, 1]	✓			1/3

explosion. Doing so is more efficient and reduces costs as compared to testing all possible combinations of prompt parameters, which is especially important when evaluating LLMs on large medical corpora. The proposed validation pipeline implements semi-automated scoring based on a "golden model", which provides diagnoses curated by medical professionals. In a preliminary study, we demonstrate severe differences in output for prompt variations given the same set of symptoms. Out of 24 test cases, only one achieved a full overlap with our golden model when using GPT-4o. Once more, this highlights the dependence on well-formulated prompts and a need for thorough testing strategies, especially in critical domains like medicine.

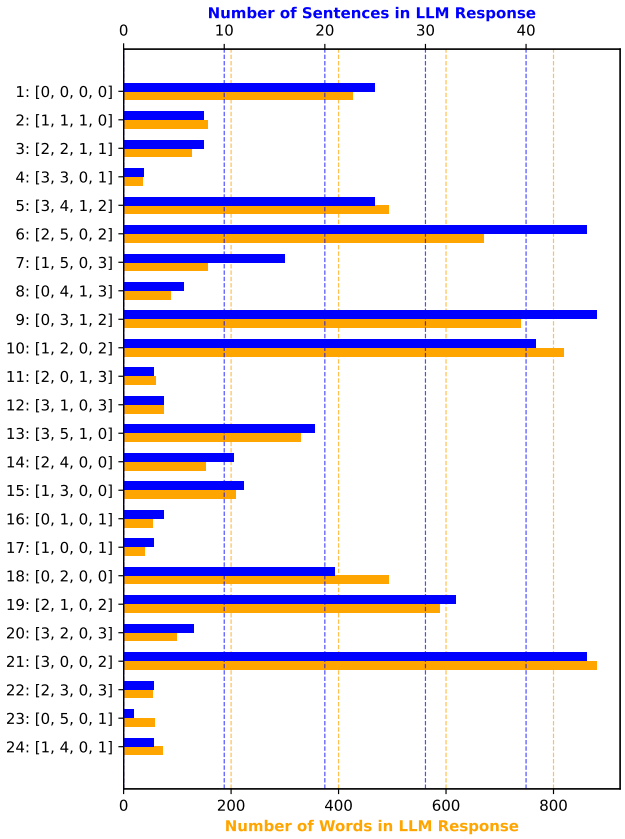

Figure 2: Textual Metrics of LLM Responses: Number of Sentences & Number of Words per Prompt

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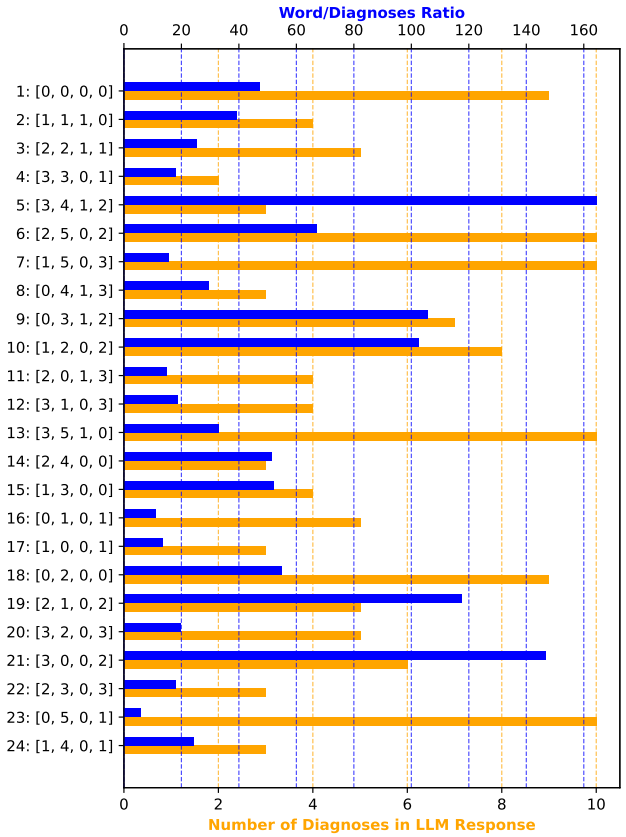

Figure 3: Conciseness of LLM Responses: Number of Diagnoses & Ratio between Number of Words and Number of Diagnoses per Prompt

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Meeting Cultural and Linguistic Demands to Accommodate Fine-Tuned LLMs to Local Medical Customs and Patient Communication

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ABSTRACT

Integrating advanced open-source large language models (LLMs), such as LLaMA and GatorTron, into healthcare offers a novel approach to enhancing communication between physicians and patients. This paper provides a comprehensive review of the potential of these models to improve patient-provider interactions, focusing on their ability to process and generate human-like language in real-time clinical settings. The review outlines the methodology used to evaluate LLMs, which includes a detailed comparison based on qualitative factors such as linguistic adaptability, cultural sensitivity, and context-awareness, alongside quantitative metrics such as accuracy rates, error margins, and patient satisfaction scores from clinical studies. Key ethical considerations are explored, particularly concerning data privacy, patient consent, and accountability. The paper delves into how adopting specific ethical frameworks or guidelines can help mitigate risks associated with bias, misinformation, and patient autonomy. Additionally, the potential for LLMs to perpetuate biases or cultural misunderstandings is discussed, emphasizing the need for fine-tuning these models to align with clinical guidelines and patient needs across different geographies and medical customs. While the paper acknowledges the gaps in current research, such as the emotional sensitivity of LLMs and their ability to understand nuanced patient concerns, it also proposes structured future research directions. This includes the development of LLMs that are more contextually aware, emotionally intelligent, and capable of operating in diverse healthcare settings. By synthesizing current studies and real-world applications, this paper aims to provide a transparent, reproducible framework for evaluating the effectiveness of fine-tuned LLMs in transforming healthcare communication, ultimately improving patient outcomes and satisfaction.

KEYWORDS

large language models, healthcare, patient-doctor communication, ethics in AI, cultural sensitivity

1 INTRODUCTION

Effective communication has always been at the forefront of successful interaction between physicians and patients. It has already been purported that integrating cultural and linguistic competency into healthcare policies, provider training, and patient care strategies will improve the quality of care for diverse populations[5]. Conversely, language barriers, cultural misunderstandings, and a lack of cultural awareness among healthcare providers can lead to miscommunication, misdiagnosis, medication errors, and other safety risks[11]. Large Language Models (LLMs) have shown immense potential in various fields due to their proficiency in generating and understanding natural language. In healthcare, models such as LLaMA and GatorTron present an exciting frontier for improving communication between physicians and patients. These models can process and generate human-like language, which could address significant challenges in clinical communication, such as linguistic, cultural, or emotional barriers. However, significant challenges remain, particularly regarding ethical implications, technical hurdles, local customs, linguistic demands, and the critical aspect of patient-doctor communication. This review examines current applications of LLMs in healthcare, the associated challenges, ethical concerns, and potential gaps, incorporating a range of recent research studies in the field from 2023 and early 2024.[1]

1.1 Purpose and Scope

This paper aims to critically examine the potential of integrating LLMs into healthcare settings, emphasizing their role in enhancing communication. The scope of this review extends to a comparative evaluation of LLaMA, GPT-4, L2M3, and GatorTron, focusing on their potential impact, ethical considerations, and future research needs. The goal is to provide healthcare practitioners, researchers, and developers with a transparent and reproducible framework for adopting LLMs.

2 METHODOLOGY

This review systematically analyzes the current applications of LLMs in healthcare by conducting a structured comparison of models such as GPT-4, Llama, GatorTron, and L2M3. The evaluation criteria include both qualitative and quantitative metrics, focusing on model accuracy, error rates, patient satisfaction scores, and the ability to generate culturally sensitive and clinically appropriate responses. The sources for this review consist of peer-reviewed studies published between 2023 and 2024, covering applications of LLMs in real-time clinical settings, mental health, and patient-doctor communication. Each model's performance is assessed based

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[1]https://doi.org/10.70314/is.2024.chtm.11

on specific clinical tasks, adaptability to local medical customs, and ethical considerations. This methodology ensures transparency and reproducibility, allowing future researchers to replicate and validate the findings.

3 CURRENT APPLICATION OF LLMS IN HEALTHCARE

LLMs are being adopted for various tasks within healthcare, with their most prominent use in medical communication, clinical decision support, and facilitating patient-doctor interactions. Conversational agents like ChatGPT assist patients in understanding medical terminology and provide immediate answers to healthcare-related queries, often enhancing patient engagement with care providers. LLMs also bridge communication gaps between patients and healthcare providers, improving clarity and comprehension in patient education[25]. In patient-doctor communication, LLMs serve as intermediaries to help patients articulate their symptoms and concerns more clearly. This enhances clinical encounters, as doctors can quickly grasp patient issues without the noise of miscommunication. They can improve the precision of patient-doctor dialogue, particularly when addressing complex conditions and explaining treatment plans[21]. Similarly, mental health applications have seen LLMs being used to summarize counseling sessions, allowing healthcare providers to focus on therapeutic interventions rather than administrative tasks[1]. Beyond patient communication, LLMs assist clinicians with diagnoses and medical research. GPT-4 and LLaMA are increasingly used as clinical assistants, offering support in diagnosis and treatment planning[29]. Large language models enhance decision-making in surgical care by answering patients' questions, thereby improving pre-surgical communication and reducing patient anxiety[18]. Figure **??** shows the areas of the medical domain where LLMs are currently being applied.

Figure 1: Applications of large language models in healthcare

4 IMPROVING PATIENT-DOCTOR COMMUNICATION

Effective communication between patients and doctors is a cornerstone of healthcare. Miscommunication can lead to misunderstanding, reduced adherence to treatment plans, and dissatisfaction with care. LLMs offer a promising solution to enhance communication by simplifying medical information into layman's terms. The role of LLMs in improving patient-doctor interactions is significant, as they ensure the translation of medical jargon into easily understandable language during consultations, ultimately leading to more informed decision-making and patient compliance[19]. Recent research explores how generative AI tools, including LLMs, have been applied to reduce misunderstandings in clinical services. They show that patients often feel overwhelmed by medical language, and LLMs can mitigate this issue by acting as interpreters, promoting clearer communication between patients and their healthcare providers[28]. A pictorial demonstration of the ways large language models can improve the communication between patients and their providers is given in Figure 2.

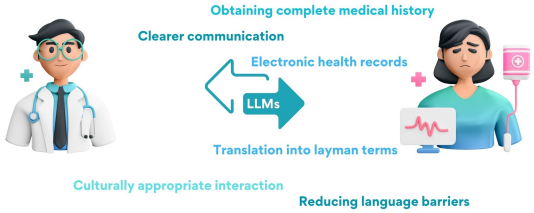

Figure 2: Patient-doctor communication facilitated by the use of LLMs

There is also research that addresses how LLMs can cater to multilingual settings, facilitating better communication in regions with diverse linguistic backgrounds. This ensures that patients from low-resource, multilingual regions receive equitable healthcare without language barriers compromising the patient-doctor relationship[3]. However, the risks of over-reliance on LLMs in direct patient communication must also be acknowledged. Some research argues that cultural sensitivity and local medical customs play a crucial role in healthcare communication. LLMs that fail to adapt to these factors may risk undermining trust between patients and healthcare providers. For instance, culturally inappropriate language or failure to understand local medical norms could weaken the patient-doctor bond and compromise care[11]. The diagram in Figure 3 shows a basic workflow of the integration of LLMs in healthcare.

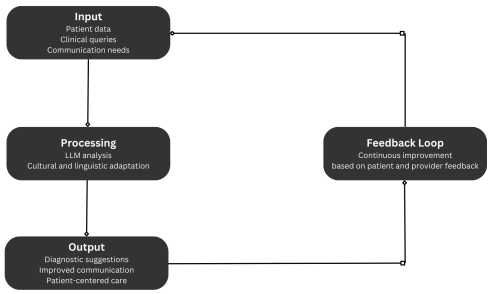

Figure 3: Workflow of LLM integration in healthcare

5 COMPARATIVE ANALYSIS OF THE MOST PROMINENT LLMS IN HEALTHCARE

Our review would be incomplete if we failed to mention the most prominent large language models that have been fine-tuned for

Model Name	Primary Applications	Cultural and Linguistic Adaptations	Current Limitations	Future Research Needs
GPT-4	Diagnostic support, patient communication	Multilingual capabilities, cultural sensitivity	Bias, accuracy issues	Domain-specific adaptations, ethical frameworks
L2M3	Health equity, multilingual support	Designed for multiple languages, cultural context integration	Limited domain-specific fine-tuning	Research on impact in low-resource regions
LlamaCare	Healthcare knowledge sharing	Tailored for healthcare terminology, multilingual support	May lack emotional sensitivity	Enhanced cultural adaptation, emotional sensitivity
GatorTron	Clinical decision-making, patient interaction	Adapted for diverse clinical contexts	Potential bias, limited contextual awareness	Improving contextual understanding and bias reduction
Additional Models (e.g., Me-LLaMA)	Specific clinical domains, patient interaction	Customizable for local languages and cultures	Challenges with generalizability	Further development for specialized clinical needs

Table 1: Comparison of LLMs in Healthcare Applications

applications in the medical domain. Therefore, this section will highlight the strong points and then perform a comparative analysis between GPT-4, LlamaCare, GatorTron, and L2M3. A graphic display of these models and their most prominent features in the medical domain can be found in Figure 4, while Table 1 below summarizes the models' strong points and current areas that can be improved, as well as areas where research can be focused in the future.

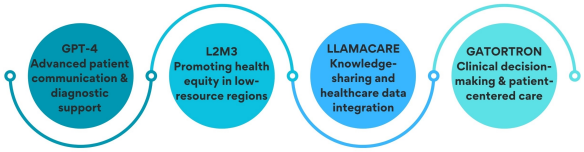

Figure 4: Overview of the key LLMs that are applied in healthcare

5.1 GPT-4

General Application in Medicine. As one of the most versatile LLMs, GPT-4 has been widely studied for its role in clinical decision-making, medical education, and patient engagement. GPT-4's broad applications, from summarizing medical records to assisting with diagnosis and patient interaction. However, GPT-4's lack of specialized medical training means it faces challenges when compared to models like LlamaCare and GatorTron[23].

Patient-Doctor Communication. GPT-4 has also demonstrated potential in improving patient communication by generating empathetic, human-like responses. The model can generate emotionally intelligent text, potentially enhancing patient trust in AI-generated advice[17]. Despite this, GPT-4 struggles with more complex medical queries where detailed clinical context is needed[24].

5.2 L2M3

Multilingual Healthcare Accessibility. One of L2M3's greatest strengths is its support for multilingual healthcare environments. L2M3 is a model designed specifically for low-resource healthcare settings where language barriers and cultural diversity pose significant challenges. By offering support for multiple languages, L2M3 has the potential to increase access to healthcare for marginalized communities globally[8].

Cultural Sensitivity. L2M3 goes beyond just linguistic adaptability by embedding cultural knowledge into its model[23]. This enables L2M3 to provide more contextually appropriate advice that aligns with local medical customs. For instance, it can recommend treatments or healthcare guidelines that resonate with the cultural practices of the patient's region, something that more generalized models like GPT-4 may fail to do effectively.

Consideration for Health Equity. L2M3 plays a pivotal role in reducing healthcare disparities by making culturally and linguistically appropriate care accessible in underdeveloped and diverse regions. It is particularly adept at filling gaps left by monolingual or culturally neutral models, such as GPT-4[23].

5.3 LlamaCare

Knowledge Sharing in Healthcare. LlamaCare was developed to facilitate knowledge sharing among healthcare professionals. Unlike GPT-4, which is designed for general applications, LlamaCare is fine-tuned specifically for healthcare, giving it an edge in clinical decision support[29]. LlamaCare's training on specialized medical datasets makes it particularly useful for knowledge-intensive tasks such as diagnosing complex conditions or synthesizing information from clinical trials[12].

Fine-tuned for Medical Data. LlamaCare's ability to provide accurate, context-specific information gives it a significant advantage over more general models. Its precision comes from training on large volumes of healthcare-specific datasets, allowing it to outperform models like GPT-4 when it comes to specialized clinical decision-making[26].

Patient Communication. Although LlamaCare's primary role is to assist healthcare providers, it can also be used to improve patient communication by offering detailed and reliable medical information. However, unlike GPT-4, which is more conversational, LlamaCare's focus remains on delivering precise medical knowledge rather than generating empathetic dialogue[4].

5.4 GatorTron

Focus on Medical Records. GatorTron is being specifically designed for the U.S. healthcare system, where it excels in processing vast amounts of electronic health records (EHRs). Its ability to rapidly synthesize and analyze patient data has made it an essential tool for improving diagnostic accuracy and reducing administrative

burden[2]. GatorTron outperforms models like GPT-4 in this regard, owing to its fine-tuning on clinical records[7].

Enhancing Clinical Workflows. One of GatorTron's key strengths is its ability to streamline clinical workflows by accurately summarizing medical histories, diagnoses, and treatment plans.[14]. GatorTron enhances clinical efficiency by reducing the amount of time doctors spend on administrative tasks like reviewing patient charts, allowing them to focus more on patient care.[16].

Adaptation to U.S. Healthcare. GatorTron's design is optimized for the U.S. healthcare system, making it particularly effective in this context. However, this focus on English-language records means it may not be as adaptable in multilingual or international healthcare environments. GatorTron's success illustrates the need for more research on how to adapt models to diverse healthcare systems[27].

5.5 Comparative Analysis

Local Medical Customs and Linguistic Demands. When comparing L2M3 and GatorTron, L2M3's strength in multilingual settings is highlighted, which makes it ideal for global healthcare applications. GatorTron, by contrast, is more specialized for English-speaking environments. GPT-4 offers broader utility but lacks the cultural and linguistic specificity of L2M3 and the clinical precision of GatorTron and LlamaCare[23].

Patient Communication. GPT-4 and LlamaCare both demonstrate potential in patient-doctor communication, but they serve different purposes. GPT-4 excels in generating empathetic responses, while LlamaCare offers more medically precise information. L2M3's focus on multilingual communication gives it an edge in culturally diverse settings, but GatorTron's role remains more data-focused[17][9][26].

Customization and Accuracy. Both GatorTron and LlamaCare excel in accuracy due to their fine-tuning on medical data[30]. GPT-4, while highly versatile, does not have the same level of specialization[23]. L2M3, on the other hand, is a standout for global healthcare, particularly in low-resource regions[3].

6 CHALLENGES

6.1 Technical Challenges of Implementing Medical LLMs

Despite promising applications, adapting LLMs to specific medical tasks presents technical challenges. A major issue is the need for domain-specific training data. The models need considerable fine-tuning for clinical natural language processing (NLP) tasks, making zero-shot learning an emerging solution[20]. When it comes to the application of zero-shot learning in preventive healthcare, it has an ability to provide accurate decision support even in niche medical contexts[13]. In addition, fine-tuning LLMs to accommodate local medical customs and linguistic variations is critical for effective patient communication across diverse healthcare settings. That is why multilingual models like L2M3, which cater to low-resource regions where local dialects and cultural practices significantly influence healthcare delivery, have such importance[3]. Without incorporating local linguistic demands and medical traditions, LLMs risk misinterpretation, leading to misdiagnosis or poor patient outcomes.

6.2 Ethical Implications of LLMs in Healthcare

The ethical implications of deploying LLMs in healthcare extend beyond technical challenges, touching on critical issues such as data privacy, patient consent, and accountability. are substantial, particularly in terms of biases, transparency, and patient autonomy. While current studies briefly mention these concerns, this review delves deeper into specific ethical frameworks that should guide the development and deployment of LLMs. One such framework is the "Data Protection by Design" principle, which emphasizes the need to integrate privacy safeguards into AI systems from the outset. In addition, patient consent must be a core element when implementing LLMs in clinical settings, ensuring that patients are fully aware of how their data is used and stored. Accountability in AI decision-making also needs to be addressed, particularly in high-stakes scenarios like diagnostics and treatment planning, where errors can have life-altering consequences. Finally, the risk of bias and perpetuating healthcare inequities through LLMs necessitates stricter ethical oversight, with transparent mechanisms for identifying and mitigating bias. Racial and ethnic biases in GPT-4 were explored for medical diagnosis and triage, uncovering disparities in the model's responses. These concerns underscore the need for ethical oversight when using LLMs in culturally diverse settings[10]. Furthermore, LLMs could reinforce healthcare inequities if not properly adapted to the specific needs and practices of various cultures[6]. Additionally, LLMs must account for linguistic diversity in global healthcare contexts. For example, healthcare systems in multilingual nations, such as India, require models that can function across multiple languages while understanding the nuances of local medical customs. There is an innate link between culture, language, and patient safety, making linguistic competency critical for patient-centered care[11]. The LlamaCare model provides a framework for sharing healthcare knowledge across diverse linguistic groups, showing how LLMs can facilitate cross-cultural knowledge sharing in healthcare[22]. Figure 5 below focuses on the challenges, as opposed to the benefits, of applying LLMs in the healthcare domain.

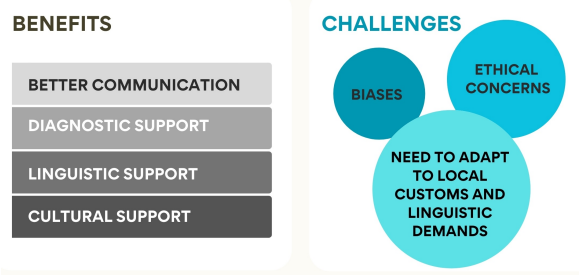

Figure 5: The benefits and challenges of applying large language models in the medical domain

7 EVALUATING THE EFFECTIVENESS OF LLMS IN HEALTHCARE

The evaluation of LLMs in healthcare requires a combination of qualitative and quantitative metrics to ensure a balanced assessment of their performance. In addition to the qualitative analysis

of their language generation capabilities, this review incorporates quantitative metrics such as accuracy rates, error rates in specific tasks (e.g., diagnosis or patient communication), and patient satisfaction scores derived from recent studies. These metrics provide a robust framework[9] for comparing LLMs across various clinical applications. For example, models like GPT-4 and LlamaCare have been evaluated for their diagnostic accuracy, while GatorTron has shown promise in reducing administrative burdens through improved EHR management. Quantitative evidence, such as the accuracy rates of LLMs in diagnosing rare conditions or the error rates in patient-facing applications, strengthens the argument for their continued refinement and deployment in healthcare.

Evaluating LLMs in medical applications, focusing on adaptability to local linguistic demands, accuracy, and transparency requires a detailed framework[9]. There are METRICS in place that serve as a tool for standardizing LLM evaluations, ensuring they are tailored to local healthcare systems and relevant cultural needs[19]. In multilingual and multicultural settings, the evaluation of LLMs should prioritize their ability to maintain cultural and linguistic appropriateness. The L2M3 model, designed for regions with limited healthcare resources, demonstrates how multilingual and culturally aware LLMs can improve healthcare outcomes in underserved communities[3].

8 GAPS IN THE EXISTING RESEARCH

As LLMs become more prevalent in clinical environments, the focus on improving patient-doctor communication and addressing cultural and linguistic considerations will be crucial. Overreliance on LLMs without adequate human oversight, particularly in sensitive clinical areas like diagnostics and treatment planning is dangerous[29]. Additionally, there is a need for stringent ethical guidelines to ensure that LLMs do not perpetuate healthcare inequities[6]. In the papers that were evaluated for this review, we have identified the most notable gap in the limited focus on multicultural and linguistic diversity. There is a need for more comprehensive studies and models specifically designed for non-Western and linguistically diverse healthcare settings. LLMs must be fine-tuned to local medical practices and languages to truly serve global healthcare needs. The second gap identified is the bias that exists in LLM healthcare recommendations[10][6]. There is a lack of clear, actionable frameworks for systematically identifying and reducing bias in LLMs. Addressing this will require a multidisciplinary approach combining AI ethics, clinical expertise, and sociocultural considerations. The third gap is the emotional sensitivity in patient-doctor communication[1][21][18]. Finally, there is the danger of over-reliance on LLMs for decision support[6][29]. Still, the field is quite promising, so exploring future directions for research is worthwhile.

9 FUTURE DIRECTIONS FOR RESEARCH

The potential of LLMs in healthcare remains largely untapped, with significant gaps in current research that need addressing. One critical area for future investigation is the development of LLMs that are emotionally sensitive and capable of handling high-stakes, emotionally charged patient interactions. For example, models could be designed to recognize emotional cues in patient language and adjust their responses to provide more empathetic care. Another vital research direction is improving the contextual awareness of LLMs, particularly in culturally diverse settings where understanding local customs, languages, and medical practices is essential. Furthermore, future research should explore ways to integrate LLMs with other healthcare technologies, such as electronic health records (EHRs), to streamline clinical workflows while ensuring data privacy. Finally, the creation of robust, standardized evaluation frameworks[19][9] will be crucial in assessing the long-term effectiveness of LLMs in healthcare, focusing on patient outcomes, model accuracy, and ethical and regulatory compliance[6][15].

10 CONCLUSION

LLMs hold immense potential to revolutionize healthcare by enhancing diagnostic support, improving patient-doctor communication, and facilitating equitable care. Their success, however, hinges on addressing challenges such as local medical customs, linguistic diversity, and ethical concerns. Proper adaptation of LLMs can significantly enhance patient-centered care by making communication between patients and healthcare providers more culturally sensitive and linguistically appropriate. Prioritizing inclusivity and transparency is essential for improving healthcare outcomes and equity. Future research must focus on addressing cultural and linguistic diversity, improving emotional sensitivity in patient-doctor interactions, mitigating biases, and establishing ethical and legal frameworks for AI in healthcare. Specialized research is also needed to tailor LLMs for specific clinical domains, such as mental health and surgery, to ensure these tools are safe, reliable, and contextually aware.

11 ACKNOWLEDGEMENT

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Zbornik 27. mednarodne multikonference

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Digitalna preobrazba zdravstvene nege - SIZN 2024
Digital Transformation of Nursing - NIIG 2024

Uredniki / Editors

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Ljubljana, Slovenia

PREDGOVOR

Pred vami je zbornik konference »Digitalna preobrazba zdravstvene nege (Sekcija za informatiko v zdravstveni negi - SIZN)«, ki je potekala v okviru 27. mednarodne multikonference Informacijska družba – IS 2024, 8. oktobra 2024 na Institutu Jožef Stefan v Ljubljani.

Konferenco je organizirala SIZN pri Slovenskem združenju za medicinsko informatiko. Partnerji konference so bili (v abecednem vrstnem redu):

- Fakulteta za vede o zdravju Univerze na Primorskem;
- Fakulteta za zdravstvene vede v Celju;
- Fakulteta za zdravstvene vede Univerze v Mariboru;
- Slovensko društvo za medicinsko informatiko;
- Zdravstvena fakulteta Univerze v Ljubljani;
- Zbornica zdravstvene in babiške nege Slovenije – Zveza strokovnih društev medicinskih sester, babic in zdravstvenih tehnikov Slovenije

Konferenca predstavlja pomemben mejnik v razvoju informatike v zdravstveni negi, saj gre za prvi dogodek SIZN na multikonferenci Informacijska družba. Predavatelji so predstavili različne vidike digitalizacije zdravstvene nege in poudarili tako znanstvene kot praktične implikacije digitalne preobrazbe, predvsem v povezavi z uporabo umetne inteligence.

Osrednja tema razprav je bila usmerjena v izboljšanje kakovosti oskrbe in učinkovitosti dela v zdravstveni negi s pomočjo informacijsko komunikacijske tehnologije. Poleg tehnoloških priložnosti so bili izpostavljeni tudi etični izzivi ter vpliv digitalizacije na zdravstvo. Večino prispevkov so predstavile diplomirane medicinske sestre in zdravstveniki, kar poudarja zavedanje stroke o pomenu digitalne transformacije za prihodnost zdravstvene nege.

Zahvaljujemo se vsem udeležencem za aktivno sodelovanje v razpravah. Posebna zahvala gre avtorjem prispevkov, ki ste obogatili naše razumevanje digitalne transformacije v zdravstveni negi in pripomogli k postavitvi sodobnih temeljev za nadaljnji razvoj informatike v zdravstveni negi. Za konec bi se radi zahvalili še dr. Maximu Topazu, vrhunskemu strokovnjaku, ki preučuje uporabo umetne inteligence v zdravstveni negi, za plenarno predavanje.

Programski odbor konference »Digitalna preobrazba zdravstvene nege (SIZN)«

FOREWORD

This is the conference proceedings of "Digital Transformation of Nursing (Slovenian Nursing Informatics Interest Group - NIIG)," which took place within the 27th International multiconference Information Society – IS 2024 on October 8, 2024, at the Jožef Stefan Institute in Ljubljana, Slovenia.

The conference was organized by NIIG, interest group within the Slovenian Medical Informatics Association. The conference partners were (in alphabetical order):

- • Faculty of Health Sciences, University of Primorska,
- • Faculty of Health Sciences, Celje,
- • Faculty of Health Sciences, University of Maribor,
- • Slovenian Association for Medical Informatics,
- • Faculty of Health Sciences, University of Ljubljana,
- • Nurses and Midwives Association of Slovenia.

The conference represents an important milestone in the development of nursing informatics, as this is the first event organized by the NIIG at the Multiconference Information Society. The authors addressed various aspects of the digitalization of nursing, emphasizing both the scientific and practical implications of digital transformation in nursing, particularly in relation to the use of artificial intelligence.

The central theme of the discussions was focused on improving the quality of care and the efficiency of nursing work through information and communication technology. In addition to technological opportunities, ethical challenges and the impact of digitalization on healthcare were also highlighted. The majority of the contributions were presented by registered nurses and health professionals, underscoring the profession's awareness of the importance of digital transformation for the future of nursing.

We would like to thank all the participants for their active involvement in the discussions. Special thanks go to the authors of the contributions, who enriched our understanding of digital transformation in nursing and helped lay the modern foundations for further development of nursing informatics. Finally, we would like to thank also Dr. Maxim Topaz, a leading expert in the field of artificial intelligence in nursing, for delivering the plenary lecture.

Program Committee of the Conference "Digital Transformation of Nursing (NIIG)"

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Ali lahko etična odobritev in soglasje pacienta sledita pogovornim robotom na področju duševnega zdravja?

Can Ethical Approval and Patient Consent Keep Pace with Conversational Agents in Mental Health?

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Povzetek

Čeprav številne znanstvene raziskave uvajajo napredne računalniške metode v raziskave na področju duševnega zdravja, ni dovolj raziskav o tem, kako se poroča o etičnih soglasjih. Ali raziskovalci rutinsko pridobijo etično odobritev ali informirano soglasje, ostaja nejasno. Ta raziskava skuša ugotoviti, kako študije na področju duševnega zdravja, ki uporabljajo avtomatizirane pogovorne robote, spregledajo ali neustrezno poročajo o soglasju pacienta in o etičnem dovoljenju ustreznih komisij. Le približno polovica pregledanih študij je omenila zagotavljanje etične odobritve in informirane privolitve, kar odraža različna mnenja o spoštovanju etičnih standardov. Ugotovili smo tudi, da obstaja povezava med velikostjo vzorca oz. številom udeležencev v raziskavi in pridobitvijo etične odobritve, zlasti pri objavah iz revij z nižjimi faktorji vpliva. V prihodnosti bi bilo smiselno raziskati, kako politike revij vplivajo na etične standarde v raziskavah. Poleg tega bi lahko vzpostavili izobraževalne programe, ki bi poudarjali in ozaveščali o pomenu etičnih vidikov, zlasti v študijah, ki vključujejo manjše skupine udeležencev.

Ključne besede

Umetna inteligenca; duševno zdravje; etika; izobraževanje; izbor pacientov; avtomatizirani pogovorni posredniki

Abstract

Although numerous scientific publications introduce advanced computational methods in mental health research, there is insufficient research on how ethical issues are reported. Whether researchers routinely obtain ethical approval or informed consent remains unclear. This investigation seeks to determine how mental health studies employing automated conversational agents either overlook or inadequately report patient consent and ethical clearance from appropriate boards. Almost half of the reviewed studies mentioned securing ethical approval and informed consent, reflecting varied opinions on adherence to ethical standards. There is a link between the size of the study sample and obtaining ethical approval, especially in publications from journals with lower impact factors. Future research should explore how journal policies impact ethical standards in research. Additionally, educational programs could be established to emphasise the significance of ethical considerations, especially in studies involving smaller groups of participants.

Keywords

Artificial intelligence; mental health; ethics; education; patient selection; automated conversational agents

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Uporaba umetne inteligence v procesu zdravstvene nege: Analiza vpliva navodil na kakovost rezultatov
The use of artificial intelligence in the nursing process: An analysis of the impact of instructions on quality of outcomes

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Povzetek

Prispevek predstavlja raziskavo, ki preučuje sposobnost ChatGPT-ja za generiranje negovalnih diagnoz, ciljev in intervencij v negovalnih načrtih zdravstvene nege. Raziskava primerja rezultate ChatGPT-ja s standardnimi negovalnimi klasifikacijami in protokoli ter hkrati preiskuje, kako študenti učinkovito uporabljajo to orodje umetne inteligence za pripravo učne negovalne dokumentacije - Študije primera. Analizirali smo besedilne odgovore, ki jih je ustvaril ChatGPT, in jih primerjali s standardi za negovalne diagnoze (NANDA), oblikovanje ciljev po SNOČ-u ter oblikovanje specifičnih in merljivih časovnih okvirov za intervencije zdravstvene nege v negovalnem načrtu. Poleg tega smo preučili vpliv različnih načinov vnosa podatkov in navodil na rezultate, ki jih ChatGPT generira. Ključne ugotovitve izpostavijo, da je učinkovitost ChatGPT-ja odvisna od jasnosti in natančnosti podanih navodil. Študenti so dosegli različne rezultate kljub enotnim navodilom, kar poudarja vpliv metode vnosa podatkov in interpelacije navodil. Predvsem so se razlike pokazale v kakovosti opredelitve/poimenovanja negovalnih diagnoz, oblikovanju ciljev, saj le-ti niso bili dovolj specifični ali merljivi ter pri opredelitvi časovnih okvirjev oziroma frekvenc negovalnih intervencij. Umetna inteligenca uspešno prepoznava negovalne probleme, vendar ne uporablja uradne NANDA klasifikacije. ChatGPT je uporabno orodje za osnovno oblikovanje negovalnih načrtov zdravstvene nege, vendar je njegova učinkovitost odvisna od natančnosti navodil in usposobljenosti uporabnika. Raziskava poudarja potrebo po boljspecifičnih smernicah in prilagoditvah pri vključevanju ChatGPT-ja v izobraževalne procese zdravstvene nege

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Ključne besede

ChatGPT, negovalna diagnoza, cilji in intervencije zdravstvene nege, natančnost navodil, NANDA klasifikacija

Abstract

Introduction: The paper presents research that examines the ability of ChatGPT to formulate nursing diagnoses, goals and interventions in the nursing care plan. The research compares the results of ChatGPT with standard nursing classifications and protocols, while investigating how students effectively use this artificial intelligence tool to produce learning nursing documentation - Case Studies. We analyzed the text responses generated by ChatGPT and compared them to the Standards for Nursing Diagnoses (NANDA), the creation of goals according to SNOČ, and the creation of specific and measurable time frames for nursing interventions in the care plan. In addition, we examined the impact of different data entry methods and instructions on the results generated by ChatGPT. Key findings highlight that the effectiveness of ChatGPT depends on the clarity and precision of the instructions given. Students achieved different results despite uniform instructions, highlighting the influence of the data entry method and the interpellation of instructions. In particular, differences were evident in the quality of the definition/naming of nursing diagnoses, the formulation of goals as these were not specific or measurable enough, and the definition of timeframes or frequencies of nursing interventions. Artificial intelligence successfully identifies nursing problems but does not use the official NANDA classification. ChatGPT is a useful tool for the basic formulation of nursing care plans, but its effectiveness depends on the accuracy of the instructions and the competence of the user. The research highlights the need for more specific guidelines and adaptations when integrating ChatGPT into nursing education processes.

Keywords

ChatGPT, nursing diagnosis, nursing goals and interventions, instruction accuracy, NANDA classification

Povezanost dimenzij informacijske varnostne kulture z namero nepooblaščenega dostopa do zdravstvenih podatkov

The relationship between the dimensions of information security culture and the intention of unauthorised access to health data

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Povzetek

V svetu je zabeležena porast groženj in kršitev informacijske varnosti. Medtem ko so v tujini javno dostopne informacije o omenjenih kršitvah, pri nas ni na voljo uradnih podatkov o kršitvah varnosti in zasebnosti zdravstvenih podatkov. Zaposleni v zdravstveni negi igrajo ključno vlogo pri njihovi zaščiti, saj predstavljajo večino zaposlenih v zdravstvu in imajo zaradi narave svojega dela omogočen neposreden dostop do zdravstvenih podatkov. Namen raziskave je s pomočjo Teorije načrtovanega vedenja pojasniti kršitev informacijske varnosti s strani zaposlenih v zdravstveni negi in pri tem preveriti učinek dimenzij informacijske varnostne kulture. V obdobju od aprila 2021, do marca 2022 je bila izvedena anketa med zaposlenimi v zdravstveni negi v Sloveniji (n = 527). Rezultati so pokazali, da imajo normativna prepričanja največji učinek na vedenjsko namero nepooblaščenega dostopa do podatkov. Identificirali pa smo tudi posredno povezavo med dimenzijami informacijske varnostne kulture (usmerjenost k zagotavljanju zasebnosti; usmerjenost k varnosti podatkov; izmenjava znanja o informacijski varnosti; varnostno izobraževanje, usposabljanje in ozaveščanje) in nepooblaščenim dostopom do podatkov. Izsledki raziskave doprinašajo k razumevanju informacijske varnostne kulture in povezanosti njenih dimenzij na vedenjsko namero zaposlenih v zdravstveni negi do nepooblaščenega dostopa do zdravstvenih podatkov.

Ključne besede

zasebnost in varnost podatkov, zdravstveni podatki, elektronski zdravstveni zapisi, kršenje varnosti podatkov, informacijska varnost, zdravstvena nega, izvajalci zdravstvenih storitev.

Abstract

The world is experiencing an increase in information security threats and breaches. While information about these breaches is publicly available abroad, we have no official data on breaches of health data security and privacy. Nursing employees play a key role in protecting this data as they make up the majority of healthcare workers and have direct access to healthcare data due to the nature of their work. The aim of this research was to explain information security breaches by nurses using the Theory of Planned Behaviour by considering the impact of the dimensions of information security culture. A survey among nursing employees in Slovenia (n = 527) was conducted between April 2021 and March 2022. The results showed that normative beliefs have the greatest impact on the behavioural intention to access health data without authorisation. In addition, an indirect relationship was found between the dimensions of information security culture (privacy oriented; security oriented; information security knowledge sharing; security education, training, and awareness). and unauthorised access to health data. The results of this study contribute to the understanding of information security culture and the relationship between its dimensions and the behavioural intention of healthcare workers regarding unauthorised access to health data.

Keywords

data privacy and security, health data, electronic health records, data breaches, information security, nursing, healthcare providers.

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Odkrivanje znanja v zdravstvenih informacijskih sistemih s pomočjo rudarjenja procesov

Knowledge discovery in healthcare information systems with process mining

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POVZETEK

Rudarjenje procesov je sinonim za množico tehnik in tehnologij, ki omogočajo avtomatsko odkrivanje znanja o procesih neposredno, na osnovi podatkov, ki so pridobljeni iz informacijskega sistema podjetja. V prispevku so predstavljene osnove rudarjenja procesov, pomen dnevnikov dogodkov in naprednih algoritmov za odkrivanje, preverjanje skladnosti in izboljšave procesov. Osrednji del prispevka je demonstracija zmožnosti sodobnih orodij za rudarjenje procesov, ki temeljijo na dnevniku dogodkov, pridobljenem iz zdravstvenega informacijskega sistema in so sledeče: avtomatizirano odkrivanje procesov, rudarjenje uspešnosti procesov, preverjanje skladnosti in analiza različic izvajanih procesov.

KLJUČNE BESEDE

Rudarjenje procesov, upravljanje poslovnih procesov, zdravstveni informacijski sistem

ABSTRACT

Process mining is a synonym for a multitude of techniques and technologies that enable the automatic discovery of knowledge about processes based on data obtained from the company's information system. The paper presents the basics of process mining, the importance of event logs and advanced algorithms for detection, compliance verification and process improvements. The central part of the paper is a demonstration of the capabilities of modern tools for process mining, which are based on the event log obtained from the healthcare information system and are as follows: automated process discovery, process performance mining, compliance checking, and variant analysis of implemented processes.

KEYWORDS

Process mining, business process management, healthcare information system

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1 UVOD

Vsaka organizacija stremi, k doseganju poslovnih ciljev, kar vključuje ustvarjanje vrednosti za stranke, povečanje prihodkov, izboljšanje operativne učinkovitosti ter trajnostni razvoj. Pomembno sredstvo za doseganje navedenega je ustrezna skrb za procese organizacije z metodologijo upravljanja poslovnih procesov (angl. business process management), ki predstavlja skupek uveljavljenih praks, tehnik in tehnologij za kontinuirano izboljševanje in prilagajanje poslovnih procesov.

Številne aktivnosti »tradicionalnega« upravljanja poslovnih procesov temeljijo na modelih procesov, ki služijo različnim namenom kot so: analiziranje procesov, komuniciranje o procesih, digitalizacija procesov in spremembe oz. izboljšave procesov. Ker v takšnih primerih odločitve upravljanja poslovnih procesov v veliki meri temeljijo na modelih procesov, je poglavitni izziv zagotavljanje njihove veljavnosti (angl. validity), kar pomeni, da modeli predstavljajo dejanske procese oziroma njihovo operativno izvajanje in da le te opisujejo v celoti (angl. completeness) [1].

V praksi se je izkazalo, da je ravno zagotavljanje veljavnih in pravilnih modelov procesov pogosto šibek člen njihovega upravljanja. Zaradi nenehnih sprememb v poslovnem okolju se poslovni procesi kontinuirano spreminjajo in prilagajajo. Modeli poslovnih procesov tako hitro postanejo neskladni z dejansko izvajanimi procesi kakor tudi s tehničnim in organizacijskim okoljem v katerem se izvajajo. Modeliranje poslovnih procesov je prav tako podvrženo človeškim dejavnikom, saj je močno odvisno od spretnosti, znanj in razpoložljivosti analitika, kar vpliva na izdelane modele procesov. Tradicionalno odkrivanje in modeliranje procesov je drago in časovno potratno tudi zaradi vrzeli v poslovnem znanju deležnikov in pomanjkanja objektivnih validacij modelov [2]. Modeli so zato pogosto nepopolni (ne opisujejo celotnega procesa), neskladni (ne predstavljajo dejanskega procesa) ali nepravilni (ne upoštevajo pravil diagramskega jezika, na primer BPMN, in so zato nerazumljivi tako za ljudi kakor tudi za izvajalna okolja). Poslovne odločitve, ki se sprejemajo na neustreznih modelih procesov, postanejo hitro neoptimalne ali celo napačne.

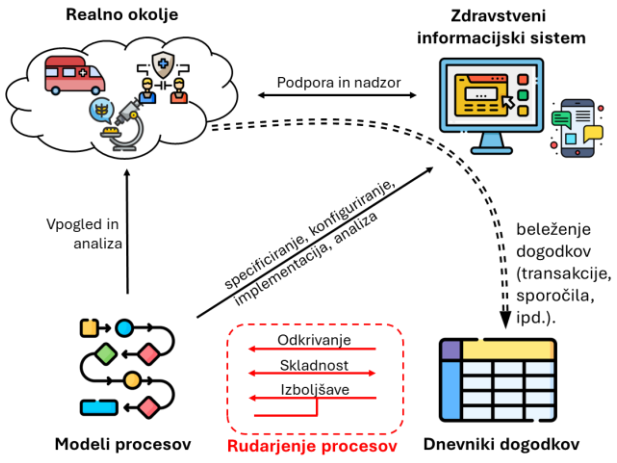
Z višanjem stopnje digitalizacije in avtomatizacije (procesov) so se pojavile priložnosti za reševanje omenjenih

izzivov, z bolj neposrednim upravljanjem dejansko izvajanih procesov na osnovi podatkov, ki jih poslovne informacijske rešitve generirajo v poslovnih operacijah (angl. business operations). Te podatke je možno z usmerjenimi tehnikami rudarjenja podatkov (angl. data mining) pretvoriti v obliko, ki je uporabna za sprejemanje odločitev upravljanja procesov. Besedna zveza "rudarjenje procesov" (angl. process mining) označujemo družino podatkovno vodenih tehnik za analizo poslovnih procesov z uporabo podatkov o dogodkih, pridobljenih iz informacijskih sistemov, kot so ERP sistemi in sistemi za upravljanje odnosov s strankami (CRM). Rudarjenje procesov predstavlja uspešen primer prehoda akademskih zamisli in rešitev v poslovna okolja [2].

2 OSNOVE RUDARJENJA PROCESOV

Rudarjenje procesov je krovni izraz ki predstavlja kombinacijo podatkovnega rudarjenja in tehnik upravljanja procesov, ki uporabljajo napredne algoritme, strojno učenje in statistične metode za analizo podatkov o dogodkih, z namenom analizirati poslovne operacije, vse od celovitih procesov do posameznih aktivnosti procesov.

Slika 1 prikazuje rudarjenje procesov v širšem delovanju organizacije. Poslovni procesi, med katere se uvrščajo tudi zdravstveni procesi, preko interakcij med zdravniki, medicinskimi sestrami, bolniki in drugimi deležniki, ustvarjajo velike količine podatkov. Zdravstveni procesi so vedno bolj podprti in nadzorovani z zdravstvenimi informacijskimi sistemi, ki hranijo podatke o izvajanju procesov. Podatke o izvajanju procesov je mogoče uporabiti za izdelavo dnevnikov dogodkov, katerih ključni gradniki so ponazorjeni v Slika 2. Pridobljene dnevnike dogodkov je mogoče uporabiti za tri osnovne namene rudarjenja procesov: odkrivanje, skladnost in izboljšanje. Odkrivanje se začne z dnevniki dogodkov in ustvari model procesa. Preverjanje skladnosti primerja obstoječi model z dnevnikom dogodkov in s tem izpostavi ujemanja in odstopanja med modelom procesa in dnevnikom dogodkov. Tehnika izboljšave se uporablja za razširitev, izboljšavo ali popravilo modela procesa, npr. da ga uporabimo za izvajanje simulacij.



Slika 1: Delovanje rudarjenja procesov [3]

Rudarjenje procesov omogoča poslovnim uporabnikom, da identificirajo ozka grla, nepotrebne ponovitve opravil, odstopanja in vire odpadkov v svojih procesih ter odkrijejo priložnosti za optimizacijo delovanja in povečanje pozitivnih poslovnih rezultatov.

V zadnjem desetletju je rudarjenje procesov dozorelo in na trg poslalo širok nabor orodij za poslovno inteligenco in upravljanje poslovnih procesov. Rudarjenje procesov se danes uporablja v skoraj vseh industrijskih sektorjih, vključno z bančništvom in finančnimi storitvami, telekomunikacijami, energetiko, zdravstvom, logistiko in proizvodnjo.

2.1 Dnevniki dogodkov

Za analizo poslovnega procesa s tehnikami rudarjenja procesov je potrebno iz informacijskega sistema pridobiti dnevnik dogodkov (Slika 2), ki beleži izvajanje procesa. Dnevnike dogodkov je mogoče pridobiti iz skoraj katerega koli informacijskega sistema podjetja, pa naj bo to iz sistemov ERP ali CRM, kot so SAP, Dynamics, Salesforce ali ServiceNow, ali iz vertikalno specializiranih sistemov, kot so sistemi za izvajanje proizvodnje, sistemi za upravljanje zavarovanj, sistemi za upravljanje bolnišnic, itd.

Case id	Časovni žig	Aktivnost	Vrsta transakcije	Vir	…
…	…	…	…	…	…
5302	23/08/2021 08:51:33	Registration	Start	Receptionist Monica	…
5295	23/08/2021 08:53:12	CT scan avl.	Complete	Radiologist David	…
5303	23/08/2021 08:54:36	Registration	Start	Receptionist Michael	…
5302	23/08/2021 08:55:01	Registration	Complete	Receptionist Monica	…
5301	23/08/2021 08:58:19	EEG test	Complete	Lab technician Jennifer	…
5302	23/08/2021 09:02:46	Consultation	Start	Neurologist William	…
5303	23/08/2021 09:03:25	Registration	Complete	Receptionist Michael	…
5301	23/08/2021 09:07:59	Consultation	Start	Neurologist Amy	…
5292	23/08/2021 09:08:12	Urine test	Complete	Nurse Robert	…
5303	23/08/2021 09:10:53	EEG test	Start	Lab technician Jennifer	…
5287	23/08/2021 09:14:49	Discharge	Start	Neurologist Lisa	…
…	…	…	…	…	…

Slika 2: Preprosti dnevnik dogodkov

Dnevnik dogodkov, kot je ponazorjen na Slika 2, je niz zapisov dogodkov, kjer je vsak zapis dogodka sestavljen iz naslednjih atributov:

- **identifikator primera** ali ID primera (angl. case ID), ki predstavlja enolični identifikator primera (instance), kot je na primer: ID bolnika;
- **časovni žig**, ki predstavlja trenutek, ko je bil dogodek zabeležen v sistemu;
- **aktivnost**; oznaka, ki se nanaša na dejavnost, ki je bila izvedena. V tem primeru je šest različnih oznak dejavnosti, in sicer: registracija, CT skeniranje, EEG test, posvetovanje, urinski test in odpust;
- **vrsta transakcije**, ki predstavlja status aktivnosti. V tem primeru dogodek bodisi predstavlja začetek ali zaključek aktivnosti;
- **vir**; član osebja ali medicinski pripomoček, povezan z izvajanjem aktivnosti. V primeru je osem različnih zaposlenih vključenih v dogodke.

Referenčni dnevniki dogodkov so dostopni na spletnem naslovu: https://processmining.org/event-data.html.

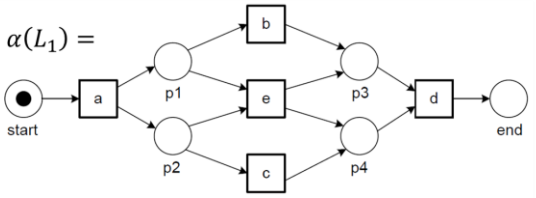
2.2 Algoritmi

Kot je razvidno iz Slika 1 predstavlja dnevnik dogodkov vhod v algoritme rudarjenja procesov. Za potrebe odkrivanja, preverjanja skladnosti in izboljšav modelov procesov, uporablja rudarjenje procesov zapletene in napredne algoritme, ki lahko temeljijo na hevristikah, mehki logiki (angl. fuzzy logic), strojnem učenju (angl. maschine learning) in genetskih algoritmih.

Med osnovne algoritme odkrivanja procesov spada algoritem Alfa, ki analizira relacije urejenosti med pari dogodkov v sledeh (angl. traces) dnevnika dogodkov kot so: neposredni naslednik (angl. direct successor), vzročnost (angl. causality), sočasnost (angl. concurrency) in ekskluzivnost (angl. exclusiveness). Rezultat algoritma α je mreža delovnega toka, ki ohranja omenjene relacije dnevnika dogodkov L, kar zapišemo kot: $\alpha(L)$. [3]

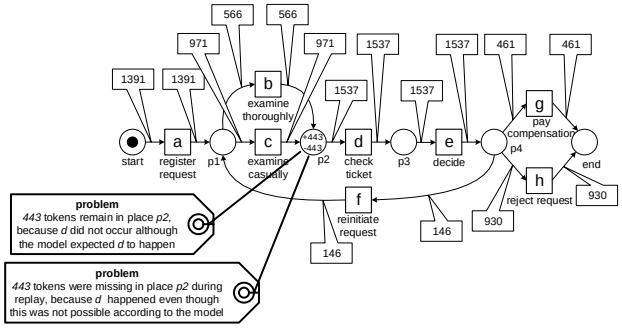
$$L_1 = [\langle a,b,c,d\rangle^3, \langle a,c,b,d\rangle^2, \langle a,e,d\rangle]$$

$\alpha(L_1) =$



Slika 3: Algoritem Alfa

Druga skupina algoritmov je namenjena preverjanju skladnosti, ki kvantificirajo odstopanja med zapisi v dnevniku dogodkov (tj. realno obnašanje procesa) in predpisanim modelom procesa. Na primer, preverjanje skladnosti na osnovi ponovitve izvedbe žetona (angl. token-based replay), natančno prešteje kateri primerki procesa odstopajo od predpisane izvedbe in v kolikšni meri.



Slika 4: Kvantifikacija veljavnih in neveljavnih korakov izvedbe procesa [3]

Z uporabo funkcije prileganja (angl. fitness) se nato poda vrednost, ki predstavlja stopnjo ujemanja izvedbe procesa z modelom procesa v odstotkih oziroma na intervalu [0..1].

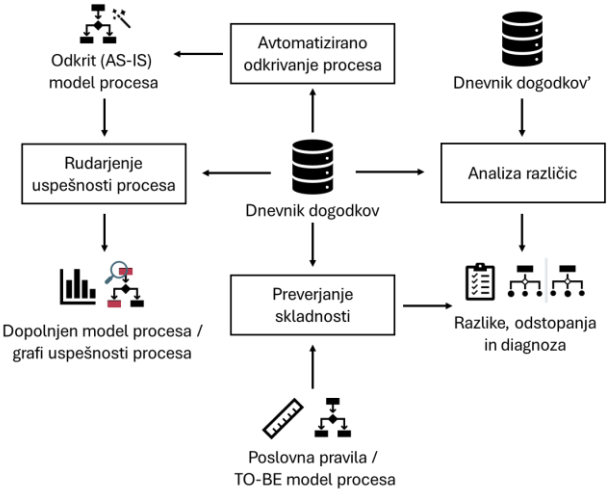
$$fitness(\sigma, N) = \frac{1}{2}\left(1 - \frac{m_{N,\sigma}}{c_{N,\sigma}}\right) + \frac{1}{2}\left(1 - \frac{r_{N,\sigma}}{p_{N,\sigma}}\right)$$

3 ZMOŽNOSTI ORODIJ ZA RUDARJENJE PROCESOV

Sodobne rešitve za rudarjenje procesov omogočajo analitikom in poslovnim vodjem:

- razumeti, kako se izvajajo poslovne operacije, na osnovi generiranih »AS-IS« diagramov procesov, ki temeljijo na podatkih o dogodkih, ki jih beleži informacijski sistem organizacije.
- analizirati podatke, z namenom, da se identificirajo točke trenja v poslovnem procesu in jih poveže s ključnimi kazalniki uspešnosti (angl. key performance indicators).
- razumeti, kaj prispeva k zaželenim in nezaželenim rezultatom procesa, na primer različne aktivnosti, ki prispevajo k naročilom, ki so dostavljena pravočasno, v primerjavi z naročili, ki so dostavljena z zamudo.
- prepoznati neskladno vedenje, razumeti temeljne vzroke odstopanj in kvantificirati vplive teh odstopanj na uspešnost procesa.
- napovedovati prihodnjo uspešnost procesa v različnih scenarijih, tako da lahko ekipe sprejemajo boljše odločitve in bolje razvrstijo prednostna prizadevanja za avtomatizacijo in izboljšanje procesov.

Pridobivanje zgornjega znanja o procesih je možno s štirimi osnovnimi zmožnostmi orodij za rudarjenja procesov (Slika 5):



Slika 5: Zmožnosti rudarjenja procesov

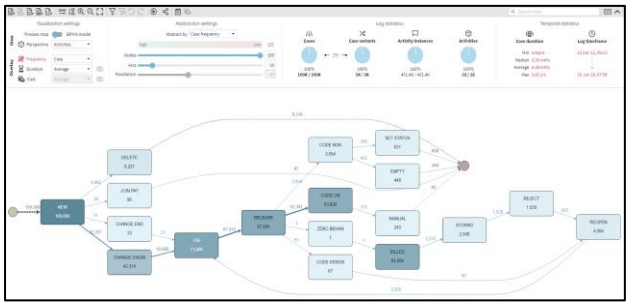
V nadaljevanju je predstavljena demonstracija zmožnosti rudarjenje procesov z uporabo orodja Apromore (www.apromore.com), ki temeljijo na referenčnem in anonimiziranem dnevniku dogodkov, pridobljenem iz zdravstvenega informacijskega sistema.

3.1 Avtomatizirano odkrivanje procesov

Kot je razvidno iz Slika 5, avtomatizirano odkrivanje procesov zajame dnevnik dogodkov in ustvari model »AS-IS«, ki natančno nakazuje, kako dejanski proces deluje, in omogoča primerjavo s tem, kako podjetje želi, da proces deluje. Aplikacije za rudarjenje procesov podjetjem omogočajo vizualizacijo procesa in razumevanje, kje so težave in kako je mogoče proces izboljšati z avtomatizacijo ali drugimi prizadevanji za izboljšanje.

Avtomatizirano odkrivanje procesov prikazuje dejanski potek procesa, točke, kjer se sprejemajo odločitve, kje se izvajajo posegi, kdo jih izvaja, kje poteka predelava in odvečno delo ter kje poteka predaja med zaposlenimi. Korak avtomatiziranega odkrivanja procesov je ključnega pomena za doseganje preglednosti procesa, kar je predpogoj za izdelavo načrta za izboljšanje procesa.

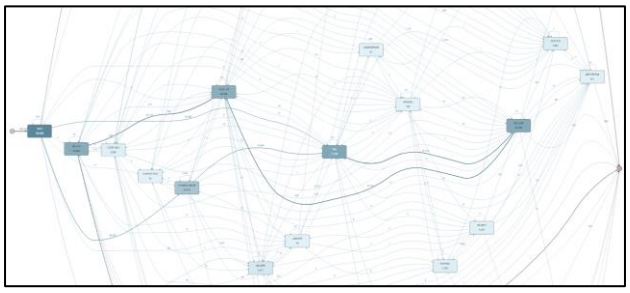
Slika 6 prikazuje z rudarjenjem procesov odkrit model procesa bolnišničnega zaračunavanja, ki je generiran na osnovi 100.000 primerkov izvedbe procesa.



Slika 6: Model algoritmično pridobljenega procesa

Iz uporabniškega vmesnika in diagrama (Slika 6) so neposredno razvidni določeni statistični podatki o izvedbi procesa kot so: število variant izvedbe procesa (v danem primeru 1000 variant), število različnih aktivnosti (v našem primeru 18), minimalni, povprečni in najdaljši čas izvedbe primerka procesa, število ponovitev posameznih aktivnosti in kvantifikacija relacij neposrednih naslednikov (tj. dveh zaporednih aktivnosti).

Zaradi kompleksnosti realnih procesov (Slika 7), predvsem iz vidika števila variacij izvedb enega procesa (varianta predstavlja vse sledi procesa z istim zaporedjem aktivnosti), so običajno tudi procesne mape kompleksne, zato orodja običajno nudijo možnosti abstrakcije pridobljenih modelov in sicer se najpogosteje omejuje prikaz glede na pogostost izvedbe aktivnosti ali povezav (na primer prikaz najpogosteje ali najredkeje izvedenih variant procesa).



Slika 7: Dejanska kompleksnost realnega procesa

3.2 Rudarjenje uspešnosti procesov

Z rudarjenjem uspešnosti procesov (angl. performance mining) pridobimo dodatne informacije o modelih procesov, ki lahko vodijo v njihove izboljšave (Slika 5). Rezultat rudarjenja uspešnosti so grafi uspešnosti (Slika 8) in modeli procesov, ki so dopolnjeni z informacijami kot so trajanja aktivnosti ali pogledi na procese iz vidika določenega vira.

Slika 8: Grafi uspešnosti procesa bolnišničnega zaračunavanja

Z rudarjenjem uspešnosti lahko pridobimo odgovore na vprašanja kot so:

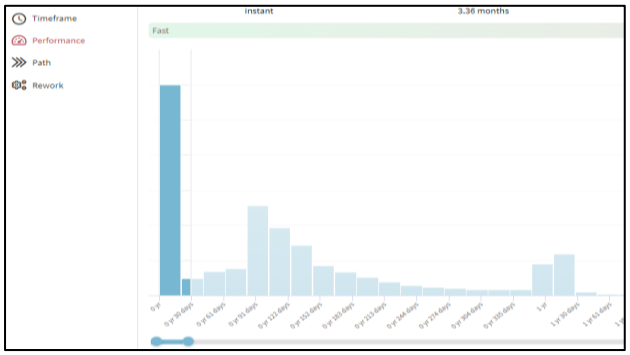
- **Kje v procesu so ozka grla (angl. bottleneck)?** (1) aktivnost je počasna zato predstavlja ozko grlo; (2) vse vhodne povezave v aktivnost so počasne, zato je najverjetneje ozko grlo vir, ki mu je dodeljena izvedba aktivnosti; in (3) počasna je predaja dela (angl. handoff) med dvema viroma.
- **Kateri viri (zaposleni) so v procesu preobremenjeni in pod-obremenjeni?** V kolikor dnevnik dogodkov beleži tudi vire, ki so bili zadolženi za izvedbo aktivnosti, lahko rudarjenje procesov generira mrežo odvisnosti med viri.
- **Kje v procesu se izvajajo ponovitve opravil?** Rudarjenje procesov lahko prepozna ponovno izvajanje opravila, parov opravil ali širših zank, ki potencialno predstavljajo redundantno ali jalovo delo.

3.3 Preverjanje skladnosti

Preverjanje skladnosti (angl. conformance checking) omogoča primerjavo izvajanega modela (oziroma dnevnika dogodkov) z definiranimi poslovnimi pravili ali definiranim modelom procesa (angl. prescribed process model) (Slika 5) in je s tem relevantno za usklajevanje poslovanja z zahtevami in za presojanje poslovanja (angl. auditing). Primeri poslovnih pravil, ki se lahko preverjajo so:

- **omejitve kontrolnega toka**, kot je analiza izvajanja obveznih aktivnosti (na primer: odobritve zahtevkov ali obvezna kontrola kakovosti);
- **omejitve nivoja storitev** oziroma SLA (angl. service level agrement), kot je najdaljši dovoljen čas izvajanja aktivnosti, pod-procesa ali procesa;
- **omejitve virov** kot je »ločevanje dolžnosti« (na primer: ista oseba ne sme izvesti dveh zaporednih aktivnosti) in
- **identifikacija redkih primerkov** izvedbe, ki so potencialno neskladni s poslovnimi pravili.

Rezultat analize preverjanja skladnosti je seznam odstopanj od pravil ali definiranega modela procesa. Slika 9 prikazuje število izvedb primerkov procesa glede na njihovo trajanje. Označeni so vsi primerki procesa bolnišničnega zaračunavanja, ki se izvedejo v manj kot 30 dneh (predpostavimo, da je to opredeljeno v SLA). Primerki, ki ustrezajo SLA oziroma primerki, ki temu ne ustrezajo, se lahko nato še podrobneje analizirano kot je predstavljeno v naslednjem podpoglavju.



Slika 9: Filtriran prikaz modela procesa bolnišničnega zaračunavanja

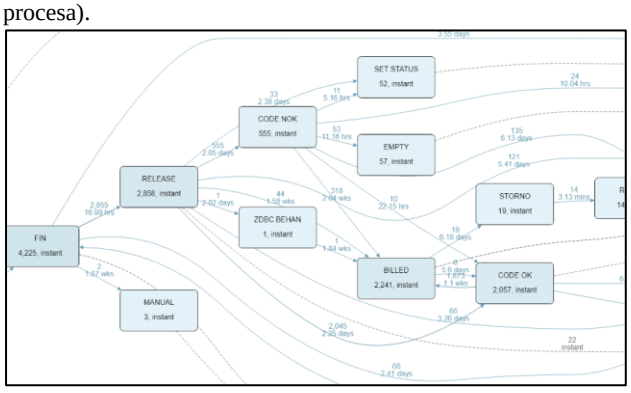
3.4 Analiza različic procesov

Analiza različic (angl. variant analysis) temelji na primerjavi dveh ali več različic dnevnikov dogodkov istega procesa (Slika 5), ki tako predstavljajo različne variante procesa (na primer, primerjava vseh primerkov procesa, ki so se uspešno zaključili glede na neuspešne). Primerjava variant procesov poda vpogled na vprašanja tipa »zakaj?«, na primer:

- zakaj se določeni primerki procesa (ki smo jih združili v eno izmed variant procesa) izvajajo hitreje kot drugi?
- Zakaj se določeni primerki procesa uspešno zaključijo, medtem ko se drugi neuspešno?
- Zakaj je vir, ki je vključen v izbrano varianto procesa manj učinkovit kot drugi?

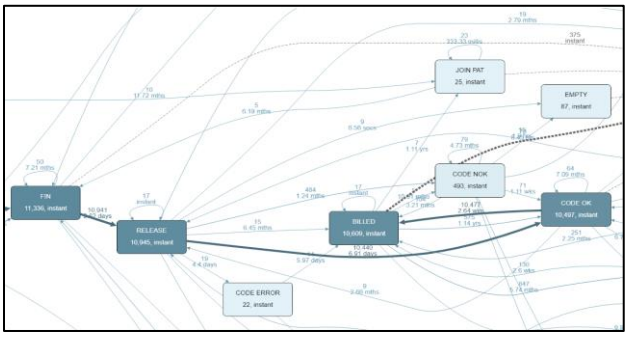
Odgovore na zgornja vprašanja lahko pridobimo z enim izmed naslednji pristopov analize različic procesov: (1) analizo metrik uspešnosti (angl. performance measures) različic procesov; (2) analizo različic procesov glede na čas izvedbe (na primer: analiza in primerjava različic procesov, ki so se izvajali pred in med pandemijo); (3) analiza različic procesov glede na lastnosti primerkov (na primer: vrsta izdelka, segment kupcev, geografsko področje, ipd.).

Na naslednjih dveh slikah (Slika 10 in Slika 11) je prikaz strukture dela procesa bolnišničnega zaračunavanja, katerih primerki se izvedejo v manj kot 30 dnevih (31% vseh primerkov procesa) in strukture dela procesa bolnišničnega zaračunavanja, katerih primerki trajajo več kot leto dni (11% vseh primerkov procesa).



Slika 10: Struktura hitrih primerkov procesa

Iz primerjave slik je razvidno, da je v primeru počasnih izvedb procesa (Slika 11) veliko kratkih zank, ki predstavljajo dolgotrajne, tudi več mesecev trajajoče ponovitve izvedbe opravil.



Slika 11: Struktura počasnih primerkov procesa

4 ZAKLJUČEK

Digitalna preobrazba in optimizacija poslovanja je prepletena s tehnološkimi inovacijami, ki morajo zagotavljati hiter in veljaven vpogled v delovanje organizacij, temelječ na realnih podatkih, na način, ki je razumljiv vsem vpletenim. Med ključne tehnike za doseganje navedenega spada rudarjenje procesov, ki izkorišča močno povezanost med fizično in informacijsko realnostjo (digitalni dvojček) poslovanja, v kateri se poslovni dogodki beležijo v realnem času, le ti pa so uporabljeni za usmerjanje, prilagajanje in nadzor poslovnih procesov. Rudarjenje procesov postaja del rutine večjih podjetij razvitih držav, k čemu je pripomogel tudi širok nabor »enterprise-ready« orodij za rudarjenje procesov. Le ta so dostopna različnim vrstam in potrebam organizacij in omogočajo relativno nizek vstopni prag v aktivnosti rudarjenja procesov. Slabost vpeljave orodij je pogosto, da so le ta v podjetjih implementirana v omejenem obsegu in zato ne pokrivajo celotnega poslovanja [4].

Poglavitna izziva širše vpeljave rudarjenja procesov ostajata kakovost podatkov in človeški dejavniki. Izkušnje kažejo, da je okoli 80% časa potrebnega za lociranje, izbiranje, pridobivanje in transformacijo podatkov, pogosto pa omenjene aktivnosti odkrijejo tudi težave s kakovostjo podatkov, ki jih je potrebno odpraviti neodvisno od rudarjenja procesov. Človeški dejavniki so pogosto povezani z nepoznavanjem področja rudarjenja procesov in »strahom« pred odkritjem dejanskih procesov, ki bi lahko izpostavili pomanjkljivo vodenje, neučinkovitosti ali neskladnosti med operativnih delovanjem in predpisi [4].

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Ocena digitalnih kompetenc medicinskih sester v klinični praksi: opisna raziskava

Assessing digital competencies of nurses in clinical practice: a descriptive study

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Povzetek

Digitalizacija prinaša v zdravstveno nego novosti in inovativne rešitve za medicinske sestre. Digitalne kompetence in uporaba znanj s področja digitalne tehnologije predstavljajo ključen vidik dela medicinskih sester. Namen raziskave je bil opisati digitalno pismenost pri medicinskih sestrah. Uporabljena je bila kvantitativna deskriptivna in eksplorativna neeksperimentalna metoda empiričnega raziskovanja. Anketiranje je potekalo na vzorcu 51 medicinskih sester (36 žensk in 15 moških). Vprašalnik je bil sestavljen iz 25 trditev, povezanih z znanjem, sposobnostmi in odnosom do uporabe digitalnih tehnologij. Upoštevana stopnja statistične značilnosti (p) je znašala ≤ 0,05. Poleg deskriptivne statistike, smo uporabili Wilcoxonov test, Mann-Whitneyev U-test, Kruskal-Wallisov H-test, Hi-kvadrat test ter linearno regresijsko analizo. Medicinske sestre izkazujejo visoko znanje in sposobnosti s področja uporabe digitalnih tehnologij in imajo do njih pozitiven odnos (Me = 122, p < 0,001). Ugotovljeno je bilo, da obstajajo razlike med spoloma in sicer so ženske dosegle višji rezultat ($\bar{x}$ = 113,73, s = 15,80). Statistično pomembnih razlik med različnimi ravnmi zdravstvenega varstva nismo ugotovili. Medicinske sestre so v večini digitalno kompetentne, kar pomeni, da imajo znanje in sposobnosti s področja uporabe digitalnih tehnologij in obenem izražajo pozitiven odnos do njihove uporabe. Pomembno je, da svoja znanja s področja digitalnih tehnologij nadgrajujejo in poglabljajo, saj tako prispevajo k izboljšanju delovnih procesov in boljši oskrbi pacientov.

Ključne besede

Digitalizacija, informatika, sposobnosti, zdravstvena nega

Abstract

The process of digitalization introduces innovations and novel solutions into healthcare, particularly benefiting nursing practice. Digital competencies and the application of knowledge in digital technologies are critical aspects of nurses' work. The aim of this study was to describe digital literacy among nurses. A quantitative, descriptive, and exploratory non-experimental empirical research method was employed. The survey was conducted on a sample of 51 nurses (36 female and 15 male). The questionnaire consisted of 25 statements related to knowledge, skills, and attitudes towards the use of digital technologies. The significance level (p) was set at ≤ 0.05. In addition to descriptive statistics, we used the Wilcoxon test, Mann-Whitney U test, Kruskal-Wallis H test, Chi-square test, and linear regression analysis. Nurses demonstrated a high level of knowledge and skills in the use of digital technologies and exhibited a positive attitude towards them (Me = 122, p < 0.001). It was found that gender differences exist, with women achieving higher scores ($\bar{x}$ = 113.73, s = 15.80). No statistically significant differences were identified across different levels of healthcare. Most nurses are digitally competent, possessing both the knowledge and skills required for the use of digital technologies and expressing a positive attitude towards their application. It is essential for nurses to continue enhancing and deepening their knowledge in digital technologies, as this contributes to the improvement of work processes and better patient care.

Keywords

Digitalization, informatics, nursing care, skills

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Prevod in validacija vprašalnika SHAIP za ocenjevanje stališč zaposlenih v zdravstveni negi o umetni inteligenci*

Translation and validation of the SHAIP questionnaire for assessment of nursing staff's perceptions of artificial intelligence

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Povzetek

Vprašalnik »Shinners Artificial Intelligence Perception« (SHAIP) je namenjen merjenju stališč zdravstvenih delavcev o umetni inteligenci. Cilj študije je bil prevesti vprašalnik v slovenski jezik in ga validirati. Vprašalnik je izpolnilo 270 zaposlenih v zdravstveni negi. Zanesljivost smo ocenili z analizo notranje skladnosti (Cronbachov $\alpha = 0{,}76$) in metodo ponovljenega testiranja (test-retest) na vzorcu 48 anketirancev. Veljavnost smo ocenili z analizo vsebinske (S-CVI/Ave = 0,91), sočasne in strukturne veljavnosti. Kriterijsko veljavnost smo preverili s pomočjo konstrukta *odnos do uporabe tehnologije umetne inteligence* ($r_{xy} = 0{,}657$, $p < 0{,}001$). Analiza odgovorov test-retest je pokazala, da pri vseh, razen zadnjih dveh elementih vprašalnika, ni bilo statistično značilnih razlik v povprečnih vrednostih rangov odgovorov med obema fazama izpolnjevanja. Omenjena elementa vprašalnika sta bila po analizi rezultatov strukturne veljavnosti izključena iz končnega prevoda. Slovenska različica vprašalnika vsebuje tri konstrukte, za razliko od izvirnega instrumenta, ki predvideva zgolj dva. Rezultati nakazujejo, da je slovenska različica vprašalnika SHAIP, ob upoštevanju razlik, zanesljiv in veljaven instrument za ugotavljanje stališč zaposlenih v zdravstveni negi o umetni inteligence.

Ključne besede

Umetna inteligenca, zdravstvena nega, stališča, veljavnost, zanesljivost

Abstract

The Shinners Artificial Intelligence Perception (SHAIP) questionnaire was developed to measure the attitudes of healthcare professionals towards artificial intelligence. The aim of the study was to translate the questionnaire in Slovenian language and validate it. The questionnaire was completed by 270 employees in nursing care. Reliability was assessed by analysing internal consistency (Cronbach's $\alpha = 0.76$) and the test-retest method (conducted on a sample of 48 respondents). Validity was assessed using content validity (S-CVI/Ave = 0.91), concurrent validity and structural validity. Criterion validity was assessed by using the *construct attitudes toward use of artificial intelligence technology* ($r_{xy} = 0.657$, $p < 0.001$). The test-retest analysis showed no statistically significant differences in the mean ranks between the test and retest phases, except for the last two items of the questionnaire. These items were later excluded from the translated version following the analysis of structural validity results. The final translated instrument consists of three constructs, while the original instrument is based on two constructs. The results suggest that the Slovenian version of the SHAIP questionnaire with the considered differences, is a reliable and valid instrument for assessing perceptions of nursing staff on artificial intelligence.

Keywords

Artificial intelligence, nursing, perceptions, validity, reliability

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Pridobivanje mikrodokazil z uporabo simulacij v zdravstveni negi

Obtaining micro-credentials through simulation in nursing

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Povzetek

Uvod: Mikrodokazila predstavljajo nadgradnjo vseživljenjskega izobraževanja s katero bi tudi zdravstvena nega lahko zapolnila vrzeli v okolju, kjer se potrebe po delovni sili hitro spreminjajo. Za reševanje potrebe po kontinuiranem vseživljenjskem razvoju in hkrati spremembe paradigme zdravstvenega izobraževanja, bi se bilo smiselno posluževati simulacijske metode poučevanja pri pridobivanju mikrodokazil. **Namen**: Preučiti vpeljevanje mikrodokazil na področju zdravstvene nege z uporabo simulacijske metode izobraževanja. **Metode**: Uporabljena je bila empirična kvalitativna raziskovalna metodologija, ki je vključevala izvedbo pol-strukturiranih intervjujev in fokusnih skupin s strokovnjaki na področju zdravstvene nege. Podatki so bili analizirani z uporabo vsebinske analize, da bi identificirali ključne teme in podteme. **Rezultati**: Identificirana je tema Simulacije kot metoda učenja za pridobivanje mikrodokazil in podtemi z naslovoma Uporabnost simulacij v zdravstveni negi in Pridobivanje mikrodokazil z uporabo simulacij. Predstavljeni so tudi načini s katerimi bi simulacije doprinesle vpeljevanju mikrodokazil. **Zaključek:** Nadgradnja sistema vseživljenjskega izobraževanja v Sloveniji je ključna za karierni razvoj zaposlenih v zdravstveni negi. Implementacija mikrodokazil in simulacij bi lahko izboljšala kompetence medicinskih sester ter prispevala k boljši dostopnosti in standardizaciji izobraževalnih vsebin.

Ključne besede

Mikrodokazila, simulacijsko usposabljanje, vseživljenjsko izobraževanje, visokošolski izobraževalni sistem.

Abstract

Micro-credentials are an extension of lifelong learning that could also help nursing to fill gaps in an environment where workforce needs are changing rapidly. To address the need for continuous lifelong development and at the same time a paradigm shift in nursing education, it would make sense to use a simulation-based method of teaching for the acquisition of micro-credentials. **Purpose**: To examine the introduction of micro evidence in nursing through a simulation-based method of education. **Methods:** An empirical qualitative research methodology was used, which involved conducting semi-structured interviews and focus groups with nursing professionals. Data were analysed using content analysis to identify key themes and sub-themes. **Results:** Ways in which simulations could contribute to the introduction of micro-evidence are also presented. **Conclusion:** The implementation of micro evidence and simulations could improve the competences of nurses and contribute to better accessibility and standardisation of educational content.

Keywords

Micro-credentials, simulation training, lifelong learning, higher education system.

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1 UVOD

Hitrost napredka in sprememb v zdravstvu je sprožila potrebo po kontinuiranem vseživljenjskem izobraževanju in profesionalnem izpopolnjevanju vseh zdravstvenih profilov. Le s prilagajanjem na potrebe zdravstvenih sistemov je možno nuditi varno in kakovostno zdravstveno oskrbo [1]. Nastajanje vrzeli med potrebami in formalno pridobljenimi kvalifikacijami, poskušajo oblikovalci izobraževalnih politik po svetu, v Evropi in tudi Sloveniji premostiti s pomočjo mikrodokazil [2]. Državna uprava Republike Slovenije [3] definira mikrodokazila »*kot zapise učnih izidov, ki jih je posameznik dosegel z učenjem manjšega obsega. Učni izidi so ovrednoteni s pomočjo Evropskega sistema prenašanja in zbiranja kreditnih točk (ECTS) na podlagi pregledno in jasno definiranih standardov. Programi so pripravljeni tako, da opremijo posameznika s specifičnim znanjem, spretnostmi in kompetencami, ki naslavljajo družbene, osebne, kulturne potrebe oziroma potrebe trga dela. Mikrodokazila so last posameznikov, ki jih lahko delijo z drugimi in prenašajo naprej. Lahko so samostojna ali se združujejo v večja. Podprta so s sistemi za zagotavljanje kakovosti in sledijo dogovorjenim standardom v sektorjih*«. Mikrodokazila so na globalni ravni še vedno v začetni fazi razvoja zato se soočamo z veliko izzivi [4].

Izobraževanje današnjih študentov in strokovnjakov zdravstvene nege postaja vedno večji izziv za oblikovalce izobraževalnih politik, zdravstvene pedagoge, zdravstvene ustanove – učne baze

in same udeležence, saj se potrebe in navade novih generacij korenito spreminjajo [5]. Avtorji v omenjeni raziskavi so dognali, da aktivno in konstruktivno učno okolje, ki temelji na izzivih in učnih ciljih, pri njih spodbuja globlje učenje, ki poudarja razumevanje in uporabo znanja ter se osredotoča na razumevanje namesto na pomnjenje. Takšno učno okolje je možno doseči tudi s simulacijsko metodo izobraževanja [6]. Simulacijska metoda izobraževanja vključuje uporabo različnih modalnosti kot so simulatorji delnih nalog, simulatorji visoke zvestobe, standardizirani pacienti, računalniško podprte simulacije, virtualna resničnost in hibridne simulacije [7].

Uporaba simulacijskih aktivnosti ima v povezavi z mikrodokazili dve prednosti. Ta pristop predstavlja inovativen način, s katerim lahko izobraževalne ustanove in izvajalci zdravstvenih storitev pridobijo kompetence potrebne za strokovni razvoj, izvajanje in vrednotenje učinkovitih strategij poučevanja ter oblikovanje učnih načrtov v spletnem in praktičnem okolju. Prav tako mikrodokazila podpirajo merjenje in nadgrajevanje kompetenc s pomočjo simulaciji, za doseganje optimalnih rezultatov posameznika [8]. Mikrodokazila so pogosto tesno povezana tudi z digitalnimi značkami. To so virtualni in digitalni simboli, ki predstavljajo dosežke, spretnosti ali znanja, pridobljene v različnih okoljih, kot so spletni tečaji ali druge vrste izobraževanj. Pogosto se uporabljajo za spodbujanje učenja in priznavanje dosežkov v izobraževalnih platformah [9–11]. Vključevanje simulacij v študijske programe zdravstvenih strok je pri študentih izboljšala pridobivanje znanja in veščin ter okrepila kakovost in varnost klinične prakse [12].

Za reševanje potrebe po kontinuiranem vseživljenjskem razvoju in hkrati spremembe paradigme zdravstvenega izobraževanja, bi se bilo smiselno posluževati simulacijske metode poučevanja pri pridobivanju mikrodokazil [1, 8, 12].

2 NAMEN IN RAZISKOVALNO VPRAŠANJE

Namen raziskave je preučiti vpeljevanje mikrodokazil na področju zdravstvene nege z uporabo simulacijske metode izobraževanja.

Raziskovalno vprašanje: Kakšne so možnosti pridobivanja mikrodokazil s pomočjo simulacijske metode izobraževanja na področju zdravstvene nege?

3 METODE

3.1 Vzorec

Uporabili smo empirično kvalitativno metodo dela in deskriptivno interpretativni dizajn. Podatke smo zbrali s pomočjo dveh fokusnih skupin in 10 individualnih intervjujev. V prvi fokusni skupini sta sodelovala dva udeleženca, v drugi skupini pa trije. Izvajanje fokusnih skupin se je izkazalo za pomanjkljivo in neučinkovito zaradi specifike področja in težav z usklajevanjem prostih terminov udeležencev. V nadaljevanju raziskave smo se odločili za pridobivanje informacij z individualnimi intervjuji. S procesom intervjuvanja smo prenehali, ko smo zaznali zasičenost podatkov. Skupno je v raziskavi sodelovalo 15 prostovoljcev, od tega 11 žensk in štirje moški. Razmerje v spolu se sklada z zastopanostjo na področju zdravstvene nege [13]. Za namenski vzorec so bile uporabljene tri demografske skupine:

- predstavniki visokošolskih učiteljev s področja zdravstvene nege, ki pri svojem delu uporabljajo simulacije kot metodo učenja (6);
- predstavniki, ki sodelujejo pri oblikovanju politike visokošolskega izobraževanja (4);
- predstavniki kliničnih mentorjev zdravstvene nege oz. strokovnjaki iz prakse (5).

Predstavniki visokošolskih učiteljev so zastopali Univerzo na Primorskem, Univerzo v Mariboru in Univerzo v Ljubljani, s čimer smo zajeli vse javne univerze v slovenskem prostoru. Predstavniki kliničnih mentorjev so zastopali primarno, sekundarno in terciarno raven zdravstvenega varstva, s čimer smo si zagotovili celovit prispevek z vseh ravni. Predstavniki, ki sodelujejo pri oblikovanju politike visokošolskega izobraževanja, so zastopali krovni organ za zdravstveno nego v slovenskem prostoru, in sicer Zbornico zdravstvene in babiške nege Slovenije – Zvezo strokovnih društev medicinskih sester, babic in zdravstvenih tehnikov Slovenije, Strateški svet za zdravstvo Republike Slovenije ali pa so zasedali visoke položaje na univerzitetni ravni.

3.2 Raziskovalni instrument

Pri izvedbi intervjujev in fokusnih skupin smo si pomagali z delno strukturiranim vodičem, ki je bil sestavljen iz treh sklopov vprašanj. Pri oblikovanju vprašalnika smo si pomagali s podobnim tipom raziskave, ki so jo izvedli Lok in sod. [1], in pregledom relevantne literature.

Sklopi delno strukturiranega vodiča so obsegali:

- sklop 1: Demografski podatki;
- sklop 2: Stališča do mikrodokazil;
- sklop 3: Združevanje mikrodokazil, simulacijske metode poučevanja in zdravstvene nege.

Vprašalnik je vseboval 6 vprašanj in kratko definicijo obravnavanega področja, ker se je to izkazalo za potrebno zaradi specifike tematike.

3.3 Potek raziskave

Prostovoljce za sodelovanje v raziskavi smo kontaktirali in angažirali preko elektronske pošte. Uporabili smo elektronske naslove dostopne preko spleta. Pridobivanje podatkov smo izvedli preko platforme ZOOM ali v živo v mesecih septembru, oktobru in novembru v letu 2023. Intervjuji so se snemali znotraj omenjene platforme oz. s telefonom. Zvočni posnetki bodo uničeni tri mesece po objavi raziskave. Od udeležencev smo pred izvedbo pridobili informirano soglasje za sodelovanje v raziskavi, kjer so pojasnjeni namen raziskave, pravila sodelovanja, pravica do odstopa in nekaj osnovnih informacij glede preučevane tematike. Sodelujoči so lahko raziskavo zapustili med celotnim procesom izvajanja raziskave brez obrazložitve. Na vprašanja jim ni bilo treba odgovarjati, če si tega niso želeli. Raziskava je potekala v prostem času vseh sodelujočih posameznikov in je bila popolnoma anonimna. Pridobljeni podatki so bili obdelani s pomočjo programa za kvalitativno analizo besedil NVivo.

Uporabljena je bila fenomenološka metodologija, ki omogoča kredibilnost in zanesljivost podatkov [14]. Po opravljenih fokusnih skupinah in intervjujih je sledila transkripcija

posnetkov in slovnično popravljanje zapisov, pri čemer je pomen vsebine ostal nespremenjen. Za obdelavo podatkov smo uporabili proces po Colaizzijevi v sedmih stopnjah [15]:

1. seznanitev s transkripti: branje in večkratno ponovno branje transkriptov;
2. identifikacija pomembnih izjav: izvleček pomembnih izjav;
3. formulacija pomenov: združevanje izjav v širše pomensko povezane skupine;
4. ustvarjanje tem: združevanje v smiselni sistem tem in podtem;
5. razvoj izčrpnega opisa: izpostavitev bistva nekega pojava in integracija vseh ugotovitev;
6. izdelava temeljne strukture: odstranitev vseh neustreznih vsebin in opisov in razkritje temeljne strukture pojava;
7. verifikacija temeljne strukture: pregled in potrditev rezultatov s strani udeležencev z namenom pridobivanja povratne informacije o pravilni interpretaciji.

4 REZULTATI

V sklopu raziskave smo prepoznali glavno temo, in sicer Simulacije kot metoda učenja za pridobivanje mikrodokazil. Poleg tem smo izpostavili tudi dve podtemi, ki sta razvrščeni k temi, kot je prikazano v Tabeli 1.

Tabela 1: Tema in podtemi vpeljevanja mikrodokazil v zdravstveno nego s pomočjo simulacijske metode učenja

Tema	Podtemi
Simulacije kot metoda učenja za pridobivanje mikrodokazil	Uporabnost simulacij v zdravstveni negi
	Pridobivanje mikrodokazil z uporabo simulacij

Citati so označeni s kraticami in številkami, ki ponazarjajo, iz katere demografske skupine in od katerega posameznika citat izhaja:

- VU 1 – 6 (predstavniki visokošolskih učiteljev s področja zdravstvene nege, ki pri svojem delu uporabljajo simulacije kot metodo učenja);
- PP 1 – 4 (predstavniki, ki sodelujejo pri oblikovanju politike visokošolskega izobraževanja);
- KMZN 1 – 5 (predstavniki kliničnih mentorjev zdravstvene nege oz. strokovnjaki iz prakse).

4.1 Uporabnost simulacij v zdravstveni negi

Simulacije kot metoda učenja so se izkazale za zaželen pristop za pridobivanje novega znanja. Intervjuvanci so jih identificirali za najprimernejši način za povezavo teoretičnega znanja s praktičnim.

»*Odlična metoda za implementacijo teorije v prakso. Veliko se o tem govori. Slovenija se v tem počasi prebuja, tujina ima že leta dodelane programe, kjer so simulacije vpete v izobraževalni program.*« (KMZN4)

»*Zelo so me navdušile, ker gre za poseben pedagoški pristop, ki ga lahko uporabljaš v kakršnihkoli razmerah, bodisi na cesti ali pa v visokotehnoloških okoljih. Predvsem je ta pristop tisti, v katerem vidim prednost.*« (VU5)

»*Simulacije poznam in jih zelo podpiram, ker se mi zdi bistveno, da določene stvari najprej poizkusimo na neživi stvari, preden se preselimo na realne paciente. To je dolžnost vsakega, da mora pred invazivnimi posegi najprej opraviti določeno število ur v simulacijskem centru. Vsekakor se mi zdi zelo dobrodošlo. Tudi študenti bi se morali tega zavedati, da se najprej 100-odstotno naučiš na simulatorju in nato preideš na pacienta.*« (KMZN5)

»*Mislim, da je velika večina zaposlenih v zdravstvu tako naravnana, da so simulacije v sožitju s podajanjem teoretičnega znanja tista metoda, s katero si bodo ljudje bistveno bolj zapomnili pridobljeno znanje. Teorija pa vsekakor mora biti prisotna. Študenti si lažje predstavljajo, kako teče določen postopek in ga tudi sami izvajajo. Mislim, da so simulacije tisti aspekt, ki bi ga morali bistveno bolj vpeljati v prakso, pa nam ne gre najbolje.*« (PP2)

4.2 Pridobivanje mikrodokazil z uporabo simulacij

Iz intervjujev in fokusnih skupin smo razbrali, da so udeleženci v raziskavi naklonjeni pridobivanju mikrodokazil s pomočjo simulacijske metode učenja.

»*Jaz ta dva koncepta vidim kot zelo združljiva, zakaj pa ne. To je seveda izvedljivo le s pravilnim načrtovanjem. Treba je razvijati celovite vsebine in sistematične delavnice. Ne vidim, zakaj se ne bi teh znanj pridobivalo s pomočjo simulacij. Vidim kvečjemu veliko plusov.*« (VU6)

»*[Simulacije] so zelo pomemben način za učenje praktičnih veščin, manj dolgočasna metoda. Ljudje jo veliko hitreje sprejmejo kot neko klasično obliko učenja in poučevanja. Je tak način zelo dober zato, da se vzdržuje kondicija. Tudi za nekoga, ki mogoče ni več 100-odstoten v praksi.*« (PP1)

»*Jaz sem zelo nagnjena k pridobivanju mikrodokazil preko simulacijske metode, ker ni vse samo v teoriji. Seveda je [teorija] zelo pomembna, toda če nimaš različnih spretnosti, ki jih pridobiš s simulacijami, je to kot učenje vožnje z avtom. Lahko poznaš vse predpise in pravila, avta pa ne spraviš s parkirišča. Zagotovo to podpiram in mislim, da bi se kakovost obravnave ne glede na področje dvignila.*« (KMZN2)

Poleg izrazite podpore pa so bili izraženi tudi pomisleki glede dejstva, da bi se mikrodokazila pridobivala izključno s pomočjo simulacijske metode učenja. Sodelujoči so bili mnenja, da se simulacije lahko uporabljajo kot metoda preverjanja znanja in da je ob simulacijah še vedno prisotna potreba po kliničnem praktičnem usposabljanju in podajanju teoretičnega znanja preko predavanj.

»*Simulacijski scenariji so lahko tudi tehnika preverjanja znanja. Veliko naših izobraževanj je zastavljenih tako, da se tega niti ne izvaja. Pri simulacijski metodi pa preverjaš tako teoretično znanje kot tudi praktične veščine in na koncu oceniš celoto. To je odlično, sploh če želimo podeliti ECTS točke, kjer potrebujemo tudi neko metodo preverjanja znanja.*« (VU3)

»*Pridobivanje mikrodokazil, ki se nanašajo na praktične veščine v zdravstveni negi, se nikakor ne more dogajati izključno v*

simuliranem okolju. Del bi moral biti izveden tudi v kliničnem okolju.« (PP3)
»*Mikrodokazil samo preko simulacijske metode jaz osebno ne bi uvajala. Za samo pridobitev dokazila je potrebno izobraževanje intervencij v kliničnem okolju. Brez dela na realnih pacientih se mi izdajanje certifikatov o znanju ne zdi legitimno*.« (KMZN5)
»*Jaz vedno vidim situacijo tako, da vedno potrebuješ neko teoretično ozadje, potem pa sledi praksa. Teoretično naj bi bile samo osnovne stvari povedane, s prakso pa utrjuješ in povezuješ znanje*.« (KMZN1)
»*Želim si, da bi bil nek manjši, krajši del namenjen teoriji. Ne v smislu, da izvajalec pride in predava, ampak da se udeleženci na usposabljanje doma pripravijo, na lokaciji pa se snov samo ponovi*.« (VU2)

5 RAZPRAVA

Rezultati naše raziskave so nam omogočili vpogled v vpeljevanje mikrodokazil na področju zdravstvene nege s pomočjo simulacijske metode izobraževanja. S pomočjo intervjujev in fokusnih skupin smo podrobneje raziskali možnosti vpeljave sistema mikrodokazil s pomočjo simulacij kot metode izobraževanja.
Vsi intervjuvanci so izrazili podporo združevanju pridobivanja mikrodokazil s simulacijsko metodo učenja. Pomanjkanje sorodnih raziskav, ki so se ukvarjale s to tematiko, je izrazito. Če primerjamo sestavne dele kvalitetnega simulacijskega usposabljanja, ki jih določajo Standardi najboljših praks za simulacijo v zdravstveni negi [16], in sestavne dele mikrodokazil, ki jih izpostavljata Bideau in Kearns [17], lahko vidimo, da sta si načrta podobna in posledično ne moremo podati smiselnih argumentov za večje težave pri soobstajanju. Oba načrta potrebujeta jasno določene cilje in rezultate, ki jih bodo udeleženci dosegali, za oba je potrebna predpriprava na vsebine, ki so jasno določene, v obeh primerih gre za specifično področje pridobivanja kompetenc, oba načrta spodbujata visoko stopnjo lastne angažiranosti udeležencev, oba načrta podpirata uporabo evalvacije, oba načrta sta jasno strukturirana in ju lahko hitro prilagajamo potrebam učečih se in delovnega okolja. Ugotovili smo, da bi se simulacije lahko uporabljale tudi kot metoda preverjanja znanja. Prav tako je še vedno prisotna potreba po kliničnem praktičnem usposabljanju in podajanju teoretičnega znanja na druge že ustaljene načine, kot so predavanja. Druge raziskave podpirajo simulacije kot metodo za dokazovanje znanja in kompetenc pri profesionalnem razvoju, če jih je mogoče uskladiti s kompetencami in cilji izobraževalnih programov. To predstavlja pomembne priložnosti za ocenjevanje spretnosti, ki ne vključujejo zgolj praktičnih veščin [18]. Peisachovich in sod. [8] navajajo, da ima uporaba simulacij kot metode za evalvacijo in dopolnjevanje vsebin mikrodokazil nekaj prednosti. Navajajo, da mikrodokazila lahko podpirajo merjenje in nadgrajevanje kompetenc preko simulacijskih aktivnosti, preko česar spodbujajo tudi optimalne učne izide. Prav tako navajajo, da združevanje mikrodokazil s simulacijami omogoča inovativen način pridobivanja kompetenc za razvoj, izvajanje in oceno učinkovitih poučevalnih strategij, oblikovanje učnih načrtov in dokazovanje znanja v obliki spletnega portfolia. Različne simulacijske metode bi lahko v okviru pridobivanja mikrodokazil dopolnjevale tradicionalne metode poučevanja, saj slednje pri učečem izboljšujejo tako tehnične kot netehnične spretnosti in utrjujejo znanje kot tudi spodbujajo kritično razmišljanje [19]. Zato je pri novih generacijah ključnega pomena, da se opredeli kombinacija metod, ki presega okvir običajnih učnih pristopov in se vključi tudi uporabo bolj inovativnih in prožnih metod učenja kot so simulacije [19, 20].
Rezultati, ki smo jih pridobili lahko služijo kot vodilo pri vzpostavljanju sistema pridobivanja mikrodokazil v zdravstveni negi.
Izvedena raziskava ima nekaj omejitev. V vzorec intervjuvancev bi bilo smotrno vključiti tudi predstavnike akreditacijskih organov in predstavnike državnih sistemov, ki so zadolženi za uvajanje mikrodokazil v slovenski prostor. Prav tako je omejitev relativna novost področja mikrodokazil in slabo poznavanje omenjene tematike med zaposlenimi v kliničnih okoljih. Ker je prenova vseživljenjskega učenja v visokošolskih sistemih še v zelo zgodnji fazi, je bilo iskanje kandidatov s primernim znanjem na tem področju zahtevno.
V nadaljnjih raziskavah na obravnavanem področju bi se bilo zanimivo usmeriti v študije primerov vpeljevanja mikrodokazil. Smiselno bi bilo izvajati kvantitativne raziskave med zdravstvenim osebjem glede želenih področij izobraževanja in pridobivanja mikrodokazil. Menimo, da je treba nadaljevati kvalitativno raziskovanje tega področja, pri čemer bi informacije zbirali preko vseh deležnikov ekosistema mikrodokazil, ki ga skušamo vzpostaviti. Digitalne značke v samostojni obliki lahko tudi predstavljajo primerno tematiko za raziskovanje na področju zdravstvene nege. Prav tako smo mnenja, da bi bila boljša komunikacija med deležniki ključnega pomena za kakovosten zagon nadgradnje vseživljenjskega učenja. Glede na to, da je vizija Evropske unije [21] vpeljevanje mikrodokazil na vseh delovnih področjih, menimo, da je prisotno občutno pomanjkanje raziskav, ki bi se osredotočale na izzive in prednosti specifičnih področij.

6 ZAKLJUČEK

Nadgradnja sistema vseživljenjskega izobraževanja v Sloveniji je izredno pomembna. Zaposleni v zdravstveni negi se pogosto znajdejo v situacijah, kjer je karierni razvoj otežen in pravi napredek z dodatnimi kompetencami skoraj nemogoč. Mikrodokazila predstavljajo novost na področju nadgrajevanja in posodabljanja znanja ter priznavanja spretnosti, ki bi zaposlenim na vseh ravneh zdravstva koristila. Simulacije pri tem predstavljajo metodo učenja, s katero je mogoče izvajati celo vrsto izobraževanj v kontroliranem okolju, pri čemer pacienti niso ogroženi. Raziskali smo vpeljevanje mikrodokazil na področje zdravstvene nege s pomočjo simulacij, kjer smo ugotovili, da je nadgradnja vseživljenjskega učenja z mikrodokazili zaželena ter prinaša mnogo prednosti, kot so boljša dostopnost izobraževanj, izboljšanje samih kompetenc strokovnjakov v zdravstveni negi, nadgradnja vseživljenjskega učenja, osredotočenost na učečega in standardizacija izobraževalnih vsebin. Dognali smo tudi, da se intervjuvancem zdi izvajanje mikrodokazil s pomočjo simulacij smiselno in pogosto tudi nujno v kontekstu pridobivanja novih kliničnih veščin ter spretnosti. Ekosistem mikrodokazil v slovenskem prostoru je še vedno v začetnih fazah razvoja. Menimo, da bi s kvalitetno implementacijo tega novega pristopa k vseživljenjskemu učenju pripomogli k nadgradnji izobraževalnega sistema. Mnogo strokovnih področij se bo

spoprijemalo z velikimi težavami, če ne bodo temelji ekosistema in zakonodaje postavljeni enotno in jasno. Menimo, da je v našem prostoru mogoče z bolj kakovostnim in konstantnim prenosom informacij med deležniki ustvariti sistem, ki bo deloval v dobro uporabnikov. Prav tako bi bilo smiselno postaviti enega od deležnikov v vodilno vlogo, ker bi tako proces imel motivatorja in iniciatorja, ki bi spodbujal ter koordiniral vse druge vključene. Glede na velikost prostora Slovenije to vsaj v teoriji ne bi smelo predstavljati prevelikih težav.

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Uporaba navidezne in obogatene resničnosti v zdravstveni negi

Using virtual and augmented reality in nursing

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POVZETEK

S hitrim razvojem informacijske tehnologije se v zadnjem času močno povečuje uporaba oblik razširjene resničnosti, kar se odraža tudi v zdravstveni negi. V prispevku najprej predstavljamo povzetek stanja raziskav razvoja in uporabe navidezne resničnosti in obogatene resničnosti na tem strokovnem področju, nato navajamo nekaj na tržišču dostopnih aplikacij, primernih za uporabo v izobraževanju, usposabljanju ali klinični praksi. Podrobneje sta predstavljeni dve aplikaciji, SimX in AccuVein. Uporaba tovrstnih aplikacij prinaša številne prednosti, ima pa tudi nekaj slabosti. V prihodnje je pričakovati še več raziskav o njihovi primernosti in učinkovitosti ter razvoj novih in/ali izboljšanih aplikacij za vse več področij zdravstvene nege.

ABSTRACT

The rapid development of information technology has recently led to a significant increase in the use of types of extended reality, which is also reflected in nursing. In this paper, we first present a summary of the state of research on the development and use of virtual reality and augmented reality in this professional field, and then list some commercially available applications suitable for use in education, training or clinical practice. Two applications, SimX and AccuVein, are presented in more detail. The use of such applications brings many advantages, but also some disadvantages. More research on their suitability and effectiveness and the development of new or improved applications for more and more aspects of nursing are expected in the future.

KLJUČNE BESEDE

zdravstvena nega, navidezna resničnost, obogatena resničnost, simulacija

KEYWORD

nursing, virtual reality, augmented reality, simulation

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1 UVOD

Zmanjševanje razkoraka med teorijo in prakso med izobraževalnim procesom je nujno. Uporaba tehnologij, kot je navidezna resničnost, podpira teorijo situacijskega učenja, ki pravi, da lahko simulacija zagotavlja alternativna okolja za učenje na kraju samem prek različnih virtualnih kontekstov, ki uporabnikom dajejo občutek prisotnosti ali "biti tam" in s tem možnost učenja v verodostojnem in edinstvenem kontekstu. [1] Tudi za usposabljanje zaposlenih v zdravstveni negi (ZN) ima uporaba novih tehnologij potencial, prinaša pa tudi izzive.

1.1 Navidezna in obogatena resničnost

Razširjena resničnost (eXtended Reality, XR) je pogosto uporabljen krovni izraz za več podvrst resničnosti, vključno z navidezno resničnostjo (Virtual Reality, VR), obogateno resničnostjo (Augmented Reality, AR) in mešano resničnostjo (Mixed Reality, MR). VR je tehnologija, ki zagotavlja skoraj resnično in/ali verodostojno izkušnjo na sintetičen oz. virtualen način [2]. Omejili se bomo na tip potopitvene VR, pri kateri dobimo občutek, da se nahajamo v računalniško ustvarjenem svetu. To lahko dosežemo s tehnologijo naglavnega zaslona (Head-Mounted Display, HMD) ali z uporabo sistema projektorjev. Pogosto VR uporabniku omogoča interakcijo z ustvarjenim 3D okoljem [3]. Za razliko od VR je AR tehnologija, katere cilj je digitalna povezava in razširitev fizičnega okolja ali uporabnikovega sveta v realnem času z dodajanjem plasti digitalnih informacij. [4]. Prikaz poteka na različne načine, npr. z uporabo kamere in markerjev v realnem svetu, na lokaciji, zaznani npr. z GPS, s projekcijo na objekte ali s prekrivanjem objektov. Rezultat si ogledujemo bodisi s pametnimi očali ali na prenosni napravi.

1.2 Ravni uporabe XR

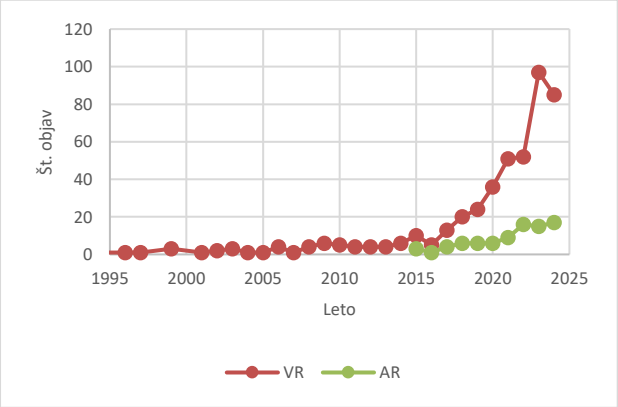
Aplikacije XR nastopajo na številnih strokovnih področjih, med katerimi ima zdravstvo zelo vidno mesto, saj se uporabljajo tako med potekom študija/šolanja, za usposabljanje zaposlenih ali v klinični praksi. Nekatere rabe so namenjene neposredno pacientom (npr. za zdravljenje različnih fobij, depresije ipd.), a jih tu ne bomo posebej obravnavali. V ZN so prisotne v izobraževanju bodočih medicinskih sester, za dodatno usposabljanje obstoječega kadra in v klinični praksi. Izobraževalni vidik sicer v raziskavah prevladuje. Med glavnimi cilji uvedbe novih pristopov poučevanja je zmanjševanje stroškov in tveganja s posnemanjem avtentičnih kliničnih scenarijev brez neposrednega stika s pacienti. [5]. S simulacijo

imajo študenti različne praktične priložnosti za ponovitev kliničnih scenarijev ter takojšnje rezultate in samorefleksije. [6]
V medicini in ZN se pojem simulacije sicer pogosto uporablja za preigravanje scenarijev, ki ni nujno računalniško podprto. Prav tako gre pri izrazu virtualne simulacije v literaturi večkrat le za prikaz virtualnega sveta na računalniškem zaslonu. V prispevku se bomo omejili na uporabe, ki vključujejo 3D potopitveno izkušnjo, torej vizualno izključujejo resnični svet okoli nas - simulacije VR. Izobraževalne simulacije z uporabo VR lahko razdelimo v štiri skupine glede na cilje [7]: učenje postopkovnih veščin za izboljšanje tehničnega znanja in spretnosti; usposabljanje za ukrepanje v sili, ki se osredotoča na zaupanje; učenje mehkih veščin, ki uči empatije; in končno, vadba psihomotoričnih sposobnosti.

2 RAZISKAVE XR

2.1 Rast števila raziskav

Raziskave XR z omembo ZN so v zadnjem času v vzponu, kar vidimo iz rezultatov poizvedbe v bibliografski zbirki podatkov Scopus, ki nam za iskalni profil (virtual-reality OR augmented-reality OR mixed-reality) AND nursing-education vrne 493 objav, pri čemer število objav v zadnjih letih močno narašča (Slika 1). Večina objav (445) vsebuje temo VR, manj (83) pa AR. Obe temi vsebuje 42 objav. Pri VR gre v določeni meri tudi za objave brez potopitvene izkušnje.



Slika 1: Rast števila objav v zbirki Scopus na temo VR in AR v izobraževanju ZN

2.2 Učinkovitost uporabe XR

Poleg temeljnih raziskav je bilo izdelanih več preglednih študij o uporabi VR v ZN. Nekatere temeljne raziskave se dotikajo področja uspešnosti pristopov (vpliv na znanje in spretnosti), druge npr. na uporabniško izkušnjo (primernost aplikacij, zadovoljstvo) ali psihološki vidik (npr. samozavest, motivacija, samoučinkovitost).
V več primerih raziskav uporabe AR v izobraževanju se je ta pokazala kot uspešna, npr. pri učenju mehanskega predihavanja (vpliv na znanje in motivacijo) [8] in namestitve intravenskega katetra (vpliv na samozavest) [9].
Pri uporabi VR pa vsi rezultati niso bili vzpodbudni. Virtualna intravenozna kateterizacija med študenti in zaposlenimi sicer ni bila učinkovitejša od klasičnega pristopa učenja, je pa izkazovala višjo samozavest udeležencev. [10] Pregled več študij o uporabi VR v ZN je ugotovil izboljšave v znanju, ne pa tudi v spretnostih, zadovoljstvu ali samozavesti. [6] Pri uporabi 360° VR videa za mehansko ventilacijo pa je prišlo celo do nižjega zadovoljstva, brez razlik v znanju ali spretnostih v primerjavi s pristopom v živo. [11] Ena od preglednih študij je ugotovila same pozitivne učinke (na znanje, spretnosti, samozavest in zadovoljstvo) pri uporabi XR v izobraževanju ZN. [12]
Kljub porastu simulacij VR v ZN je še vedno premalo študij o potopitvenih scenarijih VR, temelječih na HMD. Za večjo učinkovitost VR bi morali snovalci aplikacij razmisliti o vključitvi haptičnih naprav za vadbo psihomotoričnih veščin ter vključiti socialno interakcijo za poučevanje mehkih veščin. [7]

2.3 Prednosti in slabosti uporabe XR

Pregledne študije vključevanja VR v izobraževanje za poklice v zdravstveni dejavnosti med prednostmi navajajo dostopnost, ponovljivost in stroškovno učinkovitost pristopa, med slabostmi pa visok začetni strošek, tehnične omejitve, in možnost nelagodja za uporabnika [13]. Za tovrstno nelagodje se pogosto uporablja izraz kibernetska bolezen. Pod tehnične omejitve bi lahko šteli tehnološke težave in pomanjkanje realizma v virtualnih svetovih, s katerimi so se srečevali tako študentje ZN kot zaposleni. [1]. Pri aplikaciji z 360° VR videom so uporabniki v nasprotju z prejšnjo ugotovitvijo med drugim pohvalili tudi stopnjo realizma. Stopnja sprejemanja VR je lahko odvisna tudi od značilnosti posameznega uporabnika ter od njegovega dojemanja in odnosa do VR. Realnost, s katero se srečujemo v praksi, se lahko razlikuje od naših pričakovanj. [14] Ena od skrbi ob uporabi virtualnih okolij brez dejanskih pacientov je tudi nevarnost, da lahko pride do pomanjkanja sočutnosti. [15]

3 APLIKACIJE VR IN AR

V tabeli 1 je prikazan pregled obstoječih aplikacij VR in AR s poudarkom na uporabi v ZN. Za vsako aplikacijo je navedeno njeno ime ter opis področja uporabe. V nadaljevanju sta malo podrobneje predstavljeni komercialno najbolj poznani aplikaciji SimX (VR) in Accuvein (AR).

Tabela 1: Aplikacije VR in AR v ZN

Tip: navidezna resničnost (VR)	
IME APLIKACIJE	ZNAČILNOSTI SPLETNA STRAN
SimX	simulacije ZN za študente/zaposlene, virtualni pacienti, sodelovanje https://www.simxvr.com/virtual-reality-simulation-for-nurses/
UbiSim	simulacije ZN za študente/zaposlene, ZN, odločanje in sodelovanje https://www.ubisimvr.com/
Courseta Nursing	simulacije ZN, interakcija z AI pacienti, igra vlog, podpora odločanju https://coursetanursing.com/
3D Organon	3D anatomija, vizualizacija medicinskih slik, simulacija ultrazvoka https://www.3dorganon.com/3d-organon-solutions/
Embodied Labs	usposabljanje na področju ZN s potopitveno izkušnjo v težave staranja https://www.embodiedlabs.com/

Tip: obogatena resničnost (AR)	
IME APLIKACIJE	ZNAČILNOSTI SPLETNA STRAN
AccuVein	projekcija površinskih ven na telo pacienta https://www.accuvein.com/
Complete Anatomy	prikaz modelov organov in okostja v izobraževanju https://3d4medical.com/support/complete-anatomy/ar
EchoPixel True 3D, HTG*	interaktivni hologram srca pacienta na osnovi slikanja MRI in CT https://echopixeltech.com/true3d izvedba z ultrazvokom v realnem času https://echopixeltech.com/htg
Insight Heart	interaktivni hologram srca v izobraževanju https://animares.com/portfolio/insight-heart
HoloPatient	simulacije kliničnih scenarijev s hologramskimi videoposnetki pacientov https://www.gigxr.com/holopatient/
ARtery 3D	projekcija pacientovih arterij na telo, osnovana na slikanja MRI https://artery3d.com/

*Holographic Therapy Guidance

3.1 APLIKACIJA SIMX (VR)

Aplikacija SimX za področje ZN [16] ponuja dinamično platformo za realistične simulacije scenarijev klinične prakse v VR-okolju. Služi kot varen in nadzorovan poligon za usposabljanje, kjer lahko zaposleni ali študenti izpopolnjujejo svoje klinične spretnosti, vadijo ocenjevanje stanja pacientov in izvajajo postopke brez kakršnihkoli tveganj v resničnem svetu. Ponuja možnost timskega dela in sodelovanja med zdravstvenimi ekipami prek funkcionalnosti za več igralcev, kar spodbuja komunikacijo in usklajevanje. Omogočeno je prilagajanje scenarijev glede na posameznikove potrebe in izkušnje, kar omogoča personalizirano učenje in vodi v izboljšanje spretnosti. Poleg tega aplikacija omogoča tudi interaktivno komunikacijo s pacienti, kjer lahko zdravstveni delavci razvijajo svoje sposobnosti poslušanja, postavljanja vprašanj in razlage postopkov na razumljiv način. Po vsaki simulaciji uporabniki prejmejo povratne informacije in meritve uspešnosti, kar omogoča nenehno izboljševanje in sledenje napredka. Dostop do aplikacije SimX je mogoč z različnih lokacij, zato je vsestransko uporabna za sodelovanje in učenje tudi takrat, ko je fizični dostop omejen. Orodje ponuja več kot 300 vnaprej pripravljenih simulacijskih scenarijev, ki pokrivajo širok spekter kliničnih področij, npr. nujna medicinska pomoč, pediatrija, geriatrija, psihiatrija in kirurgija. Eden od primerov je simulacija politravme v urgentnem centru (Slika 2). Aplikacija predstavlja most med učenjem v učilnici in osebnimi kliničnimi izkušnjami.

Slika 2: Simulacija politravme v aplikaciji SimX

3.2 APLIKACIJA ACCUVEIN (AR)

Aplikacija AccuVein [17] uporabnikom omogoča projekcijo slike vaskulature na površino kože (Slika 3). Slika se kaže na zaslonu prenosne naprave v realnem času, s pomočjo kombinacije laserskega optičnega bralnika, sistema za obdelavo in digitalne laserske projekcije. Zdravstveni delavci pri uporabi lahko vidijo žile, zaklopke in bifurkacije, ki s prostim očesom niso vidne, kar vodi k boljšim odločitvam, boljši namestitvi igle in s tem boljši oskrbi pacienta. Na zaslonu prikazana vaskularnost jim pomaga najti veno prave velikosti in položaj za vensko punkcijo ter druge medicinske postopke, ki zahtevajo lokacijo površinskih ven. Aplikacijo uporabljamo tako, da zaslon naprave premaknemo nad pacientovo kožo. To lahko storimo pred palpacijo žil ali po tem, ko nam je palpacija potrdila lokacijo in primernost žile. Na zaslonu se prikaže le površinska vaskularnost. Največja globina, pri kateri so vene prikazane, se razlikuje glede na pacienta. Poleg tega vene nekaterih pacientov ali del njihovih ven morda ne bo dobro prikazan ali sploh ne bo prikazan. Možni vzroki so lahko globina ven, kožne bolezni (npr. ekcem), tetovaže, dlake, brazgotine ali druge izrazite spremembe površine kože ter maščobno tkivo. Za uporabo aplikacije AccuVein ni potrebno posebno usposabljanje. Gre za preprosto rešitev, ki lahko poveča zadovoljstvo pacientov, zmanjša zaplete pri periferni infuziji in izboljša učinkovitost postopka.

Slika 3: Prikaz uporabe aplikacije Accuvein

4 ZAKLJUČEK

Z nadaljnjim razvojem tehnologij lahko tudi v ZN pričakujemo večje število komercialnih dostopnih aplikacij VR in AR, kot se trenutno kaže, predvsem za področje izobraževanja in usposabljanja. Razvoj tovrstnih aplikacij je zahteven in drag, posledično zato tudi nakup aplikacij, skupaj s potrebno strojno opremo, predstavlja za institucije velik finančni zalogaj.

Kljub kontroverznim izsledkom nekaterih raziskovalcev o uporabi teh tehnologij lahko pričakujemo porast njene uporabe za izobraževanje in usposabljanje, saj je dobrodošel pripomoček učečim, predno se znajdejo v realnih situacijah. Zlasti v okoljih, kjer je potrebno hitro ukrepanje, bodo morda podobno kot danes piloti, lahko zaposleni tudi osveževali svoje znanje in spretnosti s podporo VR in AR tehnologij.

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Implementacija digitalnih rešitev v specialističnih ambulantah in bolniških oddelkih Splošne bolnišnice Jesenice ter njihov vpliv na kakovostno zdravstveno obravnavo pacientov

Implementation of digital solutions in specialist clinics and inpatient wards of the Jesenice General Hospital and their impact on the quality of patient care

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Povzetek

Digitalizacija v zdravstvu postaja ključna za izboljšanje kakovosti obravnave pacientov, kar se odraža tudi v Splošni bolnišnici Jesenice. Prispevek analizira uvedbo digitalnih rešitev v specialističnih ambulantah in bolnišničnih oddelkih ter njihov vpliv na diagnostično-terapevtske postopke. Pravilna uporaba digitalnih orodij omogoča bolj varno, transparentno in učinkovito obravnavo pacientov, zmanjšuje možnost napak, zmanjšuje administrativne obremenitve izvajalcev in izboljšuje zadovoljstvo pacientov.

Članek predstavlja štiri ključne implementacije digitalnih rešitev: uvedbo e-kartona v diabetološki ambulanti, vzpostavitev povezljivosti informacijskih sistemov v enoti za srčno-žilno diagnostiko, informiranje pacientov z video vsebinami v otorinolaringološki ambulanti ter elektronsko beleženje preventive ter kurative padcev pacientov. Uvedba e-kartona omogoča kontinuirano in poenoteno obravnavo pacientov, zmanjšuje podvajanje preiskav ter znižuje stroške zdravljenja. Povezljivost informacijskih sistemov v enoti za srčno-žilno diagnostiko izboljšuje sledljivost podatkov, zmanjšuje možnost napak in omogoča hitrejše odzive pri obravnavi pacientov. Uporaba informativnih video vsebin v otorinolaringološki ambulanti pacientom olajša razumevanje diagnostičnih posegov, povečuje njihovo sodelovanje in pripravljenost na zdravljenje. Elektronsko beleženje padcev pacientov omogoča zaposlenim hitrejšo zabeležko o oceni stopnje tveganja za padec ter dosledno beleženje vseh podatkov, ki jih zahteva kurativa padca pacienta.

Kljub uspešnemu uvajanju digitalnih rešitev se bolnišnica sooča z izzivi, kot so odpor zaposlenih do sprememb, potreba po dodatnem izobraževanju in usposabljanju ter vprašanja glede varstva in varovanja pacientovih podatkov. Potrebna je tudi dodatna zakonodaja, ki bi še bolj zaščitila občutljive podatke pacientov in zagotovila varno uporabo informacijskih tehnologij.

Prispevek poudarja, da je ključ do uspešne digitalne transformacije v podpori vodstva, aktivnem vključevanju vseh deležnikov in nenehni motivaciji zaposlenih. V prihodnosti se načrtuje razširitev uporabe e-kartonov na vse specialistične ambulante, nadgradnja zdravstveno-vzgojnih video vsebin z uporabo QR kod ter integracija aplikacij, ki bodo omogočale prenos podatkov iz domačega okolja v bolnišnične informacijske sisteme.

Zaključujemo, da digitalizacija in transformacija zdravstvenih storitev ponujata priložnost za bolj kakovostno, varno in k pacientu usmerjeno zdravstveno obravnavo, hkrati pa izboljšujeta delovne procese izvajalcev. Za uspešno prihodnost zdravstva bo potrebno medsebojno sodelovanje vseh ravni organizacije pri iskanju rešitev za prihodnje izzive.

Ključne besede

zdravstvena nega, elektronski zdravstveni zapisi, digitalna transformacija, elektronska dokumentacija, kakovost, varnost, izboljšani delovni procesi

Abstract

Digitalization in healthcare is essential for improving the quality of patient care, as demonstrated by the General Hospital Jesenice. This article explores the implementation of digital solutions in specialist outpatient clinics and hospital departments and their impact on diagnostic and therapeutic procedures. The use of digital tools enables safer, more transparent, and efficient patient care, reducing errors and administrative burdens while increasing patient satisfaction. The article highlights four key digital

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implementations: the introduction of electronic health records (EHR) in the diabetic clinic, the integration of information systems in the cardiovascular diagnostics unit, patient education through video content in the otorhinolaryngology clinic, and electronic documentation of patient falls. The EHR enables continuous and standardized care, reducing redundant tests and lowering treatment costs. The integration of information systems enhances data traceability and speeds up responses in patient care, while video content improves patients' understanding of diagnostic procedures and their engagement in treatment. Electronic documentation of falls allows quicker risk assessment and consistent recording of all required data. Despite the success in digitalization, the hospital faces challenges such as employee resistance to change, the need for additional training, and concerns about data protection. Additional legislation is needed to safeguard sensitive patient data and ensure the secure use of information technology. The article emphasizes that successful digital transformation relies on leadership support, active stakeholder involvement, and continuous staff motivation. Future plans include expanding the use of EHRs across all clinics, upgrading video content with QR codes, and integrating applications that allow data transfer from home environments to hospital systems. Digitalization and the transformation of healthcare services offer opportunities for higher-quality, safer, and more patient-centered care, while also improving workflows for healthcare providers.

Keywords

nursing, electronic health records, digital transformation, electronic documentation, quality, safety, improved work processes

1 Uvod

Pravilna uporaba ogromnega obsega podatkov o pacientih zahteva natančno zbiranje in analizo podatkov, vključno z zdravstvenimi zapisi, genomiko in informacijami, pridobljenimi iz različnih aplikacij. Kljub temu, da je nabor pacientovih podatkov velik analiza v digitalnem sistemu omogoča prilagojeno individualno oskrbo in napovedne modele za velike skupine prebivalstva. V informacijskih sistemih, ki se uporabljajo v zdravstvu pogosto uporabljen e-karton. E-karton ali elektronska kartoteka je pacientova zdravstvena kartoteka, ki funkcionalno zagotavlja pacientovo anamnezo, demografske podatke in podatke o pregledih za uporabo strokovnjakov, ki pogosto temeljijo na telemedicinskih pristopih [1].

Raziskovalca [2] sta analizirala uporabo informacijske tehnologije in ugotovila pozitivno korelacijo med intervencijami in zadovoljstvom pacientov, nekatere raziskave pa navajajo da se je zaradi uporabe informacijskih tehnologij in boljše produktivnosti izvajalcev zdravstvene oskrbe zniža ležalna doba pacientov za 34 %. Izhajamo iz dejstva, da je eden izmed vzrokov, ki predstavlja nujno potrebo po strategijah za preprečevanje, diagnozo in optimizacijo zdravstvene obravnave tudi veliko število smrti zaradi kroničnih nenalezljivih bolezni (leta 2015 so predstavljale 70 % vseh primerov na svetu) [3]. Hkrati pa na bolniških oddelkih nastaja visoka stopnja tveganja za pojav varnostnih odklonov, ki velikokrat nastanejo kot posledica procesa zdravljenja in ne kot posledica bolezni.

Približno 84 % vseh varnostnih odklonov, ki se zgodijo v bolnišnicah je povezanih s padci, le ti so najpogosteje zabeleženi neželeni dogodek v bolnišničnem okolju [4]. Vseh padcev ni mogoče preprečiti, a tudi neizogibni niso. Po podatkih in izkušnjah različnih zdravstvenih okolij je 20–30 % padcev mogoče preprečiti z ustreznimi ukrepi usmerjenimi v zmanjšanje prepoznanih tveganj [5]. V raziskavi [6] je bilo ugotovljeno, da ima kritična presoja izvajalcev zdravstvene nege podobne izide kot rutinska uporaba standardiziranih lestvic za oceno tveganja za padce, saj obstoječe lestvice niso dovolj specifične in ne pokrivajo vseh dejavnikov tveganja.

2 Vpeljava digitalnih rešitev v specialističnih ambulantah Splošne bolnišnice Jesenice

Uvajanje e-kartona v diabetološki ambulanti Splošne bolnišnice Jesenice (v nadaljevanju SBJ) je bilo uvedeno z namenom izboljšanja zdravstvene obravnave pacientov. E-karton omogoča zdravstvenim delavcem vpogled v celotno zdravstveno zgodovino pacienta na primarni in sekundarni ravni, kar zagotavlja neprekinjeno obravnavo. S tem sistemom se zbirajo in enotno beležijo podatki o pacientovih boleznih ter morebitnih zapletih, kar omogoča takojšen dostop do vseh relevantnih informacij in olajšuje analizo podatkov. Uvedba e-kartona preprečuje podvajanje laboratorijskih preiskav in nepotrebne napotitve, kar zmanjšuje stroške zdravljenja sladkorne bolezni. Zdravstveno osebje lahko tako bolje sledi obravnavi pacienta in izvajanju zdravstveno-vzgojnih aktivnosti. V enoti za srčno-žilno diagnostiko smo zagotovili povezljivost informacijskih sistemov za učinkovitejši prenos podatkov med različnimi bolnišničnimi informacijskimi sistemi. Nova pooblastila za dostop do podatkov zagotavljajo varnost in kakovost zdravstvene obravnave ter zmanjšujejo možnost napak, kot je npr. zamenjava identitete pacienta v specialistični ambulantni obravnavi. Cilj je zagotoviti sledljivost podatkov in kakovostno obravnavo pacienta skozi vse faze bolnišnične obravnave. Učinkovita organizacija diagnostično-terapevtskih aktivnosti v enoti za srčno-žilno diagnostiko temelji na zmanjševanju administrativnih obremenitev izvajalcev, kar omogoča večjo osredotočenost na zdravljenje, zdravstveno-vzgojne nasvete in razvoj stroke. Povezljivost podatkov omogoča enkraten vnos, ki se avtomatično posodobi v bolnišničnem informacijskem sistemu, če je vsebina podatka povezana z drugimi podatki. V otorinolaringološki ambulanti smo izdelali informativne video vsebine ki se predvajajo na zaslonih pred ambulantami, kjer pacientom predstavljajo potek obravnave in diagnostičnih preiskav. Namen teh vsebin je boljša informiranost pacientov pred preiskavami, kar pripomore k njihovemu boljšemu sodelovanju med postopki. To omogoča hitrejšo izvedbo preiskav in bolj natančne izvide. Če bo ta način informiranja učinkovit, bodo video vsebine razširili na druge specialistične ambulante in področja.

3 Vpeljava digitalnih rešitev na bolniških oddelkih Splošni bolnišnici Jesenice

Na bolniških oddelkih v SBJ je bilo vpeljano elektronsko beleženje padcev pacientov. Izbran je bil program, ki omogoča zaposlenim sistematično beleženje in obravnavo padcev, saj omogoča tako preventivne kot kurativne ukrepe, kar prispeva k izboljšanju varnosti pacientov in k bolj učinkovitemu ukrepanju v primeru padcev. Izhajali smo iz pregleda literature, da približno 2 % pacientov pade najmanj enkrat med svojim bivanjem v bolnišnici. Vsak četrti padec se konča s poškodbo, od katerih je 10 % v obliki težjih poškodb [6]. Poleg fizičnih (počasnejše okrevanje, višja stopnja obolevnosti in smrtnosti) in psihičnih posledic za pacienta (slabša kvaliteta življenja, strah pred ponovnim padcem, nezadovoljstvo z zdravstveno oskrbo) je nezanemarljiv tudi dodaten zdravstveni izdatek, ki ga predstavlja obravnava pacienta po padcu (daljše trajanje hospitalizacije, višji stroški zdravljenja, večje obremenitev zdravstvenega osebja) [4].

Cilj implementacije je bil izboljšati nadzor nad dejavniki tveganja in optimizirati odziv zdravstvenega sistema ob dogodkih padcev. Sistem beleženja omogoča:

- evidentiranje dejavnikov tveganja pri pacientih, kot so omejena mobilnost, uporaba zdravil in starost;
- identifikacijo pacientov z visokim tveganjem ter uvedbo ustreznih preventivnih ukrepov, kot so prilagoditev okolja, fizična pomoč ali prilagoditev terapije;
- beleženje dogodkov padcev, kurativnih ukrepov in spremljanje pacientovega stanja po padcu;
- povezavo s centralnim sistemom zdravstvene dokumentacije, kar omogoča učinkovito izmenjavo podatkov med oddelki in zdravstvenimi ustanovami.

V procesu implementacije smo upoštevali ključne elemente za uspešno delovanje sistema, kot so usposabljanje osebja, prilagoditev obstoječih protokolov in uvedba rednih posodobitev za spremljanje podatkov. Velik del časa smo posvetili pripravi modula za preventivno oceno in kurativno beleženje padcev. V sodelovanju z aplikativno inženirko smo opredelili ključne kazalnike tveganja za padec, v sistem vključili preventivne ukrepe ter določili redno spremljanje in ocenjevanje pacientov glede na njihovo tveganje za padec. Podoben pristop smo uporabili tudi pri oblikovanju kazalnikov za kurativno beleženje padcev. V program smo vključili opomnike za spremljanje zdravstvenega stanja po padcu in za nadaljnje ukrepe, kot so oskrba morebitnih poškodb, zdravniška poročila in podobno.

V SBJ je že dolgo v uporabi protokol za preprečevanje padcev, kjer se vsi pacienti ob sprejemu ocenijo po Morsejevi lestvici padcev. Ta ocenjevalni pripomoček preverja šest kategorij dejavnikov tveganja in tako pomaga prepoznati paciente z večjim tveganjem za padec. Pri ocenjevanju sodelujeta diplomirana medicinska sestra in tehnik zdravstvene nege, ki skupaj s pacientom in njegovimi svojci, če so prisotni, opravita oceno. Na podlagi seštevka točk (od 0 do 125) se določi stopnja ogroženosti za padec: nizka (0-24 točk), zmerna (25-50 točk) in visoka (51 točk in več) [7].

4 Razprava

Implementacija programa je v zdravstveni sistem prinesla številne pozitivne spremembe, ki so znatno izboljšale kakovost oskrbe pacientov in zmanjšale tveganja, povezana s padci. Raziskovanje možnih načinov za zagotavljanje in organizacijo prihodnjih zdravstvenih storitev zahteva kreativno in inovativno razmišljanje. Izhodišče za digitalizacijo in transformacijo bi moralo biti kolektivno razumevanje izzivov, s katerimi se sooča organizacija, kar kaže na potrebo srednjih menedžerjev oz. operativnega menedžmenta, da olajšajo komunikacijo in znanje na različnih ravneh v organizacijski hierarhiji s ciljem premostitve vrzeli v znanju in pretoku informacij. Znanje o vprašanjih, povezanih z delom, načinih zagotavljanja storitev ter zaznanih težavah in izzivih med zaposlenimi je treba sporočiti navzgor do najvišjega vodstva, da jim zagotovijo bolj niansirane repertoarje kategorij za smiselnost in alternative ukrepanja, potrebnih za odločanje. Po drugi strani pa strategije, ukazi in smernice, zlasti razloge, ki so za njimi, je treba posredovati prvim zaposlenim na način, ki jim pomaga razumeti. Posedovanje kolektivnega razumevanja in čustvene izkušnje v zvezi s posebnimi situacijami bo dobra podlaga za učenje in koristen pristop k soustvarjanju digitalizacije in transformacije prihodnjih zdravstvenih storitev [8].

Ena izmed večjih prednosti programa je hitrost in učinkovitost odziva na že zabeležene padce. Pred uvedbo sistema je bil odziv na padce pogosto počasnejši, zaradi česar so se lahko posledice poškodb poslabšale. Z uvedbo digitalnega sistema beleženja se lahko zdravstveno osebje takoj odzove in začne z ustreznimi kurativnimi ukrepi, kar vodi k hitrejšemu okrevanju pacientov in zmanjšanju resnosti poškodb. Ta izboljšava se odraža tudi v primerjavi z obdobjem pred uvedbo programa, kjer se je jasno pokazalo, da je bil čas, potreben za obravnavo padcev, bistveno daljši. Ta vidik izboljšuje kakovost zdravstvene obravnave in zadovoljstvo pacientov, saj se počutijo varnejše in bolje oskrbljene.

Druga pomembna prednost programa je izboljšana sposobnost prepoznavanja pacientov, ki so bolj izpostavljeni tveganju za padec. Z natančnim beleženjem dejavnikov tveganja, kot so omejena mobilnost, uporaba zdravil, ki vplivajo na ravnotežje in kognitivne funkcije, ter starost, je mogoče prepoznati paciente z večjim tveganjem in pravočasno uvesti ustrezne preventivne ukrepe. Ti ukrepi vključujejo prilagoditev bolnišničnega okolja, kot je namestitev dodatnih ročajev, premestitev nevarnih predmetov, zagotavljanje ustrezne osvetlitve in sodelovanje fizioterapevtov ter kliničnih farmacevtov pri načrtovanju in spremljanju terapije. Tako je mogoče ne le zmanjšati število padcev, ampak tudi izboljšati kakovost življenja pacientov.

Program omogoča natančno in strukturirano beleženje vseh podatkov, povezanih s padci, kar predstavlja pomembno izboljšavo glede na prejšnji sistem papirnatih obrazcev. Digitalizacija procesov omogoča centraliziran dostop do podatkov, kar zdravstvenemu osebju omogoča natančne analize vzorcev padcev in učinkovitost preventivnih ukrepov. Možnost

izgube ali napačne obdelave obrazcev se je z digitalizacijo praktično izničila, kar izboljšuje zanesljivost podatkov in omogoča boljše sledenje preventivnim in kurativnim ukrepom. Z možnostjo analize podatkov v realnem času je mogoče hitreje prepoznati trende in vzorce, kar omogoča nenehno prilagajanje strategij za preprečevanje padcev.
Uvedba programa je v bolnišnični sistem prinesla številne pozitivne spremembe, ki so pomembno prispevale k izboljšanju varnosti in kakovosti zdravstvene obravnave. Hitrejši odziv na padce, boljše prepoznavanje tveganj in natančnejše beleženje podatkov so ključni dejavniki, ki izboljšujejo oskrbo pacientov in zmanjšujejo tveganje za resne poškodbe. S sistematičnim spremljanjem in analizo podatkov je mogoče nenehno izboljševati protokole in prilagajati ukrepe, kar predstavlja pomemben napredek v zdravstveni oskrbi.

Za nadaljnjo optimizacijo je ključnega pomena redno izobraževanje zaposlenih za učinkovitejšo uporabo sistema. Nadgradnja sistema bi bila smiselna z vidika boljše integracije z drugimi informacijskimi sistemi in poenostavitvijo komunikacije med zdravstvenimi ustanovami. V primeru ponovnih hospitalizacij ter oskrbe v domačem okolju bi bila dobrodošla širitev digitalnih orodij na področje telemedicine, kar bi omogočilo spremljanje tveganj za padce tudi izven bolnišničnega okolja.

Pri uvajanju e-kartona v nekaterih specialističnih ambulantah se je zmanjšala papirna oblika dokumentacije. S tem smo zagotovili, da je komunikacija med izvajalci v ambulanti dejavnosti potekala preko informacijskega sistema, kar zagotavlja večjo kakovost, varnost in posledično hitrejšo obravnavo, predvsem pa transparentnost obravnave. Pri ambulantnih obravnavah se je izkazalo, da so tudi pacienti bolj zadovoljni. Podobno so ugotovili tudi v raziskavah [2, 9] in sicer je bila ugotovljena pozitivna korelacija med operativnimi inovacijami in zadovoljstvom pacientov, kar je vplivalo na zmanjšanje stroškov in izboljšanje poteka dela. Trenutno je uvedba e kartona, integracija povezljivosti sistemov v bolnišnični informacijski sistem in predvajanje video vsebin potekala samo v nekaterih specialističnih dejavnostih. V prihodnosti bi želeli imeti povezljiv informacijski sistem, ki bi nam pospešil obravnavo pacientov v specialističnih diagnostičnih ambulantah. Uporabo e-kartona nameravamo uspešno razširiti na vse nivoje specialističnih ambulant, s ciljem posredovanja različnih podatkovnih zbirk zbranih tekom obravnave pacientov na različne ravni zdravstvenega varstva.
Zdravstveno vzgojni nasveti v elektronski obliki nam pomagajo, da so pacienti, ki prihajajo v specialistično ambulanto pred obravnavo ustrezno informirani in razumejo potek obravnave saj nam to omogoča učinkovito zdravljenje. V nadaljevanju želimo video vsebine nadgradi s QR kodo, ki jo bodo pacienti lahko odčitali na zaslonu. Preko dostopa bodo v domačem okolju lahko dostopali do zdravstveno vzgojnih vsebin v digitalni obliki s katerim bomo omogočili opolnomočenje pacienta in njihovih svojcev za obvladovanje kroničnih bolezni, zmanjševanje zapletov in pogostosti hospitalizacije. Ob tem pa bi bila smiselna uporaba nekaterih aplikacij, ki jih pacienti uporabljajo v domačem okolju in bi omogočale prenos podatkov direktno v bolnišnični informacijski sistem ambulantne dejavnosti, s tem bi zagotovili bolj nadzorovano vodenje nekaterih kroničnih nenalezljivih bolezni in večji nadzor pacientov v domačem okolju.

5 Zaključek

Digitalne rešitve v zdravstvu praviloma prinašajo bolj kakovostno, varno in k pacientu osredotočeno obravnavo, hkrati pa izvajalcem olajšajo delovni proces in preprečijo podvajanje dokumentacije, ki nastaja ob papirni dokumentaciji.

Izvajalce je potrebno tudi primerno izobraziti in jim omogočiti podporo pri uporabi digitalnih rešitev. Ker živimo v digitalni dobi imajo različne gospodarske dejavnosti že v celoti digitaliziran proces, zato bi bilo potrebno razmišljati tudi o digitalizaciji celotnega procesa v zdravstvu.

Digitalizacija in transformacija zdravstva bosta vplivali na izvajalce v zdravstvu in na srednji in najvišji menedžment, zato zahtevata vključevanje in izvajanje vseh deležnikov. Vodje na različnih ravneh in vključeni zaposleni bodo pridobivali in soproizvajali znanje o negotovostih, zaželenih prihodnostih in njihovih protislovjih. Predstavljali bodo izzive in spodbude drug drugemu in drugim relevantnim deležnikom, zato je potrebno medsebojno in timsko sodelovanje ter izobraževanje izvajalcev.

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