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The effects of the use of modern technologies on learning achievement in different upper-secondary education programmes: The PISA 2022 study

Abstract: The rapid development of digital technology has had significant effects on the design of the educational environment and the integration of digital resources into the teaching and learning process. It has not only changed the way students interact with educational content but also the way teachers teach. Using data from the PISA 2022 study and a representative sample of 5,591 students aged 15, the aim was to examine the extent to which students from different upper-secondary education programmes in Slovenia report the availability and use of digital resources for learning and leisure both in and out of school, the use of digital resources by teachers in the classroom and which aspects of the use of digital resources are significant predictors of achievement in mathematics and reading. The results show that, as reported by 15-year-olds, about a quarter of teachers from all upper secondary education programmes are unwilling to use digital resources in the classroom. Students who attend general gymnasiums report better access to and more frequent use of digital resources, both inside and outside of school. In terms of the positive predictors of the use of digital resources for academic achievement, more effective and intentional use of digital resources for learning outside school appears to be more important for general gymnasium programmes. However, the use of digital resources in the classroom by students and teachers appears to be more important for vocational education programmes. The predictor with the most negative impact on mathematics and reading achievement in all educational programmes is the frequent use of digital resources in leisure time for non-educational purposes. In Slovenia, it is important to promote the effective and meaningful use of digital resources for educational purposes by academically disadvantaged students, as well as ongoing awareness-raising programmes on the pitfalls and negative effects of the excessive use of digital resources in leisure time on learning achievement in all upper secondary education programmes.

Keywords: PISA, digital resources, mathematics achievement, reading achievement, upper secondary education programmes

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Scientific article

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Introduction

Today, the role of information and communication technologies (hereafter referred to as 'digital resources'[1]) is becoming increasingly important in teaching and learning. The rapid development of digital resources has had a significant effect on the design of educational environments. The integration of digital resources into the teaching and learning process has not only changed the way students interact with educational content, but also the way teachers teach. United Nations Educational, Scientific and Cultural Organization (2023) has identified digital resources as a social necessity to ensure that education is a basic human right, especially in a world experiencing more frequent crises and conflicts. In the Slovenian educational system, there has also recently been an increasing emphasis on strengthening digital resources in the teaching and learning process and the related digital skills of teachers. As part of the European Union's response to the COVID-19 pandemic in 2022, the Ministry of Education of the Republic of Slovenia adopted the Digital Education Action Plan 2021–2027, which identifies the most important action steps and areas for the development of digital education in Slovenia (Ministry of Education, 2023). Consequently, the large-scale Digital Teacher Project has been launched in Slovenian preschools, schools and universities with the aim of training a minimum of 20,000 education professionals and managerial employees in digital, sustainable development and financial literacy skills (Digitrajni učitelj, 2023).

In line with the changes digital resource use brings to the teaching and learning process, the effects of digital resources have become an important research subject in recent years, both internationally and nationally. Research into different aspects of the use of digital resources and related teachers' and students' skills has for some time been a major focus of international large-scale assessment studies coordinated by the International Association for the Evaluation of Edu-

1 This paper is based on the PISA study, which uses the term 'digital resources' instead of 'information and communications technology'. PISA defines 'digital resources' as different types of digital resources, such as desktop computers, laptop computers, smartphones and tablet computers, as well as educational computer software and other digital learning tools.

cational Achievement (IEA)[2] and the Organisation for Economic Cooperation and Development (OECD)[3]. The results of these studies, in which Slovenia[4] is a participant, encompass representative samples and different populations of primary and secondary students and teachers. These results provide insights into different aspects of the use of digital resources, such as access to digital resources in and out of school, students' attitudes towards digital resources, the use of digital resources in learning, teachers' willingness to use digital resources in the classroom and their digital skills (Fraillon and Rožman, 2023; Hooper et al., 2017; Mullis et al., 2019; OECD, 2023a; Schulz et al., 2022).

According to the OECD (2023), in the participating countries, the PISA results' past cycles showed that students' use of digital resources can have a positive effect on reading, mathematics and science PISA scores – however, only if the digital resources are used in an effective and moderate way. This further implies that there is always a risk of negative effects of digital resource use on learning achievement if such resources are used to excess or for purposes unrelated to learning or classroom lessons. The results from secondary analyses of the PISA 2018 study (Šterman Ivančič et al., 2020) also showed that Slovenian 15-year-olds who achieved a higher mean PISA score in reading literacy did more reading online and used digital resources to find useful and educational information.

Studies conducted in other countries that also focused on the relationship between the use of digital resources in various contexts (at school, at home, for school-related activities and for leisure activities) and learning achievement show that access to computers and the Internet improves learning performance when used for instruction (Bulman et al., 2016; Fiorini, 2010) and that moderate use of digital resources improves achievement. However, excessive use can have negative effects (Fuchs et al., 2004; Kim, 2023). Similarly, the authors (e.g. Livingstone et al., 2007; Malamud et al., 2011; Spiezia, 2010) whose studies examined the effects of the use of digital resources for in-school and out-of-school activities on academic achievement found that digital resources had positive effects when used for learning but also negative effects when used excessively for leisure (e.g. for playing video games and using social networking sites). Furthermore, studies conducted in Slovenia (Šterman Ivančič et al., 2020) and elsewhere (Kim, 2023) showed significant differences in the use of digital resources in different contexts among different groups of students. For instance, boys and higher socio-economic status (SES) students reported more proficient use of digital resources both in and out of school.

The results are mixed regarding the effects that teachers' classroom use of digital resources has on students' learning achievement and on the effectiveness of classroom teaching, itself. Banerjee et al. (2007) note that the benefits of digital

2 International Computer and Information Literacy Study – ICILS, Trends in International Mathematics and Science Study – TIMSS, Progress in International Reading Literacy Study – PIRLS and International Civic and Citizenship Education Study – ICCS.

3 Programme for International Student Assessment – PISA.

4 In Slovenia, all the listed international large-scale assessment studies are conducted by the Educational Research Institute.

resource use depend on how digital resources are used in an educational setting and that teachers face various challenges when planning to integrate them into their teaching. Various studies (e.g. OECD, 2023a; Redecker, 2017; Trucano, 2005) illustrate that without proper planning, the use of digital resources can lead to students' lack of focus and lower learning performance. To plan classroom lessons that include digital resources, teachers must be able to identify, evaluate and select the resources that best fit their learning objectives, context and pedagogical approach, and to adapt or create new digital resources. Moreover, they must be trained in digital resource management so they can share digital resources with their students. In the countries that participated in the 2013 OECD TALIS international survey, teachers in lower secondary education reported spending an average of seven hours per week planning classroom lessons that included digital resources (OECD, 2014).

Study's Aim and Research Questions

Despite a growing body of research on the links between students' and teachers' in-school and out-of-school use of digital resources and learning achievement, research has revealed mixed results regarding the use of digital resources in the teaching and learning processes and the way they contribute to learning achievement. Despite the importance of this topic and the availability of representative data from international large-scale assessment studies in this field in Slovenia, the data are scantily studied, especially in the context of the OECD's PISA study, which provides insights into this field in upper secondary education programmes. While future generations of students and teachers are likely to have the opportunity to use the most advanced digital resources, it is not a given that everyone will have access to these resources or that they will use them in a responsible and useful way. Research demonstrates significant distinctions between groups of students in both the access to and use of digital resources in teaching and learning. In Slovenia the upper secondary education programme has already been confirmed as a significant predictor of both learning achievement and related factors in secondary analyses of PISA data (e.g. Šterman Ivančič et al., 2022; Šterman Ivančič et al., 2023b; 2023c). Correspondingly, it is important for the study presented herein to examine the disparities in the use of digital resources in and out of school separately by individual upper secondary education programmes. Considering the ongoing widespread digital skill training of Slovenian teachers and the increased tendency to introduce digital resources into the teaching and learning process, it is important for this study to answer the following nationally relevant research questions:

1. To what extent do 15-year-old Slovenian students from different upper secondary education programmes report the availability and use of digital resources for learning and leisure activities, both inside and outside of school?

2. To what extent do 15-year-old Slovenian students from different upper secondary education programmes report teachers' classroom use of digital resources?
3. Which aspects of the use of digital resources inside and outside of school significantly predict PISA mathematics and reading achievement in different upper secondary education programmes in Slovenia?

Methods

To answer the research questions above, secondary analyses of the OECD PISA 2022 data were conducted. The research method used (sample, instruments and data analysis) is explained in the paragraphs below.

Sample

In Slovenia, the PISA study covers students aged 15 years and three months to 16 years and two months, regardless of the education programme they attend. The PISA sampling design is multistage and stratified, and the sample includes all upper secondary education programmes in Slovenia. The final sample in our analysis includes a representative sample consisting of 5,591 15-year-old students, of which 1,486 (27%) students attended a general gymnasium programme, 2,766 (49%) students attended technical education programmes and 1,339 (24%) students attended vocational education programmes of medium duration. Students attending vocational education programmes of a short duration were excluded from the analyses because not all data on the use of digital resources had been collected for them as part of the PISA study.

Instruments

Following the PISA cognitive tests in mathematics, reading and science literacy, the students completed the PISA Student Questionnaire, which is used to identify various accompanying achievement-related factors. Scale-based student reports were used for the analysis, describing the frequency of digital resource use at school, the availability of digital resources at school, the use of digital resources in the classroom, the use of digital resources for school-related activities at school, the use of digital resources for school-related activities outside classroom hours and the use of digital resources for leisure activities[5].

To determine *the frequency of digital resource use at school*, the students answered the question, 'This school year, how often did you use the following

5 Due to how extensive the scales were, only a few item examples are listed for each scale. The complete scales are available in the internationally published questionnaire accessible via the following link: https://www.oecd.org/en/data/datasets/pisa-2022-database.html#questionnaires

digital resources at school?' They rated their frequency of use on a five-point scale ('1 – Never or almost never' to '5 – Several times a day') and rated their use of the following digital resources: 'Desktop or laptop', 'Smartphone (i.e. mobile phone with Internet access)', 'Internet access (except on smartphones)', 'Educational software, games or apps, other learning tools (e.g. Duolingo or Memrise online support)' etc.

To determine *the accessibility of digital resources at school*, the students answered the question, 'To what extent do you agree or disagree with the following statements?' They rated the items on a four-point scale ('1 – Strongly disagree' to '4 – Strongly agree'). Examples of the items are as follows: 'There are enough digital resources for every student at my school', 'There are enough digital devices with access to the Internet at my school', 'The school's Internet speed is sufficient', 'Teachers at my school have the necessary skills to use digital devices during instruction' etc.

To determine *the use of digital resources in the classroom*, the students answered the question, 'How often do you use digital resources in the following classroom lessons?' They rated the use of digital resources in the following subjects on a five-point scale ('1 – Never or almost never' to '5 – In every or almost every lesson'): 'Slovene', 'Mathematics', 'Science (Biology, Chemistry, Physics)' and 'Computer Science, Information Technology, Informatics or similar lessons'.

To determine *the use of digital resources for school-related activities at school*, the students answered the question, 'This school year, how often did you use digital resources to conduct the following activities?' They rated the items on a five-point scale ('1 – Never or almost never' to '5 – Every day or almost every day'). Examples of items are as follows: 'Create a multi-media presentation with pictures, sound or video', 'Write or edit text for a school assignment (e.g. using Microsoft® Word)', 'Find information online about real-world problems or phenomena (e.g. climate change, oil spills), measuring the height of a building)', 'Analyse data that you have collected yourself (e.g. using Microsoft® Excel™)' etc.

To determine *the use of digital resources for school-related activities outside classroom hours*, the students answered the question, 'This school year, how often did you use digital resources for the following activities?'. They rated the items on a five-point scale ('1 – Never or almost never' to '5 – Every day or almost every day'). Examples of items are as follows: 'Browse the Internet for schoolwork (e.g. for preparing an essay or presentation)', 'Browse the Internet to follow up lessons (e.g. for finding explanations)', 'Communicate with my teacher', 'Search for information on school-related activities or assignments' etc.

To determine *the use of digital resources for leisure activities*, the students answered the question, 'During a typical weekday, how much time do you spend doing the following leisure activities?'. They rated the items on a six-point scale ('1 – No time at all' to '6 – More than seven hours a day'). Examples of items are as follows: 'Play video-games (using my smartphone, a gaming console, an online platform or apps)', 'Browse social networks (e.g. Instagram®, Facebook®)', 'Browse the Internet (excluding social networks) for fun (e.g. reading news, listening to podcasts and music or watching videos)', 'Communicate and share digital

content on social networks or any communication platform (e.g. Facebook®, Instagram®, Twitter®, emails, chat)' etc.

In the PISA 2022 sample of Slovenian students, all the scales used demonstrated adequate internal consistency, with the coefficient alpha values ranging between $\alpha = 0.72$ and $\alpha = 0.92$ (OECD, 2024).

Data Analysis

To answer the first and second research questions, the values of internationally comparable indices[6] and the average PISA reading and mathematics scores from the PISA 2022 national database for Slovenia were used. They calculated the average values of digital resource use indices in different upper secondary education programmes and the percentages of students' responses to the items about the accessibility and availability of digital resources at school.

To answer the third research question, a linear regression procedure was used to identify the effects of digital resource use in explaining PISA 2022 mathematics and reading achievement. Pearson's correlation coefficient was calculated using a value of 0.80 as the criterion. It attempted to detect multicollinearity between the independent (frequency of digital resource use at school, accessibility of digital resources at school, use of digital resources in the classroom, use of digital resources for school-related activities at school, use of digital resources for school-related activities outside of classroom hours and use of digital resources for leisure activities) and dependent variables (average PISA 2022 mathematics and reading scores). Due to the sample size, the normality of the distribution of the residuals of each predictor's association with the criterion variable was assumed.

Due to the study's two-stage sampling, the data were analysed using IBM SPSS 27.0 statistical software and the IEA IDB Analyzer Version 5.0.23 tool, which allows the appropriate use of student weights (W_FSTUWT) and sampling weights to properly estimate the standard error of the parameters in the population using the bootstrap resampling method.

Results

The results of the comparison of digital resource use in Slovenia's upper secondary education programmes with the OECD average are displayed in Table 1. Compared to their peers from OECD countries, the 15-year-old Slovenians attending all three aforementioned upper secondary education programmes (general gymnasium, technical education programmes and vocational education programmes of medium duration) reported an average or somewhat above-average frequency of digital resource use and availability of digital resources at school. They also reported the below-average use of digital resources in the classroom for

6 The index is a standardised value with a mean of 0 and a standard deviation of 1.

school-related activities at school and for school-related activities outside school. Compared to the OECD average, the most significant deviations in Slovenia are the values of the index for the use of digital resources in the classroom in all three upper secondary education programmes. All are well below average. Similarly, the value of the index for the use of digital resources for school-related activities outside school also deviates, especially in technical education programmes and vocational education programmes of medium duration.

A comparison of the results between individual education programmes in Slovenia reveals that, compared to the students attending technical education programmes and vocational education programmes of medium duration, the students attending general gymnasium programmes, on average, reported greater availability of digital resources at school and more frequent use of digital resources for school-related activities outside school. However, they also reported less frequent use of digital resources for school-related activities at school and significantly less frequent use of digital resources for leisure activities.

	Gym_g		TEP		VEP	
	M	*SE*	*M*	*SE*	*M*	*SE*
Frequency of DR use at school	0.12	0.02	0.04	0.02	0.05	0.03
Availability of DR at school	0.19	0.02	0.09	0.02	-0.03	0.03
Use of DR in the classroom	-0.28	0.02	-0.34	0.02	-0.30	0.03
Use of DR for school-related activities at school	-0.19	0.02	-0.07	0.02	-0.09	0.04
Use of DR for school-related activities outside classroom hours	-0.07	0.02	-0.21	0.02	-0.37	0.03
Use of DR for leisure activities	-0.27	0.02	0.08	0.02	0.10	0.04

Table 1: Use of digital resources by Slovenian students in different education programmes compared to the OECD mean.

Note: M – the arithmetic mean of an internationally comparable index, SE – standard error, DR – digital resources, Gym_g – general gymnasium programme, TEP – technical education programme and VEP – vocational education programme of medium duration. The values of the internationally comparable index are standardised with a mean of 0 (OECD mean) and a standard deviation of 1; for availability of digital resources at school, use of digital resources for school-related activities at school and outside classroom hours and use of digital resources for leisure activities, the Gimg index value is significantly higher than the SSI and SPI index values at the level $p \leq .05$.

Table 2 details the percentage of the students' responses to the items about the teachers' use of digital resources on a scale measuring the accessibility of digital resources for learning and teaching at school.

A total of 74% of students attending vocational education programmes of medium duration, 78% of students in technical education programmes and 79% of students in general gymnasiums reported that the teachers at their school are willing to use digital resources in the classroom. Regarding the teachers' competence at using digital resources in the classroom, there were no differences in

the percentages of agreement with the item among students from varying upper secondary school programmes. That is, approximately 70% of students from all three upper secondary school programmes agreed that their teachers have the necessary skills to use digital resources in the classroom.

	Gym_g		TEP		VEP	
	%	*SE*	*%*	*SE*	*%*	*SE*
Teachers at my school have the necessary skills to use digital devices during instruction.	70.28	1.55	71.20	1.30	70.15	1.84
Teachers at my school are willing to use digital resources for teaching.	79.48	1.52	78.30	1.22	73.68	1.86

Table 2: Teachers' use of digital resources for teaching

Note: % – percentage of students who agree or strongly agree with the item; SE – standard error; Gym_g – general gymnasium programme; TEP – technical education programme; and VEP – vocational education programme of medium duration; all the differences between the groups did not prove to be statistically significant at the level of $p \leq .05$.

The analysis of the correlation coefficients between the examined variables (Table 3) reveals that, in most cases, the correlation is weak to moderately strong. The strongest significant correlation can be observed between the use of digital resources for school-related activities at school and the use of digital resources for school-related activities outside school and for leisure activities. Of all the variables examined, the strongest significant positive correlation between the mean PISA mathematics and reading score exists with the accessibility of digital resources at school. The strongest significant negative correlation exists with the use of digital resources for leisure activities.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	***M***	***SD***
1	-								0.07	0.89
2	0.01*	-							0.09	0.92
3	0.00	0.05**	-						-0.33	0.84
4	-0.01*	0.17**	0.25**	-					-0.13	0.90
5	0.02*	0.24**	0.17**	0.45**	-				-0.19	0.80
6	-0.07**	0.03**	0.26**	0.36**	0.25**	-			-0.05	0.97
7	0.01*	0.10**	-0.01*	-0.04**	0.04**	-0.19**	-		485.00	89.00
8	0.01*	0.15**	-0.05**	-0.09**	0.08**	-0.21**	0.76**	-	469.00	97.00

Table 3: Values of the coefficient of correlation between the variables examined

Note: 1 – Frequency of digital resource use at school; 2 – Availability of digital resources at school; 3 – Use of digital resources in the classroom; 4 – Use of digital resources for school-related activities at school; 5 – Use of digital resources for school-related activities outside classroom hours; 6 – Use of digital resources for leisure activities; 7 – PISA mathematics score; and 8 – PISA reading score.

As a measure of the correlation between variables, the values of the Pearson correlation coefficient were calculated; M – arithmetic mean; SD – standard deviation; $^{**}p < 0.01$; $^{*}p < 0.05$.

Furthermore, an analysis of the predictors of PISA 2022 mathematics and reading achievement within upper secondary education programmes in Slovenia shows that the significant predictors of the use of digital resources differ according to the education programme and achievement in mathematics and reading.

As part of the interpretation of mathematics achievement (Table 4), in the general gymnasium programme, the use of digital resources for school-related activities outside school was confirmed as a significant positive predictor. However, the accessibility of digital resources at school and the use of digital resources for leisure activities have been confirmed as significant negative predictors. The latter has the largest effect size in interpreting mathematics achievement in a general gymnasium programme. A one-unit increase in the index value for the use of digital resources for leisure activities is associated with a 26-point decrease in the PISA 2022 mathematics literacy score. As part of the interpretation of mathematics achievement in technical education programmes, two predictors have been confirmed as significant: the use of digital resources in the classroom as a positive predictor and, again, the use of digital resources for leisure activities as a negative predictor with the largest effect size. In a vocational education programme of medium duration, the two above-mentioned predictors have also been confirmed as significant for interpreting mathematics achievement. However, the effect size of the use of digital resources for leisure activities is not as large as in the general gymnasium and technical education programmes. Rather similar to the general gymnasium programme, the use of digital resources for school-related activities outside school has also been confirmed as a significant predictor of mathematics achievement, however, as a negative predictor rather than a positive one, which was the case for the general gymnasium programme. Overall, the explanatory model explains 6% of the variability in PISA mathematics achievement in the general gymnasium programme, 4% in the technical education programme and 3% in the vocational education programme of medium duration.

The results from the analysis of the significant effects of predictors in interpreting the mean PISA 2022 reading test score (Table 5) display a slightly different picture. In general, the inclusion of predictors of diverse uses of digital resources explains more of the variability in reading achievement than in mathematics achievement, especially in vocational education programmes of medium duration (7%) and technical education programmes (6%). In the general gymnasium programme, the included predictors explain 5% of the variability in the PISA 2022 reading achievement. There were also disparities in the characteristics of the predictors included. In the general gymnasium programme, the use of digital resources in the classroom has been confirmed as a significant positive predictor of reading achievement. Meanwhile, the use of digital resources at school and the use of digital resources for leisure activities have been confirmed as negative predictors. The latter has the largest effect, similar to the effect in mathematics. In technical education programmes and vocational education programmes of medium duration, the same four predictors have been confirmed as significant for interpreting reading achievement. These are the accessibility of digital resources at school and the use of digital resources in the classroom as significant positive predictors as

well as the use of digital resources for school-related activities outside school and the use of digital resources for leisure activities as significant negative predictors. Across all three education programmes, the use of digital resources in the classroom had the largest positive effect on interpreting reading achievement. However, the use of digital resources for leisure activities had the largest negative effect, though only in the general gymnasium and technical education programmes. This factor has also been confirmed as a significant negative predictor of reading achievement in vocational education programmes of medium duration. Nonetheless, the use of digital resources for school-related activities outside school has a somewhat stronger negative effect on interpreting reading achievement.

PISA Mathematics Score					
	B	SE_B	β	t_B	***p***
General gymnasium					
Constant	553.95	2.77		199.72	< 0.001
1	2.30	3.73	0.02	0.62	> 0.05
2	-7.74	3.23	-0.07	-2.40	< 0.05
3	0.99	2.74	0.01	0.36	> 0.05
4	-1.63	3.46	-0.02	-0.47	> 0.05
5	9.91	3.74	0.10	2.65	< 0.05
6	-24.04	3.71	-0.23	-6.48	< 0.001
Technical education programmes					
Constant	472.28	2.07		227.99	< 0.001
1	2.72	2.59	0.03	1.05	> 0.05
2	-2.98	2.76	-0.03	-1.08	> 0.05
3	7.40	2.04	0.09	3.63	< 0.001
4	-0.26	2.57	0.00	-0.10	> 0.05
5	2.57	2.29	-0.03	-1.12	> 0.05
6	-12.32	2.11	-0.17	-5.85	< 0.001
Vocational education programmes of medium duration					
Constant	413.76	2.76		150.16	< 0.001
1	4.07	2.87	0.07	1.42	> 0.05
2	3.13	3.46	0.05	0.91	> 0.05
3	8.01	2.80	0.13	2.86	< 0.01
4	0.78	2.66	0.01	0.29	> 0.05
5	-5.39	2.57	-0.09	-2.10	< 0.05
6	-5.62	2.45	-0.11	-2.30	< 0.05

Table 4: Different aspects of the use of digital resources in learning and teaching as a predictor of PISA mathematics scores within various education programmes

Note: 1 – Frequency of digital resource use at school; 2 – Availability of digital resources at school; 3 – Use of digital resources in the classroom; 4 – Use of digital resources for school-related activities at school; 5 – Use of digital resources for school-related activities outside classroom hours and 6 – Use of digital resources for leisure activities.
B = unstandardised regression coefficient; SE_B= standard error of the coefficient; β = standardised regression coefficient; t_B = t-test; p = p-value; $R^2 = 0.06$ for the general gymnasium programme; $R^2 = 0.04$ for the technical education programme and $R^2 = 0.03$ for the vocational education programme of medium duration.

PISA Reading Score					
	B	***SE_B***	**β**	***t_B***	***p***
General gymnasium					
Constant	537,61	3.13		171,70	< 0.001
1	-7.82	3.55	-0.08	-2.21	< 0.05
2	3.09	3.55	0.03	0.87	> 0.05
3	6.42	2.97	0.07	2.16	< 0.05
4	-2.33	3.28	-0.02	-0.71	> 0.05
5	2.19	4.01	0.02	0.55	> 0.05
6	-18.96	3.51	-0.18	-5.41	< 0.001
Technical education programmes					
Constant	458.31	2.49		183,87	< 0.001
1	-5.92	3.13	-0.07	-1.89	> 0.05
2	7.29	3.06	0.07	2.39	< 0.05
3	10.91	2.63	0.13	4.14	< 0.001
4	-1.12	2.54	-0.01	-0.44	> 0.05
5	-5.10	2.50	-0.06	-2.04	< 0.05
6	-12.72	2.43	-0.16	-5.24	< 0.001
Vocational education programmes of medium duration					
Constant	392,46	3.77		104.23	< 0.001
1	-3.34	3.38	-0.05	-0.99	> 0.05
2	6.43	3.15	0.08	2.04	< 0.05
3	15.47	2.99	0.21	5.17	< 0.001
4	4.27	3.54	0.05	1.20	> 0.05
5	-8.20	2.95	-0.12	-2.78	< 0.01
6	-5.83	2.65	-0.10	-2.20	< 0.05

Table 5: Different aspects of the use of digital resources in learning and teaching as a predictor of PISA reading scores within education programmes

Note: 1 – Frequency of digital resource use at school; 2 – Accessibility of digital resources at school; 3 – Use of digital resources in the classroom; 4 – Use of digital resources for school-related activities at school; 5 – Use of digital resources for school-related activities outside classroom hours and 6 – Use of digital resources for leisure activities.

B = unstandardised regression coefficient; SE_B= standard error of the coefficient; β = standardised regression coefficient; t_B = t-test; p = p-value; R^2 = 0.05 for the general gymnasium programme; R^2 = 0.06 for the technical education programme and R^2 = 0.07 for the vocational education programme of medium duration.

Discussion

The main study results show differences in the availability and use of digital resources between education programmes in Slovenia. Students attending general gymnasium programmes reported the most frequent use of digital resources at school, greater availability of digital resources at school and more frequent use of digital resources for school-related activities outside school. However, they also noted the less frequent use of digital resources for school-related activities at school and significantly less frequent use of digital resources for leisure activities. These are the very students who, on average, have scored highest in both mathematics and reading on the PISA test across all PISA cycles to date (e.g. Šterman Ivančič et al., 2023a). This result corroborates with studies (e.g. Bulman et al., 2016; Fiorini, 2010; Kim, 2023; Livingstone et al., 2007) that found that access to and use of digital resources for learning purposes improves learning achievement and that more proficient use of digital resources inside and outside school is reported by higher SES students[7].

Furthermore, the results find that predictors of distinct uses of digital resources explain more variability in reading achievement than in mathematics achievement. This is particularly true for vocational education programmes of medium duration. In general gymnasium programmes, the factors included explained more variability in mathematics achievement. Once again, these results show that the use of digital resources has different effects on different school subjects and that these effects also differ among different groups of students. These results are consistent with meta-studies (e.g. Cheung et al., 2013; OECD, 2023a; Tamim et al., 2011), whose authors conclude that the use of digital resources in the teaching and learning process has more positive effects on learning how to read than on learning mathematics. Learning mathematics often requires structured and sequential problem solving, so that traditional teaching approaches often prove to be more beneficial, and greater positive effects are observed in students with lower reading achievement.

This examination of the predictors of mathematics and reading achievement has revealed that frequent use of digital resources for leisure activities, such as browsing social networking sites, browsing the Internet for fun or communicating and sharing digital content on social networks, has significant negative effects on mathematics and reading achievement for both high- and low-achieving students. This result is consistent with the findings of other OECD studies and analyses, where such effects have been found in various participating countries (e.g. OECD, 2015; Vigdor et al., 2014). In contrast, the use of digital resources in the classroom

7 According to PISA data, the students attending general gymnasium programmes report, on average, a much higher socio-economic status than the students attending vocational education programmes of medium duration (e.g. Šterman Ivančič et al., 2023a).

appears important for improving mathematics and reading achievement, especially for students with lower PISA scores. Those who, on average, score the highest benefit more from the use of digital resources for learning purposes outside school. The role of using digital resources in the classroom and promoting mathematics and reading achievement cannot be ignored. However, the results also show the importance of developing digital skills in lower achieving students so they can use digital resources more effectively outside school as a tool to help them learn and find useful content for the classroom. Similarly, Fairlie et al. (2013) examined the effects that digital resource training for educational purposes had on students from different backgrounds and with different learning achievements. They found that the training was highly beneficial for lower achieving students, improving both their homework completion rates and overall academic achievement.

Our study revealed no significant distinctions in the use of digital resources for learning and teaching between individual education programmes. Fifteen-year-old Slovenians from all three education programmes reported significantly less frequent use of digital resources in the classroom for Slovene, mathematics, science and computer science subjects than their average OECD peers. Furthermore, 15-year-old Slovenian students reported that approximately 30% of the teachers, regardless of the education programme they teach, lack the necessary skills to use digital resources and approximately a quarter of the teachers in these upper secondary education programmes are unwilling to use digital resources in the classroom. This result is similar to the OECD average. In 2022, approximately 74% of teachers reported using a variety of digital resources in their teaching process (OECD, 2023b).

Conclusion

The study presented in this paper is based on PISA results. Because PISA is a cross-sectional study, conclusions cannot be drawn about the cause-and-effect relationships between the use of digital resources inside and outside school and PISA mathematics and reading scores. Moreover, PISA's data are based on reports from 15-year-olds, while data on teachers' use of digital resources in the teaching process are not available for Slovenia. The results also illustrate that the explanatory power of the examined mathematics and reading achievement models is relatively low.

Despite these methodological reservations, the results obtained from a representative sample of Slovenian students suggest differences in the availability and use of digital resources between upper secondary education programmes in Slovenia, with the students attending the general gymnasium programme being at an advantage. They not only reported better availability of digital resources at school but also used digital resources for learning outside school in a more effective and intentional way, which has a significantly positive impact on their higher learning achievement in mathematics and reading. This, however, is not the case for students attending vocational education programmes of medium duration. For

these students, it is more important that their teachers or they, themselves, use digital resources in the classroom, which has positive effects on their mathematics achievement and even more so on their reading achievement. Notably, regardless of the education programme that students attended, both mathematics and reading achievements are largely negatively affected by the frequent use of digital resources for leisure activities, that is for non-educational purposes.

In conclusion, the use of digital resources in the teaching and learning process has different effects on achievement in different subjects and within different groups of students. Its positive effects cannot be generalised to all areas of learning or all groups of students. It is important to increase the availability of digital resources and improve the digital skills of students attending technical and vocational upper secondary education programmes. This would allow them to make meaningful and effective use of digital resources for educational purposes both inside and outside of school. However, it is important to promote ongoing awareness-raising programmes on the pitfalls and the negative effects of the excessive use of digital resources during leisure time in all upper secondary education programmes in Slovenia.

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UČINKI RABE SODOBNIH TEHNOLOGIJ NA UČNE DOSEŽKE V RAZLIČNIH SREDNJEŠOLSKIH IZOBRAŽEVALNIH PROGRAMIH: RAZISKAVA PISA 2022

Povzetek: Hiter razvoj digitalne tehnologije ima pomembne učinke na oblikovanje izobraževalnega okolja, povezovanje digitalnih virov s procesom poučevanja in učenja pa ni spremenilo le načina interakcije učencev in učenk z izobraževalnimi vsebinami, temveč tudi način poučevanja učiteljev. V študiji smo želeli na podatkih raziskave PISA 2022 in reprezentativnem vzorcu 5591 dijakov in dijakinj, starih 15 let, preučiti, v kolikšni meri dijaki in dijakinje iz različnih srednješolskih izobraževalnih programov v Sloveniji poročajo o razpoložljivosti in uporabi digitalnih virov za učenje inprosti čas v šoli in zunajnje, o uporabi digitalnih virov med profesorji pri pouku in kateri vidiki uporabe digitalnih virov značilno napovedujejo dosežke iz matematike in branja. Rezultati kažejo, da po poročanju 15-letnikov približno četrtina profesorjev v vseh srednješolskih izobraževalnih programih ni pripravljena uporabljati digitalnih virov pri pouku. Dijaki in dijakinje iz splošnih gimnazij poročajo o boljši dostopnosti in pogostejši uporabi digitalnih virov v šoli in zunajnje. Z vidika pozitivnih učinkov uporabe digitalnih virov na učne dosežke se v programih splošne gimnazije kot pomembnejša kaže bolj učinkovita in načrtna uporaba digitalnih virov za učenje zunaj šole, v programih srednjega poklicnega izobraževanja pa uporaba digitalnih virov med dijaki in dijakinjami ter profesorji pri pouku. Na dosežke iz matematike in branja v vseh izobraževalnih programih najbolj negativno učinkuje pogosta raba digitalnih virov v prostem času, ki ni v izobraževalne namene. V Sloveniji se kot pomembno kaže spodbujanje učinkovite in smiselne uporabe digitalnih virovv izobraževalne namene pri učno šibkejših dijakih in dijakinjah ter spodbujanje programov stalnega ozaveščanja o pasteh in negativnih učinkih prekomerne uporabe digitalnih virov v prostem času na učne dosežke v vseh srednješolskih izobraževalnih programih.

Ključne besede: raziskava PISA, digitalni viri, matematični dosežki, bralni dosežki, srednješolski izobraževalni programi

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