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EUROPE NEEDS TO INTEGRATE IMMERSIVE LEARNING QUICKLY AT ALL EDUCATION LEVELS – BUT HOW? WHAT TO LEARN FROM 25 EU PROJECTS IN THIS FIELD

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Abstract/Izvleček Manifold technical developments have allowed immersive technologies - virtual (VR) and augmented (AR) realities and their fusion to mixed or extended reality (MR/XR) - to find their way into many areas of life and work. Given their almost infinite creative possibilities, they are also of great interest for pedagogy. But what are the possibilities and where are the limits, and where does Europe stand in this respect at all? To find answers, we have evaluated 25 EU projects dealing with VR/AR/XR-based learning.

V Evropi je imerzivno učenje potrebno hitro vključiti v vse ravni izobraževanja - vendar kako? Česa se je na tem področju mogoče naučiti iz 25 projektov EU?

Mnogostranski tehnični razvoj je omogočil, da so poglobljene tehnologije – virtualna resničnost (VR – ang. virtual reality) in obogatena resničnost (AR – ang. augmented reality) ter njuno zlitje v mešano ali razširjeno resničnostjo (MR – ang. mixed reality; XR – ang. extended reality) – našle svojo pot v različna področja življenja in dela. Zaradi njihovih skoraj neskončnih ustvarjalnih možnosti so zelo zanimive tudi za pedagogiko. Kakšne pa so možnosti in kje so omejitve, kje v tem pogledu sploh je Evropa? Da bi našli odgovore, smo ocenili 25 projektov EU, ki se ukvarjajo z učenjem na osnovi VR, AR in XR.

Keywords:
digitalisation of pedagogy EU projects on VR/AR/XR – European education policy

Ključne besede:
digitalizacija pedagogike, projekti EU na področju VR/AR/XR, evropska izobraževalna politika

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Introduction

In recent years, technologies that enhance or recreate real world environments are increasingly influencing our lives. With Virtual Reality (VR; 2D/3D computer-generated immersive environments), Augmented Reality (AR; real world environments overlaid with computer-generated input) and the recently introduced combination of both as well as their extension with other features (Mixed Reality/MR or Extended Reality/XR), it is possible to simulate almost any process carried out in the physical world. Originally starting in the games industry, more and more VR/AR/XR apps have since been produced for learning in all of its forms with enormous potential: they allow us to travel through the human body (https://www.medicinevirtual.com), visit the Anne Frank House in Amsterdam (https://www.annefrank.org/en/about-us/what-we-do/publications/anne-frank-house-virtual-reality), fight the fear of speaking in front of 1,000 virtual listeners (https://virtualorator.com), conduct experiments in laboratories (https://www.labster.com), undergo safety training in various professions (https://www.vrsafety.co.uk/) or teach ourselves to cook (https://jobsimulat–orgame.com) -- all without even needing to leave your own living room. The possibilities are almost endless, realism is amazingly high, and it can be applied to all kinds of learning: from early childhood education to higher education (HE), from vocational training (VET) to social pedagogy and the training of people with special needs, and from cultural heritage to the arts.

However, VR/AR/XR technologies, services and offers have not only improved rapidly, but at the same time acquisition costs have also fallen dramatically. In the past, these technologies were mainly used for the development of premium products, owing to their high cost. Today, these technologies have become much more common in many areas of social, professional and economic life, and their cost-effectiveness has increased significantly. Thus, the value of investing in VR/AR/XR has become much more broadly recognised within many private, public and business sectors.

As a result, the revenue generated on the global extended reality VR/AR/XR markets is projected to witness an explosive 48.3% Compound Annual Growth Rate (CAGR) between 2020 and 2030. Thus, the industry value will rise massively from a mere $18.5 billion in 2019 to more than $1,005.9 billion by 2030 (Kumar, 2020).

This will have an enormous impact on many areas of the economy, HE and VET, and this revolution has been reflected at many major fairs and conferences n recent years, e.g. at the Hannover Messe/DE in the field of smart industry, at the BETT Show/UK for education and at the University Industry Interaction Conference/FI for HE business cooperation. Of course, it plays a central role in the regular events of the EuroXR network; its 2020 conference in Valencia/ES is to be held exclusively virtually for the first time, for safety reasons (https://i3b.webs.upv.e–s/webs/eurovr).

Although immersive technologies are generally on the rise, the radical changes and partial restructuring in many areas of life, work and learning caused by COVID-19 will most likely further strengthen this trend. Although comprehensive scientific studies on this topic are still largely lacking, it can be observed everywhere that digital forms of communication, knowledge exchange and knowledge transfer have increased - and for many they have now become the norm. It has been shown that those who were previously familiar with digital and immersive forms of communication and learning found it much easier to adapt to the new situation and to transfer their work and communication processes to a virtual environment relatively quickly. Those who had little or no experience of digitalised forms of working and learning before the outbreak of the pandemic have had to travel long distances and make great efforts to reorient themselves mentally, psychologically, infrastructurally, process-wise and with regard to the necessary development of skills in order to return to a regulated daily routine. From this perspective, COVID-19 is expected to have a major impact on the digitisation of our society and economy and will sustainably initiate urgently needed investment and further developments.

Quo vadis, immersive Europe?

The important issue now is how well European society and especially its economy is prepared for this technological challenge. Unfortunately, compared to its major global business competitors in the USA, China, Japan, South Korea and India, Europe has started slowly in utilising VR/AR/XR business and learning environments and is in danger of lagging further behind. The problem exists less amongst Europe's larger enterprises, with their high investment levels in technical equipment and HDR, but these represent only 0.7% of all European enterprises.

The remaining 99.3% consists of SMEs, the backbone of Europe's economy, who generally experience greater difficulty in investing staff, time and financial resources in order to keep pace with ICT developments (Eurostat, 2019).

A good example is the situation in Germany, one of the largest economies in the world, where two of its main areas - manufacturing and engineering - are heavily affected by smart industry. 99% of German industry is represented by SMEs that are not well prepared for this challenge. Paradoxically, the strong economic position of SMEs currently being experienced in Germany is in fact an enormous barrier to their smart development: Many German SMEs are – at least they were before COVID-19 - too busy to pay appropriate attention to this issue. It is a combination of lack of time and of awareness, which many see as the most serious threat to SMEs. Therefore, the German Federal Ministry of Economic Affairs and Energy initiated the *High-tech Strategy Industry 4.0* (www.bmbf.de/en/the-new-high-tech-strategy-2322.html), which targets the consolidation of resources and promotes transfer, strengthening the dynamism of innovation in industry, to create favourable conditions for innovation, and thus boosting dialogue and participation.

However, the situation is not like this in Germany alone. Right across Europe, SMEs feel that they could be left behind in terms of digitisation and fear for their future prospects (SMeART, 2018). Everywhere politicians are frantically launching investment and digitisation initiatives to prevent this from happening. How successful these measures will be (if at all), remains to be proven - in any case, it would have been desirable had national and regional politicians given greater attention and urgency to this issue earlier.

And what has happened at the European level? In comparison to many individual Member States, the digitalisation of the public and commercial economic sectors has long been postulated and promoted by various strategies and programmes at the European level. In particular, the EU has recognised that the successful digitisation of European society is not only a technical and infrastructural challenge, but that awareness raising as well as digital education and training are at least equally important.

As early as 2011, the Commission launched the *Agenda for Modernisation of Europe's Higher Education* Systems (EC 2011/567 final), which sought to improve "the quality and relevance of higher education by exploiting the potential of ICTs" (p. 7), aiming to make the "knowledge triangle work by linking higher education, research and business for excellence and regional development", by creating close and effective links between education, research and business. Lastly, it sought to "build on the pilot project to strengthen the interaction between universities and business through knowledge alliances" (p. 11).

It was followed by the *Digital Single Market Strategy*, which underlined a new dynamic across the European economy as a whole, fostering jobs, growth, innovation and social progress, since all areas of the economy and society are becoming digital; consequently, it postulated that a "change is needed in the way education and training systems adapt to the digital revolution" and to the empirical findings that showed "teachers' lack of digital competences, and their lack of confidence in using digital technologies meaningfully in teaching. […]. Additionally, a recent public consultation on the "Agenda for the Modernisation of Europe's HE Systems" showed that "over two-thirds of students and recent graduates perceive a mismatch between the supply of graduates and the knowledge and skills that the economy needs. […] Other important challenges identified by stakeholders include the impact of technology and globalisation on higher education […]" (EC 2015/196: final).

From this, initiatives were derived to increase the digital competences of educators as quickly as possible (EC 2017/29000, 41), and as a consequence, the European Framework for the Digital Competence of Educators endorses initiatives that set up learning activities in digital environments for both teachers and learners; these allow teachers to experiment with and develop new formats and pedagogical methods (EU: DigCompEdu, 2017, 52). This includes the continuous evaluation of information technology curricula at all training levels as well as the creation of applied blended learning environments in authentic settings, such as in workplace-based learning.

All these policies and programmes may appear to be comprehensive and numerous, but in reality, they are insufficient and fall far too short for Europe to swiftly catch up with other industrialised nations. The EC is aware of this and has just proposed the creation of the first ever Digital Europe Programme, which will invest €8.2 billion to align the next long-term EU budget 2021-2027 with the increasing digital challenges.

With this programme, European Digital Innovation Hubs (EDIHs) will play a central role in stimulating the broad uptake of artificial intelligence, high performance computing (HPC) and cybersecurity, as well as other digital technologies by industry (in particular SMEs and midcaps) and public sector organisations across Europe. EDIHs will function as one-stop shops to help companies respond dynamically to the challenges and become more competitive (https://ec.europa.eu/digital-single-market/en/europe-investing-digital-digital-europe-programme).

The political leadership of Europe has thus taken very important and highly necessary steps towards a digital future - and hopefully, they are not too late.

Nevertheless, it is fair to admit that the Commission has already long been funding projects concerning immersive developments and learning. One of these is the VRinSight project, whose full title tells us all about its main objective: Boosting Virtual Reality Learning within Higher Business Management Education (www.vrinsight.org). During the project's lifetime (10/2018-09/2020), the project group conducted a European survey of the needs of HEIs and SMEs concerning VR learning and teaching (VRinSight, 2019: Cumulative Report); it also developed and implemented a VR-based training programme for HE business management teachers (VRinSight, 2019: Curriculum), including a specially programmed VR classroom, and collected, analysed and presented 25 best practice apps for immersive learning (VRinSight, 2019: Showcase). Finally, the project group undertook European-wide research into all ongoing EU-funded projects dealing with immersive learning. What experiences did they make, what lessons did they learn and what immersive solutions did they come up with? Even more importantly: what can we all learn from them? The project group concluded that perhaps it was a good idea to ask all of the projects these precise questions.

The meta-data analysis of 25 EU projects

In our search for all ongoing VR/AR/XR projects and initiatives, we sifted through the databases of several EU programmes such as ERASMUS+ (links to all programmes mentioned are under References) and CORDIS as well as the programme websites and project catalogues of the Directorate-General for Communications Networks, Content and Technology (CNCT), Internal Market, Industry, Entrepreneurship and SMEs (GROW), Informatics (DIGIT) or Research and Innovation (RTD).

Overall, around 2,000 approved EU projects during the years 2016 to 2020 were searched, another 80 projects were collected via free internet research, and four projects were recommended by project partners and other experts. From November 2019 to April 2020, 41 of these projects and initiatives were selected through peer evaluation based on a criteria catalogue using the following indicators:

- projects and initiatives must deal with immersive learning (in its widest sense)
- projects and initiatives dealing with immersive learning in HEIs and/or SMEs are preferred
- although the focus is on VR learning, projects with an AR and/or XR focus are also welcome (this open approach is simply better suited to current developments in the field)
- "projects and initiatives must not have been completed by September 2019 (to ensure a certain level of actuality)"
- projects and initiatives must be supported by EU/EC funds (including purely national funds; however, transnational cooperation projects were preferred).

The leaders or public relations officers of the 41 projects were contacted and invited to publish their project work results and experiences by means of articles in the VRinSight Green Paper "Boosting Virtual Reality in Learning" (VRinSight, 2020). Eventually, the following 24 projects were selected as examples of good practice and were published:

N°1: Active Learning in Engineering Education (ALIEN)
Country: Greece
Funding programme: ERASMUS+
Duration: 15/10/2017-14/10/2020
In a nutshell: ALIEN designs, implements, and validates an active learning methodology based on PBL environments addressing real-life issues related to STEM concepts. This methodology aims to build student skills that are demanded by industry and facilitate their easy transition into the workplace. (http://projectalien.eu)

N°2: Country: Connected Teacher Education (CoTeach)
Country: Germany
Funding programme: German Federal Ministry of Education and Research (BMBF): "Funding for teacher training with a focus on digitalization in teacher training"
Duration: 01/03/2020-31/12/2023
In a nutshell: CoTeach develops and evaluates innovative teaching and learning contexts for student teachers and scholars. One work package couples the potential of VR with principles of intercultural learning to create tangible experiences with pedagogically responsible value. (www.uni- wuerzburg.de/pse/forschen/co-teach-connected-teacher-education/)

N°3: An Adult Digital Education Skills Kit to Foster Employability (DESK)
Country: Greece
Funding programme: ERASMUS+
Duration: 01/11/2018-30/04/2021
In a nutshell: The aim of the DESK project is to develop a novel toolbox with which adult trainers can attract, reach out to and assist adult learners to catch up with their digital literacy. (http://desk.e-sl.gr)

N°4: Digital Innovative Media Publishing for All (DIMPA)
Country: France
Funding programme: ERASMUS+
Duration: 01/11/2018-31/10/2020
In a nutshell: The goal is to create accessible learning materials and tools for people to remain employable in an increasingly digital workplace. This first European Massive Open Online Course provides adequate learning concerning six technologies including VR and AR. (www.dimpaproject.eu)

N°5: Teaching and Learning with Technology in Higher Education (EDUTECH)
Country: Spain
Funding programme: ERASMUS+
Duration: 01/09/2019-31/08/2021
In a nutshell: The main aims are to prepare a platform to design teaching activities based on technology with learning analytics as well as to generate a guide and MOOC

to help all lecturers to implement these methodologies and to create content for disadvantaged people that is based upon these methodologies (www.edu–techproject.eu).

N°6: Fast and easy previsualisation for creative industries (first.stage)
Country: Germany
Funding programme: Horizon 2020
Duration: 01/06/2016-30/09/2019
In a nutshell: Virtual reality glasses and newly developed software help directors, actors, stage designers and other participants to plan the scenes of a theatre or film production realistically in advance. (http://first-stage.eu/)

N°7: Training teachers and trainers for the 4.0 paradigm (Fit for 4.0)
Country: Italy
Funding programme: Erasmus+
Duration: 01/09/2019-31/08/2022
In a nutshell: The project aims to improve teachers' skills to fully embed the 4.0 paradigm in their daily work. It will deliver and pilot a self-assessment tool, a train-the-trainer MOOC, plus policy recommendations to stakeholders and decision-makers.

N°8: Advanced VR, iMmersive Serious Games and Augmented REality as Tools to Raise Awareness and Access to European Underwater CULTURal heritagE (iMARECULTURE)
Country: Cyprus
Funding programme: Horizon 2020
Duration: 01/11/2016-31/01/2020
In a nutshell: Raise public awareness of European identity by focusing on maritime cultural heritage. iMareCulture aims to bring inherently unreachable underwater cultural heritage within the digital reach of the wider public by implementing virtual visits, serious games with immersive technologies and underwater augmented reality. (https://imareculture.eu)

N°9: Inclusive Cultural Heritage in Europe through 3D semantic modelling (INCEPTION)
Country: Italy
Funding programme: Horizon 2020
Duration: 01/06/2015-31/05/2019
In a nutshell: Semantic modelling of Cultural Heritage buildings using BIM to be managed through the INCEPTION platform for the advanced deployment and valorisation of enriched 3D models, for better knowledge sharing and the enhancement of European Heritage. (https://www.inceptionspinoff.com/; https://www.inception-project.eu/en)

N°10: Inclusive Intelligent Verification/Validation for Extended Reality Based Systems (Iv4Xr)
Country: Portugal
Funding programme: Horizon 2020
Duration: 01/10/2019-01/10/2022
In a nutshell: Iv4Xr aims to develop an AI agent-based verification approach to test XR systems; a computational approach for the automated appraisal of human factors and user experience; and to deliver a framework and toolkit to support the automated testing of XR systems. (https://iv4xr-project.eu)

N°11: Learning mathematics through VR (MVR)
Country: France
Funding programme: ERASMUS+
Duration: 01/10/2018-30/10/2020
In a nutshell: The objective is to develop new tools by means of inquiry non-formal education, hands on pedagogical methodology and the usage of VR for enhancing current didactics of mathematics and increasing engagement with learning mathematics. (www.math-reality.eu)

N°12: A human-factors based (VR) training solution for decision-making and acting capabilities under stress and in high risk situations for European LEAs (SHOTPROS)
Country: Austria
Funding programme: HORIZON 2020
Duration: 01/05/2019-30/04/2022

In a nutshell: After the validation of a human factors model for DMA-SR, the project defines guidelines for (VR) training for Europe's LEAs and develops a training curriculum as well as a VR training environment; finally, a European network and a policy-maker toolkit for knowledge transfer concerning VR training are set up. (www.shotpros.eu)

N°13: University Business Cooperation for Promoting Virtual, Augmented and Mixed Reality Applications within Small and Medium-sized Manufacturing Companies (VAM Realities)
Country: Germany
Funding programme: ERASMUS+
Duration: 01/01/2020-31/12/2022
In a nutshell: The project aims to support European SMEs to become familiar with immersive technology and to assist with the integration of this technology into business operations through cooperation between SMEs, HEIs and technology providers. (https://vam-realities.eu)

N°14: Virtual Reality Archive Learning (ViRAL)
Country: Austria
Funding programme: ERASMUS+
Duration: 01/09/2018-30/08/2021
In a nutshell: ViRAL is a project that aims to develop non-formal adult education using digital tools, such as virtual reality, augmented reality, and 360º videos, with information from archives, museums or initiatives in post-industrial cities. (www.viraltraining.net)

N°15: Fostering Virtual Reality applications within adult learning to improve low skills and qualifications (VIRAL SKILLS)
Country: Austria
Funding programme: ERASMUS+
Duration: 01/10/2018-30/09/2020
In a nutshell: Virtual reality allows learners to immerse themselves in complex topics, with actively experiencing learning content taking the place of memorising. To exploit the full potential of this new medium, VIRAL SKILLS offers comprehensive supporting materials. (www.viralskills.eu)

N°16: We learn to apply augmented and virtual reality in our technology classes (VleaRning)
Country: Spain
Funding programme: ERASMUS+
Duration: 31/12/2018-30/12/2020
In a nutshell: The VleaRning project aims to adapt and introduce AR and VR technologies in European schools. Stakeholders can learn how to integrate these technologies into their classrooms through the Vlearning eLearning platform. (www.vlearningproject.eu)

N°17: Future schools using the power of virtual and augmented Reality for education and training in the classroom (VR@School)
Country: Romania
Funding programme: ERASMUS+
Duration: 01/09/2018-28/02/2021
In a nutshell: The project's main aim is to create a collection of online tools to facilitate teaching and to motivate students to use VR and AR in class. Train the trainer sessions as well as VR lessons for STEM classes will be developed and implemented in VR labs at different schools. (www.vr-school.eu)

N°18: Virtual Reality in Higher Education: Application Scenarios and Recommendations (VR_Education)
Country: Liechtenstein
Funding programme: ERASMUS+
Duration: 01/09/2018-28/02/2021
In a nutshell: Firstly, the project aims to identify virtual reality application areas in higher education. Secondly, the project will result in recommendations enabling lecturers to implement virtual reality in their teaching activities. The project mainly targets educators in higher education and will provide materials to aid the first steps with VR-enhanced practices. (https://www.researchgate.net/project/Virtual-Reality-in-Higher-Education-Application-Scenarios-and-Recommendations)

N°19: VR-Together (VR-T)
Country: Spain
Funding programme: HORIZON 2020
Duration: 01/10/2017-01/10/2020
In a nutshell: VR-Together offers new VR experiences based on social photorealistic immersive content, creating an end-to-end pipeline integrating state-of-the-art technologies and off-the-shelf components and introducing new methods for social evaluation. (https://vrtogether.eu)

N°20: Integration of Experiential Learning and Virtual Reality into Gifted Education (VR4GIFTED)
Country: Turkey
Funding programme: ERASMUS+
Duration: 01/11/2018-30/04/2021
In a nutshell: The main objectives of the project are to develop a new reference curriculum based on experiential learning theory and Virtual Reality resources to be used in Teacher Training with a focus on the inclusive education of gifted and talented children. (http://vr4gifted.com)

N°21: Virtual Reality for Rehabilitation (VR4REHAB)
Country: Netherlands
Funding programme: INTERREG NEW
Duration: 20/09/2017-19/03/2021
In a nutshell: VR4Rehab enables the co-creation of Virtual Reality-based rehabilitation tools. Combining forces from SMEs, research institutes, clinics and patients, VR4Rehab aims to create a network in which state-of-the-art VR-technology can maximise rehabilitation potential and adhere to the needs of patients and their therapists. (www.nweurope.eu/projects/project-search/vr4rehab-virtual-reality-for-rehabilitation)

N°22: Virtual Reality Audio for Cyber Environments (VRACE)
Country: Austria
Funding programme: HORIZON 2020
Duration: 01/03/2019-28/02/2023
In a nutshell: VRACE aims at providing physically correct and perceptually convincing soundscapes in VR. This goal is pursued through training ESRs in all VR-related domains, namely physical modelling, sound propagation, audio rendering and psychoacoustics. (https://vrace-etn.eu)

N°23: Virtual Reality applied to roadwork training in European construction industry (VROAD)
Country: Spain
Funding programme: ERASMUS+
Duration: 01/10/2018-20/09/2020
In a nutshell: Tackling specific needs for work-based training and hazard prevention in roadworks training through the development, testing and implementation of a training system based on VR. (http://microsites.fundacionlaboral.org/v–road?idioma=1)

N°24: eXtended Reality for All (XR4ALL)
Country: Belgium
Funding programme: HORIZON 2020
Duration: 01/12/2018-01/12/2021
In a nutshell: By creating a pan-European community the project discovers existing XR technology to develop an agenda for further research. It also awards grants to innovative projects and seeks to increase the levels of investment and technology transfer to help high quality products reach the market. (http://xr4all.eu)
Last but not least, our own project has also contributed to this research:

N°25: Boosting Virtual Reality Learning within Higher Business Management Education (VRinSight)
Country: Germany
Funding programme: ERASMUS+
Duration: 01/10/2018-30/09/2020

In a nutshell: VRinSight aims to usher in VR technology across HE business management studies by identifying the challenges faced by the SMEs as well as the current deficiencies of HE in relation to VR technology, by spearheading a VR training programme for educators and SMEs and by increasing awareness of VR technology across HE and business Europe. (www.vrinsight.org)
In addition to the meta-data analysis of the project presentations and the information and products available on the individual project websites, interviews were also conducted with 10 selected project promoters to validate the data obtained and to gain important, in-depth information.

What have we learned - and what should happen now?
All in all, we have become familiar with a range of projects dedicated to the topic of immersive learning from different perspectives, in different sectors and areas and with regard to different target groups.
On the one hand, this provides confidence, because it testifies to a diversity of innovation and creativity in this important field of future development in Europe.
On the other hand, it is somewhat frustrating to see that the projects are not embedded in any overall concept or have any overarching coordination. It is therefore to be feared that many of the projects will work - as is unfortunately quite usual in the European funding area - solely on their own, although networking within the different project groups would be extremely important and would also create meaningful, cost-effective synergies and know-how transfers.
After reviewing the project websites and publications as well as the implementation of the interviews with 10 selected coordinators, the following findings can be summarised, and conclusions drawn:

- All projects agree on the following starting position and general conditions for their work: Digitalisation of life at all levels is a global challenge which cannot be tackled at national levels alone. Generally, strong global competition is ongoing within industry and commerce, which determines who will take the lead with smart industry and who will be left behind; with the USA, China but also Japan, South Korea and India, Europe has extremely strong opponents to compete against – and it is currently not well positioned.

- An important advantage held by Europe's opponents is the relative homogeneity of their political and economic structures. While here, Europe still has much catching up to do and is very busy dealing with (increasing) national interests and the strong diversity of economic development within its member states. This makes it more difficult to work together in transnational cooperation groups and develop products for the "European market|. This market – including the educational one - does not exist in reality, but is rather only the sum of many individual national markets.
- This is especially true for immersive learning and working. The stages of development of digital learning and working, the degree of awareness and openness to it among target groups, basic knowledge about available hardware and software as well as the skills and experience necessary to use them efficiently and purposefully vary greatly from one member state to another. If no specific countermeasures are taken, these differences will increase rather than diminish in the future. However, these differences do not only exist geographically. They can also be observed in terms of age groups, levels of education, occupational groups and rural/agricultural and urban/industrial living spaces.
- All project leaders confirmed that the cost factor is becoming less and less of a decisive obstacle in dealing with VR/AR/XR-based learning and working. Of course, certain investments need to be taken into account, especially if a larger group of users is involved, but the supply of a powerful internet connection plus basic equipment such as computers and smartphones is available almost anywhere. In addition, relatively inexpensive and high-quality VR/AR/XR hardware is now much more widely available. Also, these devices are becoming lighter and more mobile to handle. The first factor is important because head-mounted displays (especially for VR) quickly lead to fatigue and pain in the head and neck muscles, which hinders longer study and working periods. The second factor is important so that people can move around freely without being bothered by cables connecting head-sets to computers; here, the first stand-alone device, Oculus Quest (www.oculus.com/quest), has made a decisive breakthrough and has opened up completely new application qualities.

- There has also been great progress with software development, and more and more apps are being used - besides in the pure gaming and leisure sectors - for increasingly serious tasks such as learning support in schools and universities, for vocational training and further education, for the almost authentic experience of culture, art, history and geographical regions, in accident prevention and safety training, in the health sector, for therapeutic treatment, in the planning and construction sector, and as a communication medium etc.
- Although there is in principle a high degree of satisfaction with the - partly self-developed - software used in the projects, all still see a (substantial) need to widen the areas of applications as well as to improve visualisation, graphic resolution, opportunities for interaction with other users and easier movement throughout the environment. At first glance, virtual rooms always look impressive and lifelike, but on closer inspection, there are still many deficiencies and inaccuracies. This is where further developments are urgently needed to ensure that immersive learning and working can be applied successfully and sustainably, especially in areas where accuracy and precision are crucial (for instance, in various medical fields, such as surgery, or plant engineering).
- While solutions for technical challenges seem to be on the right path, there are still many gaps to be bridged in relation to general awareness and knowledge about the possibilities, chances, limits and risks of immersive learning and working. Greater effort must be made in the future to develop sustainable AR/VR/XR strategies, to inform the general public about these technologies and their added value for many areas of work and life. Only if we succeed in reducing the psychological barriers and fear of contact can digitisation reach the centre of society and become firmly established in the long term.
- The high percentage of young people who are already familiar with complex virtual simulations and immersive worlds is very promising for the future. Although their experiences are mainly acquired through computer games, this is a starting point on which to build. The fact that young people often have the appropriate knowledge and skills to quickly pick up how to apply VR/AR/XR hardware and software is a great advantage compared to most other groups of learners. It is important to actively build on existing pre-knowledge and transversion skills, as well as on the basic passion for everything digital, to make young people not only immersive gamers, but also immersive learners.

- In general, it is advisable to approach immersive learning and working very carefully, slowly and professionally. In particular virtual worlds can quickly enchant you with the impressive spaces they create and the bizarre situations to which they expose the user.

  One becomes surprised at how easily our brain can be deceived - and how much we like to be deceived. However, this is not enough to achieve sustainable learning. In the majority of projects, we have experienced that the initial magic quickly fades, and the disappointments become greater and greater the more we realise that immersive learning requires much effort and preparation, that the visual and content-related elaboration of many apps still leaves something to be desired and that technical problems can always occur. Anyone who has ever organised a virtual meeting with several people (e. g., via AltspaceVR, https://altvr.com) or who faces a group of 20 learners but has only one pair of working VR glasses will know about this.
- Therefore, especially at the beginning of immersive learning and working, the overall effort, the sometimes limited possibilities of the apps and the technical sources of error should not be underestimated. Extensive and precise preparation at the infrastructural, technical, organisational and pedagogical levels is essential.
- The biggest problem at present is that there are far too few trainers, teachers and educators who themselves have comprehensive knowledge of VR/AR/XR technologies or the skills to apply them as learning and working tools. Only when these multipliers are professionally trained and educated, can they pass on their knowledge and skills to others. Therefore, it is absolutely necessary that train the trainers programs in all educational areas (school, vocational training, general adult education, higher education, social pedagogy, etc.) be developed as quickly as possible and made widely available. Among others, the pedagogical universities will be challenged to develop and offer such training programmes, not only for their own students, but also on a part-time basis for anyone involved in education and training.
- One experience that all projects have shared is that - at least in the first encounter with immersive learning and working - it cannot function without technical support. It is recommended to obtain advice from a real expert. This begins with the purchase of the right hardware and software and will probably continue during the learning or working process.

Although the devices are quite easy and largely self-explanatory to operate, you will still be faced with minor and major problems that will need to be solved quickly.Therefore, cooperation with VR/AR/XR experts or at least with other people who already have extensive experience, knowledge and skills with immersive learning and working is recommended.

- What would certainly promote knowledge about VR/AR/XR technologies and their use in the world of education and work would be a central platform where all EU projects related to this topic would be collected and presented. Not only could these projects be made available to a wider public, but one would always have an up-to-date overview of innovative developments in this field. It would also allow the project groups to compare themselves with others and exchange ideas, learn from each other and develop new ideas and projects together Many project leaders have regretted this lack of easy networking and professional exchange with other project groups and experts. It is hoped that the recently launched project showroom by the VAM Realities project (https://vam-realities.eu/related-projects) will fill this gap.

What can be learned from this? Europe still seems to be struggling in its development towards an innovative, modern digital society and economy. However, there are many individual developments and efforts that point in the right direction; these have certainly been given a strong tailwind by the experience of the COVID-19 pandemic, and there is a justified hope that this trend will continue to strengthen in the future. There is still a great deal of catching up to do in terms of their holistic embedding in overarching national and European strategies and policies. This is why the EU, many member states and regional governments have launched initiatives and policies in recent years that all postulate the same bottom line: In addition to technical equipment and infrastructure, an open-minded, well-educated and networked society is an elementary prerequisite for development into a digital future. However, this should not hide the fact that in many regions and (economic and educational) areas, strategies are currently not being developed, and there seems to be little hope of adequate funding being made available.

The greatest need for action is currently in the areas of comprehensive awareness-raising campaigning, access to high-speed broadband internet for all European citizens, relevant basic digital hardware and software equipment for all learners, and the training of trainers at all educational levels.

Here, the aim is not to rely exclusively on formal educational pathways, but rather - especially in order to achieve short-term improvements - to promote informal and non-formal forms of learning.

The good news is that some progress is already being made in developing and equipping technical devices and applications and that their declining acquisition costs will make it possible for future investments to achieve greater effectiveness; in any case, however, further substantial investment in infrastructure and equipment will be necessary. As things currently stand, rapid and successful digitisation at all levels and in all areas will be the decisive factor in creating an economically, ecologically, politically and socially successful society in the 21st century. Accepting and proactively tackling this major challenge should be on our agenda sooner rather than later.

With comprehensive digitisation priorities for the budget period 2021-2028, the EU is setting the right course; however, this policy will only be successful if the same priorities are set at national, regional, sectoral and institutional levels throughout Europe. Ultimately, however, it will also be the responsibility of each one of us to be open to these developments and to continue our lifelong learning concerning digital innovations.

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