Never Leave the Learner Alone!

Findings, lessons learnt & recommendations from 21 EU projects on how to integrate immersive learning in education

Metadata analysis implemented by XRforPed project group

Analysed and reported by

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CONTENT

I. Introduction

The starting point for working on the idea of *Mixed Realities for Pedagogues - XRforPED* (www.xr4ped.eu) were two different observations:

On the one hand, this project was conceived under the impression of the first violent corona wave that had reached Europe. Most educational institutions were closed for months, yet somehow classes had to continue. This meant that large areas of teaching, as well as the communication with colleagues or parents that accompanies teaching, had to be carried out remotely and digitally. Many of the educators had their first experience with digital learning and communication platforms, document archives or data collection and assessment tools. We wanted to know what educators' experiences were during the period of lock-down-caused distance and digital learning, what media and tools they mainly used and to what extent this influenced their attitudes towards digital learning in general. These are extremely important findings because educators not only played a key role in maintaining social and professional life to cope with the C-19 pandemic, but because without their support, enthusiasm and competencies, a comprehensive digitisation of our society would be more difficult to achieve. Of course, children would continue to grow up as digital natives without the help of teachers, but it is necessary to provide children with appropriate digital knowledge and skills that will enable them to enter a successful professional life and participate meaningfully in social and political life. To do this, educators themselves need to be fully trained in digital working, learning and teaching. It was also interesting to collect data in this regard.

The second reason was that immersive technologies (virtual realities, augmented realities, mixed realities, extended realities) are becoming more and more established in our lives. While for a long time they were exclusively known in the fields of leisure and entertainment, their potential has now been discovered for many other areas, including education. Since it can be assumed that the success of these meta-worlds will continue[1], it is highly appropriate for educators to deal with these techniques in a timely manner and to find out whether, in which areas and under which conditions immersive learning makes sense and can be used in teaching, especially with larger groups. Therefore, we wanted to find out to what extent trainers and teachers are aware of immersive technologies and whether or not they have experience and/or interest in using them in the classroom.

In order to answer these questions, the project group conducted two Europe-wide studies with different set-ups, methods, instruments and target groups:

The first was an online-based questionnaire survey with largely closed questions, which ultimately asked 324 teachers and trainers with at least one year of teaching experience about their experiences with the use of digital methods and tools in the context of Corona, about their opinions and attitudes towards the digitisation of pedagogy in general and immersive technologies in particular.

In a second one, 21 coordinators of EU projects on immersive learning were asked in semi-standardised interviews about their experiences, what opportunities and risks they see for pedagogy and what advice they have for the orientation of the XRforPED training programme. In addition to the interviews, the studies and data collection carried out by these projects themselves were evaluated and analysed with regard to the project goals and products of XRforPED.

The data collection phases of both studies lasted from autumn 2021 to spring 2022. With the report *Before C-19, I Thought Digitalisation in Education is Evil*, the evaluation and the derivations for further project work from the online survey are now available. The evaluation and the conclusions drawn from the interviews with the 21 project promoters were summarised and published in the *Never Leave the Learner Alone* report. Both papers formed the basis for the development of our 4 ECTS training programme for students of pedagogy and educational sciences.

Both reports, the training programme and all other products of this project are freely accessible and downloadable at www.xr4ped.eu.

[1] Just think of the renaming of Facebook to Meta.

II. Overview of projects participating at interviews

All project partners searched for several months very intensively for best practice examples of EU projects; they searched in their own networks and platforms (e.g. that of E.N.T.E.R., www.enter-network.eu), but above all they searched national data bases and the huge databases of the large EU programmes, especially those of ERASMUS+ (https://erasmus-plus.ec.europa.eu/projects/search) and CORDIS, which provides access to Horizon 2020 projects (https://cordis.europa.eu).

About 60 EU projects were selected and contacted, of which the managers of the following 21 EU project finally agreed to participate in the interviews:

Tab. 1. Overview of best practice EU projects

N°	County	Acronym	Full title	Duration	Fund	Website	Project in a nutshell	Education level	Target sector / group
1	AT	ViRAL Skills	Fostering Virtual Reality application within Adult Learning to improve low skills and qualifications	10/01/2018-03/31/2021	Erasmus+	www.viralskills.eu	The partnership of the Viral Skills project aimed at fostering necessary skills of adult educators that allow them to integrate VR in their training offers and make the use of VR "viral" – it should spread quickly and effectively in order to make learning attractive again.	General adult education	Educators, trainers
2	EE	VirSTEM	Virtual technology for use in STEM	11/01/2020-10/31/2022	Erasmus+	www.virstem.info	The goal of VirSTEM is to create an international open educational resource – online course "Basic Engineering Graphics" 3 ECTS which innovatively integrates Building Information Modelling.	Higher education	Lecturers and students in engineering of construction
3	PT	VRSCiT	Virtual Reality Science Tour	12/01/2020-11/30/2023	Erasmus+	https://vrscit.pixel-online.org	The VRSciT project consists of conducting a virtual educational visit to places of cultural, social and natural interest of each partner involved, from PT, ES, IT, LT, VR immersion and interaction techniques to provide users a unique learning experience.	General adult education	Visiting places of cultural, social and natural interest
4	TR	Able-WithTech-Tools	Developing Virtual Reality Resources Introducing Technology Tools for Children with Autism Spectrum Disorder to SEN Teaching Undergraduates	09/01/2019-31/08/2021	Erasmus+	https://autismtech-tools.com/	The objectives of the project are a) capacity building of Special Educational Needs (SEN) teaching undergraduates and enabling them to excel in teaching; b) promoting assistive technologies for better social and communication skills of students with autism spectrum disorder (ASD); c) investing in innovative technologies as VR teaching materials and contributing to the development of education technologies. d) development of a curriculum "Introduction to Technology Tools to Improve Social and Communication Skills of Students with ASD" and of teaching materials VR Resources	Special pedagogics	SEN students and their teachers
5	FI	ECIU University XR Campus	XR Campus - THE EUROPEAN CONSORTIUM OF INNOVATIVE UNIVERSITIES	01/01/2020-01/12/2022	Erasmus+	www.eciu.org	ECIU XR Campus is a virtual environment which can be accessed from anywhere and anytime to be fully immersed into interaction and co-creation together with others. In XR Campus, avatar-based interaction, 3D-space, and spatial sound simulate natural face-to-face communication.	Higher education	Lecturers and students at an immersive university

6	CY	PIECIT	PIECIT – Our inclusive schools	30/06/2021-29/06/2023	Erasmus+	http://ourinclusiveschools.eu	PIECIT aims to address different needs in digital learning in school. It is necessary to recognize genuine educational practices linked to digital media from resources at their disposal and to generate new ones that cover the deficiencies they have experienced in the face of the situation of the COVID-19. and social workers.	Higher education, School education	School teachers, management and stakeholders
7	NL	GEN-AI	Generation AI: Teaching kids about Artificial Intelligence	01/12/2020-31/12/2023	Erasmus+	https://generation-ai.eu/	The aim of the GENERATION AI project is to support educators and younglearners understand the basic principles of AI and help them become more critical consumers of technology applications across their life span. It a) supports educators in understanding AI uses in everyday life, b) prepares educators to teach their students about AI, its applications,strengths, and weaknesses, in line with DigiComp and DigiEDU, c) supports teachers and students in developing problem-solving skills, as well as d) in developing their digital skills and a critical understanding of AI and its application to everydaylife.	Education in general	Educators and students
8	NL	AHA	AdHd - Augmented	11/01/2017-31/10/2019	H2020	https://aha.ucd.ie	AHA pilot project focuses in particular on the implementation and integration of existing technologies (such as mobile apps, online literacy programme, and augmented reality development) to enhance learning for students with ADHD, assist their parents and educators during the teaching and assessment process, and investigate whether the combination of such technologies can assist students with ADHD to stay focused, make fewer mistakes, and finish assignments at school as well as homework. AHA delivers an Augmented Reality (AR) solution for an existing online literacy programme, which integrates a set of specific technologies and supports interactive educational content, services, assessment, and feedback.	Social pedagogy	Students with ADHD, their trainers and parents
9	PS	TESLA	VR as Immersive Learning Tools in Palestinian HEIs	01/01/2018-31/12/2021	Erasmus+	https://generation-ai.eu/	Tesla is a capacity-building project aimed at creating a typical virtual reality development framework throughout Palestinian institutions. It provides excellence in instructional design, development, and exploitation of services,answering critical needs related to the Palestinian horizontal policies for the Higher Education sector.	Higher education	HE teachers and managers
10	UK	SI!BIM	Step into BIM / Step into Building Information Modelling	01/10/2019 - 30/09/2021	Erasmus+	www.sibim.eu	This project aims to help employers and employees address digital skills training challenges in Building Information Modelling (BIM) by creating an accessible learning portal that improves knowledge and awareness of digital skills for existing and new entrants to the industry. The project will explore and evaluate key areas of innovation and best practice in DS in the areas of BIM, cloud-based computing, innovations in VR and AR technologies and their use in VET training, and the use of 3D modelling and "virtual building design" in construction.	Building Information modelling	Employers and employees

11	SI	ENVISION	Virtual Gaming Simulation	01/03/2021 - 28/02/2023	Erasmus+	www.lu-velenje.si/projekti/mednarodni-projekti/aktualni-projekti/item/134-envision	The goal of the Envision project is to develop two generations of virtual simulations that users will be able to use in teaching, either distance learning, blended learning or classroom learning. Teachers and students will thus have support in developing their readiness for digital education and the use or development of virtual simulation games.	Gaming and learning	Trainers and students
12	EE	URBAN TECH	Accelerating Innovation in HealthTech, Smart City and GreenTech	01. 09. 2021 - 31. 08. 2024	H2020	www.urbantech-project.eu/urbantech-in-a-nutshell	Today's urban systems need to adapt to a growing population in order to sustain and provide a healthy, smart and green environment. Smart technologies, solutions and innovations are needed. The URBAN TECH project will support the acceleration of competitive success of European SMEs through market launch of new or significantly improved products and services with higher value in Health Tech, Smart City and Greentech industry sectors.	Smart cities	SMEs, municipalities
13	SI	SKILLCO	Sector skills alliance for transfer of knowledge and skills of VET workforce in construction	01/11/2016 - 31/01/2020	Erasmus+	www.skillco.eu	The main objectives of the project were to define and identify existing and anticipated skill needs and to elaborate and define learning units using ECVET principles that can be integrated into formal vocational education and training programs (VET P) or used as training courses.	VET - construction sector	Trainers and workers
14	FR	MVR	Math Reality	01/11/2018 - 30/04/2021	Erasmus+	https://math-reality.eu	Math Reality project offers teachers and students an innovative methodology, tools and strategies based on the use of VR technology in order to succeed in deepening students' knowledge of mathematics through engaging virtual simulations, encouraging the development of creativity and their connection with other disciplines and concepts to improve their engagement and success in mathematics. This project is hands on directly with teachers and students in school environments.	School education	Teachers and students in mathematics
15	IT	VET Reality	Virtual Reality based training to upskill VET Teachers and Trainers and foster inclusion of SEN Students in WBL	01/11/2020 - 31/10/2022	Erasmus+	https://vetreality.erasmus.site	VR is hardly represented at VET level in the frame of WBL with a focus on SEN students. VETEREALITY seeks to contribute to relevant EU education and digitalisation and aims at raising VET Teachers and Trainers awareness and knowledge on how to handle and integrate VR technology into own teaching programmes for facilitating SEN students' access to WBL.	VET centres and companies	Students in VET, with focus on SEN students
16	GR	DESK	An adult Digital Education Skills Kit to foster employability	01/11/2018 - 30/04/2021	Erasmus+	https://desk.e-sl.gr	The main goal of DESK is to provide Adult Educators the means to understand the uses of Augmented Reality and integrate it within their teaching, thus making Life Long Learning an attractive process for adults needing to catch up, by creating the DESK Toolkit.	General adult education	Educators
17	DE	VRinSight	Boosting Virtual Reality Learning within Higher Business Management Education	01/10/2018 - 30/09/2020	Erasmus+	https://www.vrinsight.org	The VRinSight project is a European partnership from business and education established to introduce VR technology across the institutes of higher education in the context of business management education.	Higher education in business management	Lectures and students

18	FI	VEGA	Virtual reality Education & Game based Achievements in classrooms	12/01/2020-11/30/2022	Erasmus+	www.vegaproject.eu	The VEGA project addresses mobilisation and interest of students in school activities by promoting computer games-based learning (GBL) as well as VR and AR. The project team develops the pedagogy of play and at the same time meaningful learning using the affordances of digital games and VR/AR applications across the school curriculum of primary, secondary and upper secondary schools.	School education	Teachers and students
19	IE	ARETE	Augmented Reality Interactive Educational System	01/11/2019-01/05/2023	H2020	www.areteproject.eu	ARETE project aims to build a Europe-wide competitive ecosystem that supports fast dissemination of augmented learning content. ARETE will focus on three pilot studies in STEM, English literacy skills and positive behaviour intervention.	Higher, school and general education	STEM, English literacy skills, Positive behaviour: Researchers,
20	RO	UMARG	Using Mobile Augmented Reality Games to develop key competences throughlearning about sustainable development	12/01/2019-11/30/2021	Erasmus+	www.umarg.eu	UMARG project aims to explore the potential of Mobile Augmented Reality Games (MARG) as means to develop students' digital and civic competences. MARG are gaming environments played in mobile devices that augment physical world with virtual, location-specific and contextual information, teamworking and communication abilities, and thus provide opportunities for in-situ or inquiry-based learning.	School education	Teachers and students
21	ALB	VTech	Accelerating Western Balkans University Modernization by Incorporating Virtual Technologies	01/11/2019 – 30/10/2022	Erasmus+	https://vtech-project.eu/	VTECH project's general aim is to introduce for the first time at Western Balkan universities the concept of Virtual Technologies as a tool for accelerating university modernization, while contributing on developing knowledge-driven society. By incorporating Virtual Technology in the academic culture of universities, this project aims at increasing the quality and level of efficiency in teaching and knowledge retention through interactive learning methods, thus contributing on skills enhancement and further building of digital society at Western Balkan countries.	Higher education	Managers and lectures

We have selected the projects in such a way that we can cover as wide a geographical spread and diversity as possible in terms of the coordinators' home countries. The coordinators of the 21 projects come from 17 different countries, 13 from the EU (AT, CY, DE, EE, FI, FR, GR, IE, IT, NL, PT, RO and SI), 4 from non-EU countries (ALB, TR, UK and Palestine). Of the funding programmes, 18 are from the ERASMUS+ programme, 3 from the H2020 programme. At the same time, different education sectors are represented, among which higher education (7 projects), general adult education and school education (4 each) and vocational education and training (3).

Although this sample of EU projects is not representative, it is not a one-sided survey, but encompasses the diversity of projects in the field of immersive learning, which speaks for the quality of the interview results.

III. Manager's feedback on obstacles when applying VR/AR/XR in education

Our first question focussed on whether the different projects had undertaken their own studies on the use of immersive technologies in education or whether they had drawn on research from outside the project group in their work (Tab. 2). 12 of the projects have conducted their own studies, 7 have relied on data from outside, in 1 project no research results were used at all for project work, from 1 project we received no answer. This enabled our project group not only to draw on the experiences and insights of the project managers, but also to benefit from their data analyses. This approach of metadata analysis in our interviews thus provides a valuable contribution to the further use of already collected data and their linkages from our own research results.

Tab. 2. Research inside/outside EU projects

2.2 Implementation of own research within the course of the project	Yes, inside the project	Yes, outside the project	no	No answer
	12	7	1	1

During the interviews we confronted the project managers with 15 statements below on the framework conditions and positive or negative prerequisites for the use of immersive technologies in education and asked them to agree or disagree with these on a four-point scale of strongly *disagree - disagree - agree - strongly agree*, the number of mentions made in each case can be found in columns 2-5 Tab. 3; in addition to this, we asked the managers to briefly explain and comment on their answer. The comments collected can be found - in a slightly corrected and summarised version - in the column *Comments*. We have not further edited this data in order to obtain as authentic and unbiased a view as possible of the opinions and experiences of the project managers.

Tab. 3. Feedback on statements regarding immersive learning frameworks

2.2 Statements	strongly disagree	disagree	agree	strongly agree	Don't know/ NA	Comments
a) Educational managers have good knowledge about the use of VR/AR/XR in education	8	10	3	0	0	• Generally speaking, managers have knowledge about these technologies but there is a lack of communication with managers. • Concerning our museum visitors, in particular the younger people already have some experience with VR. • Most managers have never used these technologies before and they don't know the capabilities of AR/VR technologies. • Even though many do not yet understand the technology itself, managers are just now beginning to realise the potential of XR technology for educations. • School management in our XR projects were always very excited and positive about the developments. • Many managers are aware of the buy words but have no real concrete understanding of the technology's potential. • It differs, some countries/institutes have more knowledge and experience with VR than the others. In general, there is some knowledge. • Good support from the head of education for use of VR/AR/games. Anette has known them for a long time. Cooperating long and well. • Not sure what you mean by managers, if you mean administrators and coordinators, you are correct. From our own analyses we understand that they have a knowledge gap regarding the use, benefits and implementationof new technologies. • I would rather agree with that statement. Our experience from the project showed that most managers had little or no knowledge about AR technologyand thus their ideas on how to implement/utilize this technology in their institutions were quite limited. • I think school-managers often rough a vague idea about the educational use of VR/AR/XR technologies but they do not knowspecific applica-tion domains • The teachers and technicians have the technical knowledge and skills aboutthese technologies, but they lack the pedagogy behind the scenes, interaction design concepts, and working within theoretical frameworks.

						• According to Kuzma, there are many concepts (such as VR, AR, etc.), but first we need to know them, their advantages and also the investment range. In the project, VET schools tested (tried) VR, which was funded by the European Commission (European costs). • Slovenian students at the University of Ljubljana at the Faculty of Civil and Geodetic Engineering (UL FCGE) have recently been trying AR. They can even gain knowledge of XR, e.g., through "Trimble XR10 with HoloLens 2" if the UL FCGE approves (or buys) a sample of the HoloLens, which costs about 5,000 euros. • The managers not only that they do not have enough information to use XR technologies, even more of this technology cannot see (or not seen - to mention the mint under the auspices of Zuckerberg) as one of the key technologies of the future. However, there are also bright exceptions among them.
b) Trainers/teachers have good knowledge about use of VR/AR/XR in education	7	11	3	0	0	• For questions a & b: the people who have experience mostly have it from the private/ leisure time area of their life as they may have tested VR/AR games prior to getting in touch with our project. Hardly anyone has had professional experiences with this technology. • It depends on the area of expertise, but generally speaking, teachers don't have experience and need some training about how to use AR/VR technologies. They have little or even no knowledge about this technology. • In most cases, teachers have never used these technologies before. They don't know how to use it. • Educators are more aware than Managers of the potential, and some are aware of the research that is going on. • Younger teachers are interested and aware of XR technology and its potential as an education tool, but require support. • Many are aware of the technology but have very little knowledge and comprehension of its potential as a teaching tool. • It also differs, some countries/institutes have more knowledge and experience with VR than the others. In general, there is some knowledge. • Initially low experience. After sharing vision and explaining, inviting over and showing, they get hands on and understand possibilities. • From our experience in the project, the majority of the educators had noknowledge about AR and its affordances in education. This negatively affected their intention to use the technology, since they had the misconception that AR cannot be used as a tool in their teaching. • Same for teachers and educators. I think it is also a function of age,with on average older teachers being less informed/interested than younger colleagues. • The teachers/trainers think only in the technical way of these technologies.We still miss in Palestine people with hybrid skills who can consider technical and pedagogy in a parallel manner. • In the Tesla project, we faced a lot of resistance against change during the training phase, primarily when we focused on the work's pedagogical side. They are trained to think only in a cartesian way like engineers. However, they still need extensive training to work the pedagogy and design a suitable excellent user experience for students and teachers. • Unfortunately, only the most advanced and innovative teachers and trainers know most of the current and potential concepts (such as VR, AR, etc.) and they can use the free tools available, for example, to create "3D BIM viewers". • According to Kuzma, AR and XR are very expensive, even "too expensive for the Slovenian education system." (She added that 3D glasses for VR and MR are less expensive.). • Among the teachers there is a lot of information and interest to know XR technologies, but there is really lack of knowledge how to implement this in the education and training processes.
c) Trainers/teachers are highly motivated to use VR/AR/XR in their classes	0	2	6	13	0	• At the moment, using VR/AR in education required either a good/sufficient budget or a lot of creativity to use low-budget/free software. • These are rapidly developing technologies, there is a lack of time for tracking their development and detailed acquaintance. • In another finished Erasmus+ project, VRSchool, we trained teachers in VR. The teachers that participated were very motivated to have training while others were too busy to participate to the training. • Teachers make long days, making preparations, teaching and correcting and on top of it they may also have other responsibilities in their school. So, there is very little time left to dig into a new area like this. • Educators are curios and motivated about the technology but pessimistic about implementation as the solutions are not yet available to accommodate a plug and play usability. Educators are aware of the bottlenecks and limitations and not prepared to deal with them. • Younger teachers involved in our XR projects were open, motivated and certainly had no fear of the technology. • The average age of math teachers is quite high. They are usually not familiar with new technologies. Not motivated to use something that they aren't familiar with. Teacher's credibility in danger, they want to know what is happening in classrooms. • Motivation is there, they just have to be encouraged and given self confidence that they can be used in the classrooms. Try and learn the devices before using them in class environment, so they don't look silly in front of students' eyes. • From our XR projects we have witness that teachers/trainers are motivated at their first experience of XR and this motivation is increased once they begin to have their own idea on XR content and discover the opportunities it brings to enhance education. • The motivation is there and some have limited experience from before. Others without digital background can be sceptical at first, but after introduction to the technologies and possibilities, the scepticism disappears.

						• This statement is true. Most teachers participated in UMARG project believed that implementing AR requires high technical skills, which is not exactly true. By providing them with training on AR creation platforms fornot technical users, teachers were more confident to experiment on the creation of their own content. • Dedicated training would increase teachers' interest and motivationtowards VR/AR/XR tech. Practice can help overcome concerns about usability and make advantages more salient. • Teachers should be motivated and educated on how VR, AR, MR, and XR can be used in the classroom, and they should also be supported with skills and tools. She recommended that good practices should be used, and advanced teachers should be supported to motivate and help others to use VR, AR, etc. • This is one of keynote of what we notice when teachers (with or without kids) come to our lab.
d) Trainers/teachers have enough time to learn about how to apply new methods in classes	7	8	5	1	0	• Implementing VR/AR/XR requires time for didactic and technological preparation as well as testing before implementing a session with learners. • It is advisable to provide them with information about VR/AR/XR, rather than to organise training in this stage. If teachers are interested in this technology, they will be prepared to do some self-study work. They will get motivated when shown the unique characteristics and potential benefits of AR/VR technology in education. • Teachers make long days, making preparations, teaching and correcting and on top of it they may also have other responsibilities in their school. So, there is very little time left to dig into a new area like this. • Yes, all educators are too busy to deal with XR, especially if they have to deal with remote learning during Covid. • Yes they are usually too busy, but they will make time for XR technology if they are convinced tat it is beneficial to their teaching. • For this situation, they need to find time. For those who are older, ready-made instructions and guides beforehand help. With Googling and self-learning, these technologies can eat a lot of time. Easily overwhelmed with the amount of information. They should be given in a clear way, with examples how it will improve teaching and engaging students in classrooms. • Of course, somewhat true, but the interest and motivation are not out of reach or vision. Benefits of engaging young students with VR/AR/games for learning is worth the time investment. • If teachers receive how to use new technologies and good coaching andguidance, I am sure that they are willing to do so. • Although COVID19 pandemic put an extra pressure on teachers in terms ofcreating digital learning material, providing asynchronous feedback etc. the majority showed interest to experiment and use AR in their teaching. I think that teachers recognized the unique advantages of this technology andwere convinced to invest time on it. • Specifically dedicated and remunerated training would help increaseteachers' availability. • I call this the comfort zone. In the TESLA project, we faced resistance topush (especially Ph.D. holders) to act like trainees and accept to think differently out of their comfort zone. • According to Kuzma, teachers are not supported. Currently, they are under pressure on how to organize classes due to the Covid measures, and they are struggling to support their colleagues who are sick or in isolation/quarantine. According to Kuzma, face-to-face training is definitely needed to acquire the knowledge of VR, AR, etc., but the fundamental question is when. She believes that the Institute of the Republic of Slovenia for Vocational Education and Training could support VET schools (i.e., certain secondary schools) with various workshops for teachers, trainers, and mentors who deliver lessons on specific topics in VET curricula. Certainly, they should start the education transformation only for some qualifications as a pilot project and then adapt the others. • It is hard to say, by my opinion is more in the enthusiasm
e) VR/AR/XR has a good reputation as high-quality teaching method	1	4	8	7	1	• There are even concerns that VR/AR aims to completely substitute real trainers and teachers, hence requiring less qualified personnel. This is of course not the case in reality, however, especially trainers/teachers with moderate or little knowledge have this fear. • When a teacher needs a new type of learning material, he/she will start to search for it and to discover it. Students can also indicate which type of learning material they prefer and trigger their teachers. Teachers want to be convinced that the new type of learning/teaching tools bring a clear added value. • The quality of teaching depends on how these VR/AR/XR tools are used and the kind and quality of the AR/VR/XR applications that are available for the topics of our lessons. We have experience with an AR developer, but actually, it's an expensive service. Before an AR/VR developer starts developing an application, a pedagogic expert should determine how the application should look like. So, the quality depends on the developer and is related to the teachers needs too. Of course, the quality of education also depends on how the teacher meets the needs of the pupils. • It's the opposite: VR promotes high quality learning and allows to visualise abstract matters. • I know that with VR you can produce really high-quality content and at this moment high quality content is already available. • No, educators are aware of the potential for education, but they are also aware that a lot of input and energy is required to make it happen.

						• Our projects have engaged with schools and teachers, and they have made time for our research and cooperation. However, staff need to be given the time to develop and discover new teaching methods and technologies. This needs to happen at a structural level and be led by the Ministry. There is of course already too much workload in the normal teacher schedule. • Technology evolves, old headsets might not be used for long. • More use cases needed on the table, not just one app/headset. • New technology provides new tools to provide high-quality teaching and learning. Fitting content and organizing it well is in key role. • Yes, we need to work out the working ingredients and a learning environment inwhich the affordances are such that the MR can work. • I strongly disagree with this statement. In the case of UMARG, no such concerns existed. The advantages of AR technology were very well demonstrated at the beginning of the project and all teachers were aware ofits expected impact on students. The fact that AR was later implemented through in-situ, inquiring basedexperiences-that were proven very effective and engaging for students justified the initial beliefs. • I do not agree. I think teachers are aware that technology onlysupport but not substitute different teaching practices. • It depends. The use of VR, AR, etc. could be a small part of regular teaching at the beginning - as an attractive ("fun") part of the lesson (e. g. gamification). According to Kuzma, it all depends on the pedagogic staff, especially teachers, trainers, their motivation, how they are motivated, and administrative support from educational organizations/schools. • It certainly will, with Meta all XR sector got big bust, and big changes are coming to the education sector as well.
f) Level of digitalisation should still be increased in education, such as by the use of VR/AR/XR	0	0	10	10	1	• Yes, digital and virtual learning can never full replace real, F2F learning settings and it should not aim for that. Nonetheless, it is a great new didactical methodology than can be used in suitable contexts and in a suitable scope. • Just as flipcharts, power-points, web-quests, webinars, learning games, role plays and so on it is simply an addition to an educator's didactic repertoire that should be embraced and appreciated. • I have no information about negative impacts on the students. But, the need to take care of the AR/VR equipment represents additional work for the responsible teacher. He has to provide interactive exercises and is responsible to keep the system up and running. The drawback of all these developing efforts is that quickly the applications become obsolete due to the rapid evolution of AR/VR technologies. On the other hand, hardware prices are dropping and it becomes more and more affordable to implement these technologies. That's why we have to look for valuable applications for education. • We need to continue to produce more digital learning materials and to improve existing materials in order to support teachers and make it easier for them to explain complex matters. • I don't think, at this moment, there is too much digital teaching. • Generally, educators are interested in technology that helps their students; educators we worked with more curios and subsequently convinced of the technology's potential. • VR has mostly been welcomed as a new way to teach math after experiencing and realizing its potential. • Quite the opposite. Digital teaching allows to engage young students better with digital technology they are more familiar with already in their lives. • Again, it depends on the educational goal with which you use them. • This is a rational concern. However, from the perspective of UMARG, AR technology was implemented outdoors. So, although students were still interacting with digital content, this was done in a meaningful way, supplementing physical environment and promoting social interaction. So,it is all about the context of using these technologies. • I really do not think that digital teaching may per se have a negative psycho-social impact. The impact of digital learning strict depends on the used pedagogical framework. • There are real concerns about the impact of VR, XR, etc. on the emotional, mental, social, etc. child development. But Kuzma asks if we have an alternative, because digital skills will be an even more important part of people's general literacy. So, according to Kuzma, digital transformation is a necessity for education. She also says there is plenty of room to improve the way digital tools (VR, AR, etc.) are used, which are underutilized in practice. • Of course not, the XR is exactly the same thing about that as we know from the world of computers and phones.
g) Nowadays, most of the education institutions are sufficiently provided with high-speed internet	2	4	4	10	1	• Almost all educational organisations I know have pretty well internet connection. The same holds for our students at home. At this moment already a lot of learning and teaching is provided via the internet. Students also go online with their smartphones. • We need to continue to produce more digital learning materials and to improve existing materials in order to support teachers and make it easier for them to explain complex matters. • The speed of the internet varies all over Turkey but at all Turkish universities, they provide high speed internet. • This is not an issue in Finland. • This depends on schools. From our experience, for example 2 public schools did not have a high-grade internet connection, but it was workable. 1 private school had high grade internet and own IT personnel.

						• Yes, this is an issue that is often overlooked. • I would rather agree with that. In our case, we had schools from Romania, Greece, Cyprus and the Netherlands. Half of them were private. So, we had significant differences in school's infrastructure and of course in internet speed. Hopefully, we used mobile devices with 4G connection outdoors, so school's internet speed did notaffect the project's activities. • Yes, this is true especially for schools of rural or disadvantageareas. • Some organizations and institutes have problems, but in general the situation is not so bad. According to Kuzma, schools have high-speed Internet, but they lack equipment and resources. • In Slovenia all school and most of the institution have access to high-speed internet. And for using of XR is not necessary to have strong connection to web, it is more important to have good HW and SW.
h) Education institutions are sufficiently provided with VR/AR/XR hardware and software	9	7	2	1	2	• Hardware is too expensive at this moment. Moreover, due to the Covid situation and the worldwide chip shortage, it has become hard to find for example an available Oculus Quest for sale in Portugal. A lot of equipment, including computers, are out of stock at this moment. The Portuguese government offers one computer to each student but due to Covid-19, not enough computers are available to distribute among students. We also need more plug and play technology. • Concerning software: there is a lack of educational software and teachers don't know what educational software is available and how to use it in a classroom. So, schools don't buy VR software. • They don't have hardware and software apps because they don't know what hardware and software are on the market and how to use them in education. • Organisations are often unsure about what investments to make and have very little knowledge of the XR technology market in terms of hardware to purchase and what XR applications are suitable. • Some do more than the others, especially initially. In some countries, the teachers got their first touch on VR with this project. For this project, the appropriate apps were created within the project. • Research is important to find the fitting hardware and apps to use. The options for hardware and apps are there. • That is a problem. • Only one partner institution from the 8 of the consortium was able to support UMARG activities with its own hardware (in our case mobile devices with internet connection). The rest of the institution severely lacked the appropriate hardware and purchased it through the project's funds. In ourcase, we used a free platform Taleblazer, so the needs in software were easily addressed. • Yes, this is a common problem and again this is especially trueespecially for schools of rural or disadvantaged areas. • Educational institutions really lack appropriate VR hardware and software/apps, although they are cheap, according to Kuzma. The problem, she said, is that schools have to have the virtual model, otherwise there's no point in using VR. The worst situation is the lack of suitable AR and XR hardware and software/apps, because in Slovenia not even universities and faculties have such devices, but they plan to buy them probably in the next academic year. Kuzma believes that the Slovenian Ministry of Education, Science and Sports should help. • It is true but, many institutions are nowadays buying an Oculus Quest 2 which is really good to start.
i) VR/AR/XR hardware and software are meanwhile cheap enough to be purchased by training institutes	3	8	7	2	1	• Maybe I'm wrong. Maybe for some educational institutions purchase costs for AR/VR hardware and software are a problem. There is a risk that all equipment will quickly become obsolete. An important factor is how it meets the needs of educational institutions and what alternative solutions can offer at a lower price. Educational institutions will only invest in this equipment when they are convinced that there will be a pedagogic added value. As a conclusion, someone has to show educational institutions that VR/AR hardware and software can have an added value in education. • Schools don't have the money to buy the VR glasses. When they want to have a VR experience, our research institute borrows them some glasses. On the other hand, software is not so expensive. For €20, you can buy a decent VR software app but there is a lack of educational software. • Indeed, both hardware and software are too expensive. It is not possible to buy equipment for every student, even not for every classroom. There are 13,000 students in our university! • Most hardware is currently purchased in the context of research projects etc. Although hardware is relatively inexpensive, In order to implement and scale up XR in education, significant investment is required. A central VR management system is required with financing that can management large numbers of headset usage and coordinate training and IT integration etc. • Licensing for software and service providers becomes very expensive as an organisation wishes to scale up its use of XR. • There is a large cost involved but XR Education is scalable, as our XR projects with schools have all used open-source applications. • In our experience it is not too expensive for an institution to take the first leap into XR and first XR experience in education. HMD such as Oculus Quest retail at approx. €500. However, scaling up across all classes and departments is of course expensive and costly. • Fancier hardware is expensive and developing apps is also expensive. More apps could have been developed in this project if budget hadn't been an issue. Also had to cut down on things wanted in the apps.

						• I would rather disagree with that. I think that buying a few tablets to experience AR or VR hardware is not an expensive purchase for most schools. However, in order todo so, schools have to be convinced and be ready to incorporate this hardware/software in their teaching practices, so that they can justify their investment. • I think this is the main reason for poor devices availability atschool. Italian school have reduced budget even to buy essential goods (e.g., hand soap and toilet paper). • Situation improves but, yes, for development we still need some good computers and of course sw.
j) Training organisations have good knowledge in what VR/AR/XR equipment to purchase	11	8	2	0	0	• Educational institutions have no idea what to buy. They don't buy it because they don't have specialists who master these technologies. Someone should help us to train our teachers. • If they really want, they can buy the equipment but since they don't have the professors/teachers asking to explore the technology, they don't buy it. Probably, they need advice to make the right choices. • They have to do an effort to have a look at available equipment and apps on the market but the effort is not so big. They can research it. This is not the reason why they don't invest in AR/VR. • It is clear that schools need support on what investments to make. • Yes, even if funding is available, organisations are often unsure about what investments to make and have very little knowledge of the XR technology market in terms of hardware to purchase and what XR applications are suitable. • Within the project, the focus was on good technology and hardware. The decision was to purchase Oculus Go headsets, not some cheaper headsets that need phones inserted in them as monitors. Oculus Quests were also in use; the app developer had to make the apps work on both headsets, which caused more work. • Hardware and software were evaluated based on needs and use cases. Differs between schools and countries. Some schools have enough budget to get hands on high-end hardware. In Cyprus for example, the school got Cardboard VR goggles instead of Oculus Quests/Valve Index. • I agree with that. This also adds to my previous answer. In order for schools to investin these technologies, they need to know how to do that and with what kind of equipment. • Again, I think that the main problem is budget limitation. • People who are interested in VR, XR, etc. in education know what devices to buy, but the institutions (schools) where they are employed do not have money to buy them. People who don't know what devices to buy generally don't have interest in using them. Kuzma believes that specific guidelines on digital literacy (including the use of VR, AR, etc. in education) should be adopted in Slovenia and written in the relevant national education documents, such as the White Paper of Education in the Republic of Slovenia. The crucial role should be played by the Slovenian Ministry of Education, Science and Sports. • Yes, that is true, most question in connection with XR, form our visitors are exactly this way.
k) Education institutes are sufficiently equipped with IT experts	8	7	3	1	2	• Maybe it is more related to the learning directions of a country or even the institution. It is also related to cost. • In many cases, the technical staff even doesn't know about AR/VR. Moreover, they are understaffed. • They don't have staff with expertise to implement VR in teaching. Maybe, it is because it is a new area. Most schools have only one ICT expert and he/she has too much work to keep the ICT infrastructure up and running. • Standalone headsets (such as Oculus) are fit for purpose and for many solutions you don't need expertise. More integrate software requires expertise, especially when creating own content. However, the IT support in organisations is usually not XR experts either and are unable to support Educators in this field. • It difficult for teachers to run this smoothly without experience or good IT support. Schools need access to good and secure servers, and cloud services to really scale the XR education experience. However, this could be managed centrally by a local authority or ministry for a large number of schools in a district or region. • Often, amongst the academic departments such as educational science, there is certainly a lack of expertise and sufficient IT support. However, in the specific technical subject departments there is often internal IT expertise available. • This was not a problem in the project. • A rather small team of focused staff can get it going well. • Yes, you need a coordinator in a school to be trained to do so. • I agree with that. In most cases, schools participating in our project had no technicalsupport in their institution. To address that we focused on training usually a ICT teacher in their school and providing external technical support from each country's Higher Institution. • Generally, technical staff only solves technical issues and isnot engaged in teaching activities. • First, staff/experts need to acquire the appropriate knowledge with the appropriate tools (models, etc.), then teachers need to be trained in the use of VR technologies, etc. in the classroom.

						• Yes, it is true, this is the main problem in educational institutions, so more project to educate teacher will be really appreciate.
l) VR/AR/XR hardware in suitably well developed to be used in classes without major problems	5	11	2	3	0	• It really depends on the learning content and context, if AR/VR/XR are easily usable in class. There is a lot of potential, however, the software is lacking in terms of high quality, topically widespread content. • In many areas, specific and specialised hardware is also necessary to allow full immersion and adequate skill development (e.g., driving simulator, surgery simulator). • One of the issues is that people who wear normal glasses have problems to put a VR HMD. For older people, it takes time to put the VR HMD on and off. It is true that he majority of the people like the VR experience but there certainly is room for improvement. In our museum, until now, we don't have problems with battery life since a VR session only lasts for 10 minutes and all 4 devices are constantly charging. But, longer battery life would open new opportunities. • At the moment, devices are still too complex to handle and also too heavy. But both hardware and software are developing fast. Within 10 years, I expect AR/VR will have become much more user friendly. • Standalone headsets (such as Oculus) are fit for purpose. However, VR demonstrations are always challenging in larger groups. • On a small scale it is possible, but to scale to a large number it is more difficult. • HMD such as the HTC VIVE and Oculus Quest are suitable headsets to use in educational settings, as they are mobile, user friendly and often not overly expensive. However, our XR project have shown that in an educational setting, users and learners often have a limited time range of usage (approx. 20-30 min) before they get tired of the HMD. Usage of these HMD types is also often limited due to the battery live of mobile units (approx. 2 hours batter life) • Oculus Go headsets were sufficient and easy to use in classrooms with large groups of up to 20 people (with 10 headsets). No external computers/wiring needed with Oculus Go/Quest. • Large groups need space to operate, which limits the efficient group size. The devices themselves are not the issue, but rather the operational room the user needs. • Accessibility Is a problem. • I would rather disagree with that. AR/VR/XR technology is constantly developing andbecoming better. Of course, there are UX issues when this technology is being used by younger users, however I think that all these are under research and will be solved in the near future. • Many applications, as the one developed forthe AHA project, are easy to use. • The main problem is the financial resources and the lack of knowledge and skills of the teachers about the VR/AR/XR hardware. • Oculus Quest 2 is really simple to use and all students also have smart phones to run ar applications.
m) VR/AR/XR software in suitably well developed to be used in classes without major problems	5	8	7	1	0	• Maybe, I don't have enough information about this. My students use a VR viewer application to view 3D houses, gardens, furniture, etc. The quality of the graphics should be better. Working with detailed high-quality objects (with big file size) goes too slowly, but it is also related to the performance of the computer, in particular the performance of the graphical card. And for architectural cases, the file size is almost always very big. Of course, we could split big designs into smaller parts and view them separately but that would even take more time to look at the whole architectural project. For our use case, we need high performance equipment. • In all areas! E.g., in mathematics, it would be interesting to have some abstract contents but it doesn't exist yet. VR would be amazing for biology: there are already some apps but the available apps do not cover the complete curriculum yet. If there would be more educational applications available, it would be easier to select the right application for a lesson. As a result, students will be more committed to learning. • See question l. • The current software is still not sufficient. • There is a large number of suitable apps for XR education, many of which are open source. • There is a number of education apps on the market, but there are currently not enough to service the wide variety of educational subjects and settings, and they are not openly accessible enough for educators. • Developers in this project made multiple apps for math. Budget for VR apps is challenging: they had to cut down on some things they wanted. With bigger budget it could have been way more apps/features. Fitting apps made for math teaching in classroom. • Not all apps are fitting for pedagogical purposes, but the creativity of teachers can also find educational sides from apps and games that might not initially be obvious. • These are developed from a functional point of view and not from a educational point of view. • AR has shown tremendous expansion in various learning subjects. Furthermore, thepossibility for a teacher to find an educational AR app that fits his/her needs is way higher than 5 years ago. The vast majority of these apps have great content and graphics, The problem exists for non-English speaking teachers though. • This may be the case for some applications, but the one developed for the AHA project wascompletely developed although improvable.

						• The main problem is the teachers' lack of knowledge and skills. Teachers need to start using VR/AR/XR software and apps. This is the main requirement to be able to say anything at all about the development and use of VR/AR/XR software and apps. • There are a lot of companies including google and Elon reality which provide really nice content for XR classroom.
n) Curricula which teachers/trainers have to follow enable easy use of VR/AR/XR in classes	10	10	1	0	0	• I think, each classroom is fit for the use of VR/AR/XR technologies (e.g., 3D camera recording or 3D visualisation of architectural designs). Our students don't have to move physically while using our VR applications, so some extra free space in the classroom is not needed. • Nowadays in Portugal, schools have to follow an imposed curriculum, but they are totally free to choose the appropriate working method and so they have the opportunity to use AR/VR technologies to support their teaching, if they like. In the coming years, we will have some space in the new curriculum (also in higher education) to be filled in freely with content (about 10%). Of course, at universities and in higher education, content and working methods are freely but carefully chosen by the professor. • Because of legislation initiated by the ministry of Education, schools must adhere to the imposed study programme, especially lower-level schools. In certain cases, they also have to use specific handbooks. And if AR/VR is not mentioned in the handbook or no AR/VR examples are included in the handbook, schools see no reason to buy any AR/VR equipment. • Current curriculum will have to be updated to reflect advances in educational technology. But XR needs to be implemented where it creates a benefit and is not just for the sake of it (i.e., using power-point slides in VR brings little benefit, but displaying 3D models in VR in an Architecture or engineering lecture is highly beneficial) • This must of course be handled centrally by the ministry to allow teachers to discover new technology. • If the curricula are altered to accommodate XR technology, then this will not be an issue any longer. However, this has to be centrally managed and changed by the educational authority. This change is coming and organisations will have to embrace it sooner or later. • VR is still very new and not much used in math. • For VEGA this wasn't a problem. Finding fitting apps/games in the perspective of curriculum and educational side was in key role. • They usually have autonomy to use applications. • In many countries. including Greece. Romania and Cyprus, schools follow a centralcurriculum. VR/AR/XR are still undetected in these curricula, probably due their emergent nature. • VR/AR/XR technology can also be usedduring extra-curricular lessons. • VET curricula are partially open, about 20% according to Kuzma. So innovative teachers can find ways to incorporate VR, AR, etc. • That is also the problem in Slovenia we don't have enough digitalisation program in schools. Not even on faculties.
o) Classro structure and architecture enable easy use of VR/AR/XR in classes	5	15	0	1	0	• In our museum, people have to sit down in a very nice rotating chair when they look at the VR application. That's because sometimes when people, especially older people, take of the VR glasses they feel dizzy. For older people it usually is their first amazing VR experience while younger people have already used it before. • In classrooms a free space for VR experiences is needed but is not always available. • In a regular classroom, there are too many tables. There is not enough free space to safely use VR. • If you have 10-15 people using VR, a lot of space is required, clear of furniture. However, many new software apps focus more on users in a seated position to replicate workstations/desks. • A lot of space is required to use VR headsets especially. Classrooms are design for sitting, XR is designed for physical movement. • One school had a dedicated classroom for VR. Tables easy to use and move. Schools with big rooms were utilized. As a teacher you need to plan ahead. Teachers sometimes had to rearrange the classrooms with students' help. • Small classrooms could only fit 2-3 Oculus Quests/headsets at the same time without causing chaos. Managing and organizing students in the classroom is important (as it is without VR as well). • Learning environment is necessary to review. • Learning spaces are also not prepared for these technologies. Although somecurrent classrooms' structures that allow teamwork, may benefit AR activities, school need to rethink the architecture of classrooms so that to support learning with VR/XR also. • I do not think this is a main issue: space can always be adapted. • According to Kuzma, schools should have dedicated spaces in the form of shelters.
p) Other	-	-	-	-	-	• Not all learners are able or willing to use this technology. Physiological, neurological or psychological reasons could be a barrier for a learner to participate in VR/AR/XR learning. • In case of distance learning, the learners have to be provided with the necessary hardware/software, which is also a relevant financial obstacle. • Some users don't know how to set up or change the safety guardian (Oculus Quest) and so they cannot walk and move safely while using a VR app. • AR/VR/XR hardware and software will become more affordable, more performant and more user-friendly in the future.

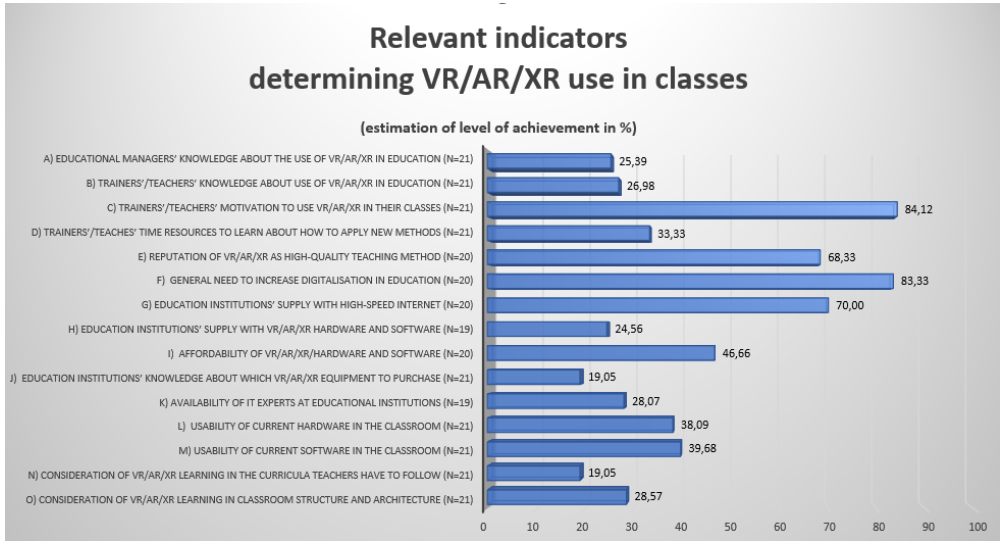
						• One challenge faced by teachers in using VR headsets is the vulnerability of using HMDs for both teachers and school students in a classroom setting with a large group. Teachers often require support and other staff to control the room and the students and to look after the students. • There were challenges with the developers and creating apps as wanted. Budget also can limit how much and deep the apps are. • Buying apps and games is a big challenge. Only 3 from the staff (school/municipality) have credit cards and no specific budget for apps/games, which makes it a difficult process. Verification codes also difficult. Buying same app/game many times for all the devices. • Pedagogical use and educational review is necessary and catering to what children need. • Another "obstacle" are sometimes students' parents. Unfortunately, XR/VR/AR technologies are followed by misinformation i.e. they cause cognitive overload, or worsen students' abilities to focus. In UMARG project we experienced this kind of concerns and tries to also inform parents regarding AR affordances and advantages. • lack of knowledge • lack of teachers/ trainers/ practitioners' professional development • lack of time due to given curricula of the Ministry of Education • lack of connection with XR significance and connection with real learning outcomes • lack of a digital database with OERs' for application in preschool and primary • education available in native languages (e.g., Greek). Hence, this acts as a barrier for teachers to utilize XR tech in classroom. • Other obstacles, according to Kuzma, are the aforementioned lack of funds for education, educational guidelines and the renewal of the White Paper on Education in the Republic of Slovenia. • Maybe is problem in focusing on teachers, because if we could turn mindsets and asking students what they are want learn, we could got the right answers and faster deployment of new curriculum.

In order to also give a basic overview of how the different statements were rated by the managers, we assigned percentages to the semantic ratings (*fully disagree = 0%, disagree = 33%, agree = 66% and fully agree = 100%*) and calculated the mean values from these. Tab. 4 shows to what extent (= to what percentage) the project managers see conducive framework conditions for the use of immersive learning fulfilled. The managers assume that very important indicators such as the motivation and interest of teachers in immersive learning is very high (84.12%) and the vast majority of educators is positive about the need for further digitisation of education (83.33%); also, the reptuation of immersive learning among educators is high (70%) and most educational institutions are now equipped with good internet connections. (68,33%).

These are very positive results, but they are also the only indicators above 50% compliance. All the others are below this, in some cases even very significantly below. Underperforming indicators are the knowledge of trainers but also of managers about the possibilities and the use of immersive technologies, the lacking skills, time and training of educators, the lacking support by IT experts, the lack of knowledge about which devices and apps should be used; moreover, curricula do not provide for immersive forms of teaching, classrooms are not sufficiently designed for this.

By and large, these are the same results that we arrived at in our online survey. From a methodological point of view, it is satisfactory to arrive at the same results using different instruments and methods and interviewing different experts. However, this also confirms that there is a great need for improvement in most areas and that major tasks still await those responsible for education in Europe.

Tab. 4. Feedback on statements regarding immersive learning frameworks



IV. Derivations for developing immersive learning courses

Finally, we asked the project managers what they would recommend (DOS) or what they would definitely advise against (DON'TS)when using immersive technologies in the classroom or when developing immersive learning modules. As the project managers have all developed learning materials themselves, they are very experienced and we can benefit from their mistakes, successes and lessons learnt. We have qualitatively collected the feedback from the project managers in open questions, then clustered them according to content/statements in each case ranked in frequency of mention. The following lists are the result of this work.

3.1 Question set: What is the best way to deal with low prior knowledge or even possible reluctance and low motivation among people you are supposed to train in VR/AR/XR teaching? How is it possible to overcome concerns that VR/AR/XR teaching is of generally inferior quality or that it can lead to emotional, mental or physical problems for learners? Etc.			
DOS – this is recommended	Hits[2]	DON'TS – this should be avoided	Hits
• Showcase the (educational) potential with concrete cases for learners and teachers	8	• Don´t expect too much from teachers and learners and avoid terminology difficult to understand	4
• Learners with previous knowledge should be encouraged to share their experiences with other learners or even act as co-coaches / knowledge exchange	4	• Don't focus on technical details (explain too many (technical) details, use too high-resolution applications, technical teaching)	4
• Use applications concerning an area of interest and fun of the target group	4	• Don´t force the learns to use the technic and don´t think they are used to the technic – let them time to get familiar with it step by step	3
• Let teachers time to practice with VR materials/guide them in preparation and get familiar with it	4	• Don't ask questions learner cannot answer (because they have no experience in this field) and avoid content not relevant to the target group/age	2
• Removing any restrictions on using VR/AR/XR material, hardware should be easy to use	3	• Don´t let teachers and learners learn by themselves	2
• Learners should be encouraged to go through online tutorials and clips to get familiar with the overall topic	3	• Don´t miss out the "wow" effect VR/AR/XR can give with good content	1
• Mirror the screen, so that others can follow the VR/AR/XR user and stay motivated	3	• Don´t make lessons too long	1
• Start with 360° videos and easy introductions before using VR/AR/XR and go on step-by-step	3	• Don´t worry about negative impact of VR/AR/XR – there is no one	1
• Test the application before using it		• Don´t use it as teacher replacement but as supporting tool for teaching	1
• Have a rewarding system after each task as well as feedback rounds and continues support	3	• Don´t persist in present school systems	1
• Work with interdisciplinary teams, involve school psychologists and leave usual school structures	2		

[2] Number of project managers (21 in total) who recommended or advised against it.

• Go into practical experience as soon as possible	2
• More governmental financial support (for technical equipment in school, qualification of teachers)	1
• Provide enough documentation	1

3.2 Question set: How best to deal with the fact that there are no VR/AR/XR devices in most institutions and no one is familiar with existing software? Do you find the cost factor a sufficient argument against immersive learning? Do you know innovative ways to acquire hardware and software cheaply? Which devices do you personally feel are best for use in the classroom?

DOS – this is recommended	Hits	DON'TS – this should be avoided	Hits
• Take time to decide what fits best to your institution. E. g. Oculus Quest/Oculus Go/Oculus Rift/Valve Index is good for class rooms. For larger groups and a smart start google VR cardboard with 360° views is recommended	9	• Don´t focus on cheap hard- or software as alternative that do not meet your criteria (e. g. devices with inserted phones, cheaper equipment than students have or cheap smartphone based VR application) which can lead to negative encounters with VR; rather focus on good but not too expensive technology	5
• Create partnerships/communities with schools and industries, EU projects or private institutions and use your contacts	7	• Don´t raise unrealistic expectations (purchase, handling) who can lead to disappointments and frustrations.	1
• Invite teachers for interactive demo sessions and make them familiar with hard- and software and support them permanently with material/training	6	• Don´t show VR/AR/XR games to avoid a "toy" image.	1
• For a first glance - organise testing/visits to external suppliers that offer VR/AR/XR technology, use private equipment or rent the equipment to get a feeling for the potentials	5	• Don´t pay too less attention on the IT support. This can lead to administrative barriers, stop downloads and inhibited usage.	1
• Be aware of the available budget of the institutions.	4	• Avoid overwhelming teachers and trainers	1
• Organize the central management of hard- and software (including updates, servers) as well as the central management of an effective official information channel (including digital repertoire) within the institutions to relieve the teachers	4		
• Integrate personal equipment of the students/teachers (e. g. smart phones)	4		
• For VR, stand-alone hardware solutions are to be recommended, as they are more affordable in relations to pc-based hardware. They are also easy to use in a classroom, as the setup is easy and quick, multiple ones can be used at once and there are no cables, hence less danger to fall/hurt a learner.	2		
• Use software/apps with limited access/free trial option that allow actively to experience the application	2		
• If an organisation/institution has the means, high quality products should be purchases (even if they are more expensive); cheap software or hardware often result in low graphics/resolutions or poor implementation, leading to negative learning experiences (disappointment in the content scope or even motion sickness etc.)	1		
• Produce your own VR content	1		

• Persuade managers first	1
• Use our projects full open-source applications in the class rooms which give students and teachers their initial VR experience	1
• Provide high quality and secure server access as well as cloud services	1

3.3 Question set: How big do you think the learner groups should be when using VR/AR/XR? What are the problems when many people work with VR/AR/XR in one room at the same time? How big can the self-learning part of a VR/AR/XR training programme be? How long should working sessions last if learners need to wear headsets (e.g., to avoid neck pain)?

DOS – this is recommended	Hits	DON'TS – this should be avoided	Hits
• Learning session shall take 5-10 minutes with clear instructions for everyone. Using the VR shall not exceed 20 minutes at all, because learners will get too tired.	5	Don´t make the groups too big (pace, sound) and if persons share headsets, it is important to divide the time fair and equally.	8
• There shall be a maximum of 5-7 persons together in a room using headsets each.	4	• Don´t miss hygienic and safety risk management. If persons share headsets, hygienic safety is very important. Trainers should offer disinfection sprays and disposable inlays for the headset (or silicone inlays, which can be easily cleaned or allocated to specific persons) and should give safety and health risk instructions.	4
• When using multiple headsets there shall be sub-groups of 3-4 people max. The other ones shall follow on a linked device (laptop screen, smartphone). They can share and interchange between sessions. Or they shall cope in pairs (one with headset).	4	• Don´t overestimate the users (usage, time-management). First steps in VR/AR/XR should be carefully prepared. If the users feel comfortable in easy virtual surroundings, a more intense app/software should be used.	2
• Trainers/teachers shall support the learners the whole time and provide guidance. Start with a demonstration.	3	• Never let the user alone.	1
• The self-learning part shall be adapted to the users, but shall not exceed 30%.	3	• Don´t expect self-learning of students outside the school environment (because of missing equipment of students at home)	1
• Generally: Persons per group and duration of learning sessions depend on the age of the users.	2	• Don´t organise VR sessions outdoors (danger of injury)	1
• Teachers and trainers can learn the theory in max. 60 - 90 minutes and have 2 x 15 minutes or 3 x 10 minutes of practical work. After 2 months the whole study program should be re-peated and then evaluated.	1		
• Experiencing VR/AR/XR should be used as cherry on top of the regular learning content.	1		
• Provide an adequate room with enough space and no furniture.	1		

3.4 Question set: Are there specific target areas and fields of knowledge/skills/competences for which you particularly recommend the use of VR/AR/XR in training? And where have you had negative experiences and you think immersive learning DOS not work there? Which apps can you recommend … and which not?

DOS – this is recommended	Hits	DON'TS – this should be avoided	Hits
• AR/VR/XR are great to immerse in complex topics/abstract contents and relations such as in chemistry, physics, astrology, astronomy, mathematic and biology.	7	• I don´t have any negative experiences with VR/AR/XR.	4
• In fact, it can be used for all age groups and all teaching areas, especially for learning that requires physical interaction.	6	• Don´t buy software if you don´t know the added value of it for your education. An evaluation document with use cases for education would be very helpful.	1
• AR/VR/XR provide a completely new medium and dimension for arts and/or history	4	• The planned budget for developing apps can set limits.	1
• In combination with specialised hardware, VR/AR/XR is great for practical training that requires a certain environment and to train specific skills in simulators (e.g., driving, flying, surgery, welding or do experiments in chemistry, physics and biology).	4	• Avoid struggles with the developers of the app. Only work together with developer who you trust.	1
• For primary school's students, the app should be engaging and offering a "wow" effect, but also educational content with pedagogical side.	2	• Don't forget to pay attention to the further development of the trainers/teachers. Avoid that student's skill progress goes on faster than those of the trainers/teachers.	1
• It is particular appropriate in academic subjects such architecture and engineering	1	• ClassVR: Made for education and schools but missing the wow effect. Not recommended.	1
• It is useful to support students in their self-learning.	1	• I used Oculus rift in a user study and this caused me nausea for over an hour.	1
• AR/VR/XR are also great to train personal/social competences such as public speaking or learning languages.	1	• Avoid timely immersion in VR environments	1
• Recommended apps: Apps specifically made for mathematics can be found at https://math-reality.eu/resources	1		
• Teacher´s creativity is important. Seemingly one-dimensional game like the famous Beat Saber can first only seem like good physical exercise, but it also offers a good app for musical theory, pulse and rhythms in education.	1		
• "World of Physics": the XR experience is very beneficial in enhancing education and learning in science. This involved the use of avatars and experimentation that may not be possible in the science classroom due to lack of facilities/health and safety.	1		
• UMARG project's perspective: Mobile AR games provide the development of 21st century skills and competences like problem solving, critical thinking, information and data literacy, communication and collaboration.	1		
• MARG: focused on sustainability, teachers managed to incorporate several learning subjects in these games such as Sciences, Biology, Civic education, Economics	1		
• EON reality: They are pioneers in this field. SAS solutions. Anyone with Internet access can access the app. Free to use. If you want to create your own content you pay a license.	1		

3.5 Question set: Which specific target sectors and groups do you particularly recommend the use of VR/AR/XR in training – and with whom do you think it might not work well? What recommendations can you give when working with people with mental, cognitive or physical disabilities? Do you also have experience in immersive learning with young learners (<16 years)? Again, are there any apps can you recommend to use … or to avoid?			
DOS – this is recommended	Hits	DON'TS – this should be avoided	Hits
• All people can work with this type of equipment and interactive objects: children, elderly people, disabled people, vocational training; you only have to use appropriate application (e. g. story-based ones for children, fitting content, adaptions to special needs). You have to prevent that they feel unsafe and anxious.	10	• Don´t forget the special needs of learners and make necessary adaptions/deviations/limitations (e. g. working with children under 6, blind people, weak IT literacy of older people)	4
• The best group are students/young people (secondary school onwards) because they have the basic IT know how, are usually highly motivated and they learn very fast how to use them.	7	• Don´t forget to check apps/games from the market before using, because there might be some inappropriate content for students and schools (such as weapons or items used wrong, adult content)	1
• Learners with high IT literacy usually have better first impressions of VR/AR and are less at risk of getting motion sickness or other negative experiences. They usually are also quick to use the controllers and act intuitively.	1		
• Learners who do not have many experiences with technology and digital screens are often either highly interested and motivated to use the new technology or hesitant.	1		
• Recommended app for disabled people: VRSCit is a VR project to help people with dementia to remember how to do everyday tasks like walking, cooking, eating, dressing up, etc. The big advantage of such VR applications is that all movements and actions of the user can be saved, so afterwards you can analyse these data and help the doctor.	1		
• Recommended app for young learners: Valve Index, Google Earth: VR experiencing the Eiffel Tower, while his/her pair is explaining about Eiffel Tower or show VR apps about the human body, for example how the heart and the blood circulation works, or a VR app about the Leonardo da Vinci Museum	1		
• Recommended other apps: Assistive technology of SEN-ss, AR/VR applications inside VIRTEC project (find them to download on project website). It works nicely and young learners did enjoy the application. We got positive feedback from their teacher, who also asked for additional information about the project.	1		

3.6 What other recommendations can you give us as we develop our course. And what should we avoid at all costs?			
DOS – this is recommended	Hits	DON'TS – this should be avoided	Hits
• The course shall be adapted to the target group needs (define them). Think of VR, AR, etc. as a learning aid or displacement (tool) with examples and case studies.	5	Do not try to convince the persons who do not find joy or sense in the new technology. New experiences or alternatives can be offer, however, some may still prefer reality over digital means.	1
• Implement VR step by step and let trainers/teachers/learners experience/explore it within a pedagogical framework. There is a learning curve at the beginning with the teachers. Once that has been overcome, they are more familiar and relaxed to bring the equipment into use at classrooms.	4	• Avoid hand gestures in the applications because they have no clear intuitively meaning.	1
• Teachers/Trainers as well as students have to be made aware of the new learning opportunity and their requirements (organisational integration, using and integration in their learning process).	4	• Don´t have too many learners at the same time.	1
• Check thoroughly what already exists on the market/other projects and talk to and involve experts/educators/users. Keep in mind: many existing apps are not full at a high-quality level in all possible areas (e.g., content, graphic, scope, handling). This is okay and a natural development process.	4	• Try not to focus your course on special software or apps but on the idea behind, because software and apps can run out of work.	1
• The course shall attract the attention of the learners and shall include a fun factor: Play and learn! Play first - have fun first and become familiar with the technology. Afterwards educational side follows.	2	• Don´t forget the addictive potential of the technology – use it carefully (see film Ready Player One)	1
• The course shall be content rich, but not information overloaded.	2		
• Ensure safety with guidelines (physical, COVID-19)	2		
• Ensure that the focus is on expanding to groups of learners from an early stage of the project. An idea can be the purchasing of gift cards with certain amount of money, which makes the purchasing process easier. Also licenses for schools, how to easily buy games and apps for the equipment.	2		

3.6 What other recommendations can you give us as we develop our course. And what should we avoid at all costs?

- It's important to merchandise things you are doing to spread them more.
- VR is already bigger in the American universities. Something could be learnt from them as well.
- Always when you find a new fancy app/game that is nice to use, you should have curriculum perspective in mind and see how it fits for educational purposes.
- When using a curriculum check, which part of the curriculum is fitting and which app/game is good to go along for your needs.
- If access to XR education can be centrally managed this is, of course, an issue for GDPR, where usernames rather than real names and identification have to be used. However centrally managed access also opens up opportunities for performance analysis and reporting on the educational progress of student.
- Keep the sustainability of the project in mind (not cheap and not easy to learn apps but long-term use).
- Schools can have a fear of cost vs. benefit or will be not enough interested in new technology.
- VR/AR/XR will continue to produce more and more suitable hardware and software in the future. Hence, it can be expected that the usage will accelerate in the upcoming years. Trainers and organisations who prepare now are still early adapters in this area.
- Google searching: First results aren't usually fitting for educational perspective. Steam on the other hand gives nice hints about what kind of app/game it is in question.
- 360 video experience in VR can also be a success with students, showing e. g. nature and kayaking with the teacher (familiar face).

Following the feedback and recommendations of the project managers, we developed the pedagogical concept for the XRforPed course and the learning materials and methods according to different methodologies. For all further information, please see www.xr4ped.eu .

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XR4Ped fosters digitisation in Higher Education in general
and the promotion of XR-based immersive learning in particular.

→ xr4ped.eu

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