

PROS AND CONS OF USING EXTENDED REALITY IN EDUCATION

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Abstract

Education has always been one of the important pillars of society. Whether it was done in Ancient Egypt, Rome, or Greece, in the Enlightenment period or in modern times, it has been in the centre of humans preoccupations, and it was surrounded by challenges and opportunities. Nowadays, new technologies appear every day and there is a justified question whether they can boost education and how. With the advance of the 4th Industrial Revolution (Industry 4.0), which is about the rapid changes that occur in technology, industries and society, because of the interconnectivity and digitalization, one of the most promising environments for education is Extended Reality (XR), which is a mix of virtual reality, augmented reality, and mixed reality technologies. In this brief article, we analyze the similarities and differences between the previously mentioned technologies, as well as their benefits and challenges in design and implementation. We also mention the challenges that appear with the implementation of such technologies on a large scale – privacy, safety, and accessibility. Overall, however, the article is a manifest for using such technologies in teaching and learning, from kindergarten to universities, because they have all the ingredients students need: they are scalable, help motivate students, lower the cognitive load, can be used remotely and have a lower impact on the environment.

Cuvinte-cheie: realitate extinsă, virtuală, augmentată, educație, tehnologii noi.

Keywords: extended reality, virtual, augmented, education, new technologies.

1. INTRODUCTION

Education is the act of teaching or being taught something, whether it is a concept, an idea, or a new skill. This can be formal, usually done by a recognized institution, or informal, done at home, within the family or society. It can be done within a classical format of an indoor dedicated space or can have a more relaxed approach, seen both in ancient times (e.g. the Greek Agora) and recent ones. It can happen in large groups or at an individual level. Regardless of the many elements it can comprise of, it is considered successful when new knowledge or skills appear

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and improve the quality of life, for the person being taught and for the society (Razinkina *et al.*, 2020).

One of the important aspects of education has been the used methods and techniques, and nowadays we see more and more how technology can and should become an essential part of how we teach and learn (Lai & Bower, 2019).

In this short article, we stand for the use of a particular part of technology in education, namely the one encompassed under the term of XR, which stands for Extended Reality. This includes other types of realities such as Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR). XR first appeared in gaming and entertainment and is rapidly capturing other areas such as business communication or product development, and many countries have begun to implement it in education and training too (Coie, n.d.). It is also more and more present in areas like clinical psychotherapies or neurosciences (Parsons, Gaggioli, & Riva, 2020), where it can improve patients' body awareness, affective regulation and foster empathetic abilities.

The two main categories of immersive technology are VR and AR, with the main difference being that VR uses computer generated information for the full immersive experience, while AR combines computer generated information with reality and blends them together. There are three types of VR technologies: non-immersive, semi-immersive and fully-immersive VR. As their name states, the first one, the non-immersive VR allows the user to remain aware of the physical reality around, the semi-immersive VR uses only some senses, while the fully-immersive VR completely surrounds the user in a virtual environment (Coie, n.d.). As for AR, there are four types: marker based (e.g. QR code), without a marker (e.g. Google Maps Live View), projection based (e.g. Disney Parks) and superimposed (e.g. IKEA).

On an industry breakdown, gaming is the first industry that adopted XR and one with the most investments. Then comes the health industry and on the third place, worldwide, is education.

2. BENEFITS AND DISADVANTAGES

Whenever an industry is considering the use and implementation of new technologies, it must first look at the pluses and minuses of that change. While there is no doubt that we are supporting the use of new environments such as XR, we also admit that there are costs to using these technologies, which will be briefly presented in the following paragraphs.

We will begin with the disadvantages of implementing XR on a large scale, which can bring huge financial costs for certain technologies. There are three types of costs with XR technology. First, there is the cost of hardware (e.g. high-end computers, VR goggles), software (e.g. proprietary software built from scratch or subscriptions) and, last but not least, the cost of teaching people how to use these

technologies. Another disadvantage has to do with the ethical issues, because of privacy, data security, identity, bullying or harassing problems. Recent research published in *Nature* journal showed that 95% of the participants involved in a VR study could be recognized based on their nonverbal movements, with less than 5 minutes of system training (Miller *et al.*, 2020). Based on such results, the previously mentioned authors caution about using nonverbal data as personally identifying ones and warn about the importance of designing and implementing ethical XR technologies. Therefore, any XR technology implemented on a large scale must first ensure an airtight data privacy. Although there is mentioning of physical harm for long term use of XR technologies (Chuah, 2018), the data is scarce and only time will tell whether this is true or not. Until then, however, common sense and history shows that anything in excess can be harmful.

Knowing these disadvantages, it is possible to take them into account when designing and implementing a large scale XR environment. And then benefit from all the pluses it has. One of the most important is its scalability (Logeswaran *et al.*, 2021). As with everything that has to do with technology and the Internet, XR can also be scaled, if there are available resources (financial, environmental, and human). Another plus is that XR can remove barriers and people can connect and communicate remotely. There is also the benefit of physical safety, especially in more dangerous fields such as chemistry, where students can explore any substances, without the risk of being injured. The quantity of information is higher with XR than with classic approaches because 3D images and videos relay more data. The experience itself is somewhat unusual and exciting, and students can visit places that would be expensive or almost impossible to see otherwise. And, finally, there is the possibility to automate the use of gamification within the learning process, regardless of the number of students or the moment they decide to learn. In a classical approach, it is almost impossible for the teacher or trainer to observe all the milestones or positive interactions of students and reward them every time. In XR however, this is possible, because the teaching-learning process can be prepared ahead of time and can even benefit from the help of artificial intelligence (AI), which is another huge topic on its own, and will not be discussed here.

3. XR IN EDUCATION

Before the COVID-19 Pandemic, education was considered an industry with a very slow adapting technology rate, and sometimes even reticent to change. With the Pandemic however, this has changed worldwide, and the educational sector started to adopt technology in an exponential way. The potential for XR is seen in a lot of areas, such as the workplace training, real world simulations, knowledge retention or skills development and remote education (Carter, 2022). In response to this raw and unexplored potential, some of the tech giants have announced huge investments, thus setting the trends of the near future: 5G connectivity, the

Metaverse from Meta (formerly known as Facebook), a merge between XR and AI, hybrid learning and haptic technology, for the most immersive process possible (Carter, 2022).

XR can be used in education and training at any age, from kindergarten kids to adults. The number of studies involving the use of XR for kindergartners has increased in the last decade and the Pandemic has accelerated the process. Neha & Archana (2020), using an exploratory factor analysis, have suggested a number of 23 principles suitable for AR applications for kindergartners, divided in four categories: cognition, orientation, design and support. The authors suggest that XR apps can and should be developed for kindergarten children, provided they respect the following 23 principles: accuracy, learnability, effectiveness, satisfaction, efficiency, reduce short-term memory load, support procedural and semantic memory, user-oriented, multi-modality, aesthetic and minimalistic design, consistency, enjoyment, customisability, relationship between real world and virtual objects, interactive design, skip non-playable content, design dialogs to yield closure, simplicity, context based learning, help and documentation, early test, error management and low physical effort. AR can be used for teaching English to kindergartners (Lee *et al.*, 2017), the English alphabet (Safar, Al-Jafar & Al-Yousefi, 2016) or vowel usage (Cieza & Lujan, 2018), tracing letters (Nigam *et al.*, 2019), learning the concept of numbers (Huang & Yang, 2020), for promoting collaborative learning (Campos & Pessanha, 2011), learning about animals (Markamah, Subiyanto, & Murnomo, 2018) or natural sciences (Cascales *et al.*, 2013), learning about daily prayers (Hidayat *et al.*, 2020), early art education (Huang, Li, & Fong, 2016) or basic knowledge learning (Kurniawan *et al.*, 2019).

Moving higher into the primary school, user acceptance remains one of the main aspects to be considered when adopting XR technologies, and this refers both to the primary school students and even more to the teachers using this environment (Alkhatabi, 2017). Alkhatabi (2017) concludes that primary school teachers are willing to accept and use AR in their teaching process and that an appropriate Information-Communication and Technology (ICT) infrastructure combined with the skilled human resource can be strong motivators in this endeavor. After this barrier is overcome, XR can be successfully used in primary schools in a plethora of disciplines: for the study of astronomy concepts (Midak *et al.*, 2020), natural subjects (Midak *et al.*, 2020), marine education (Lu & Liu, 2015), botanical learning (Chien *et al.*, 2019) understanding atoms and molecules (Ewais & Troyer, 2019), for teaching English (Boonbrahm, Kaewrat & Boonbrahm, 2015; Mahadzir & Phung, 2013), mathematics (Ahmad & Junaini, 2020) and geometry learning (Rossano *et al.*, 2020), historical reasoning (Efsthathiou, Kyza, & Georgiou, 2018), understanding idioms (Edyanto *et al.*, 2021), developing collaborative learning experiences in the classroom (Alhumaidan, Lo, & Selby, 2015).

In secondary school, XR can enrich education by providing a more natural experience, can enhance attention and motivation, save time, and space, and develop skills such as problem solving and creative thinking (Yilmaz, 2018). At this age group, there are problems too, for both teachers and learners, especially because there can be technical issues in creating the 3D objects necessary for AR lessons (Yilmaz, 2018). Besides the already mentioned general benefits, XR has been used in secondary school for the following reasons: reading comprehension and learning permanency (Bursali & Yilmaz, 2019), interactive physics (Dünser *et al.*, 2012), algebra (Saundarajan *et al.*, 2020) and geometry (Rashevskaya *et al.*, 2020), science education (Davidsson, Johansson, & Lindwall, 2012), biology (Tan & Waugh, 2013; Weng *et al.*, 2016), chemistry (Nechypurenko *et al.*, 2018), foreign languages (Gündoğmuş, Orhan & Şahin, 2016), physics (Volioti *et al.*, 2022), mathematics (Fernández-Enriquez & Delgado-Martín, 2020), history (Ibharim *et al.*, 2021; Schiavi *et al.*, 2018) and geography (Prisille & Ellerbrake, 2020).

In high school, XR has the advantage of transforming education as we know it, by reducing the cognitive overload (Bower *et al.*, 2014) and offering more attractive and immersive learning experiences. Besides AR, VR can also be successfully used in high schools, in disciplines like chemistry (Cai, Wang, & Chiang, 2014), physics (Gusmida & Islami, 2017; Kim *et al.*, 2001), human anatomy (Manrique-Juan *et al.*, 2017; Kurniawan & Witjaksono, 2018), geography (Chenrai & Jitmahantakul, 2019; Stojšić *et al.*, 2016), environmental issues (Klopfer & Squire, 2008), mathematics (Hsu, 2020; Kaufmann, 2004; Kaufmann & Schmalstieg, 2002), history (Utami & Lutfi, 2019) or developing collaborative learning (Klopfer *et al.*, 2017).

In universities, XR is still in its incipient stages, while universities evaluate the benefits and costs of designing and implementing these technologies with their students. Professors understand and know the benefits for learning based on XR technologies, and at the same time they warn about the lack of guidance in the development and implementation of such technologies in education (Alnagrat, Ismail, & Idrus, 2022; Idrees, Morton, & Dabrowski, 2022). Although the current XR apps are seen as useful and successful, they are not widely used in universities (Kluge *et al.*, 2022). The barriers that stand in the way of a large-scale implementation of XR technology includes funding, infrastructure, support, and maintenance. To overcome these barriers, university institutions must commit to long term changes that begin with the identification, development, assessment, and validation of scalable solutions (Kluge *et al.*, 2022). Beyond this, there are studies (Ratcliffe *et al.*, 2021) that suggest XR technology should be used for remote experimentation in psychology and social sciences. Through a process of content analysis and scientific bibliometric, Guo, Guo, and Liu (2021) found that the main institutions interested in the application of XR in education were universities and colleges, with an obvious benefit for applying knowledge into practice.

With the proper motivation and research methods, XR technology can be designed and implemented in any university, to become a standalone environment or complementary to the classical teaching methods. There are already attempts for testing or implementing XR technology in teaching languages (Tegoan, Wibowo, & Grandhi, 2021), chemical engineering (Carberry *et al.*, 2023), agriculture/farming/aquaculture studies (Anastasiou, Balafoutis, & Fountas, 2022), management education (Zwoliński *et al.*, 2022), medicine (Andrews *et al.*, 2019), neurosurgical education (Iop *et al.*, 2022), neuroscience (Vaida, & Pongracz, 2022), healthcare (Logeswaran *et al.*, 2021), mathematics (Lai, & Cheong, 2022), etc.

4. WHAT COMES NEXT IN EDUCATION

With the rapid advances in technology (Industry 4.0, Internet of Things = the interconnectivity and data exchange between devices and systems over the internet, new computing technologies), XR has the potential to design teaching and learning based on the principles of transmedia learning framework (TLF) (Ziker, Truman, & Dodds, 2021). TLF represents a new way of thinking about teaching and learning, one that goes beyond the classical approaches, making the entire experience immersive, even at a neurological level (Raybourn, 2018). One of the challenges in implementing XR is making 3D production easier for everyone, or at least finding and preparing in each institution the right personnel, capable of authoring such content and offering maintenance (Ziker, Truman, & Dodds, 2021). Because XR can feel so real, our brains almost see no difference between reality and XR and the biochemical traces of learning are the same as the real experience (Bailenson, 2018). Therefore, behaviors can be positively changed, by increasing empathy, curiosity or diminishing negative stereotypes (Ziker, Truman, & Dodds, 2021).

When people completely change environments, this can come with a whole range of issues that need to be addressed. These have been mentioned in the second chapter of this article and we will briefly list them here again: privacy, safety, and accessibility. On the other hand, there is no danger to the learners, as they can test any ingredients without the fear of making mistakes. Also, there are no limitations of time and space, as in an XR environment space is unlimited and time can always be reloaded indefinitely. Finally, after the initial investments for hardware and software, the cost for materials is (almost) zero.

For XR technologies to be implemented on a large scale, they need to prove worthy and more effective than classical ones, or to be complementary to classical teaching and learning. Future research is needed on both specific disciplines and technology (apps, programs, software, and hardware). When testing existing technologies or developing new ones in the educational field, students are to be asked and involved in the design process. Also, universities should collaborate with universities and other institutions in adapting existing technologies and developing

new ones. Englund (2017) considers that these technologies provide the proper learning opportunities, because they are both immersive and collaborative, with a shift from the traditional approaches which focus on learning about something, on learning of being.

Of course, there are those who will oppose all these changes for all possible reasons. However, doing this nowadays is like trying to oppose the shift from the agrarian economy to the industrial revolution. Change is the only constant, which means that change will happen, whether we like it or not. So why not embrace it and adapt to it? Time will tell whether the industries will adopt and incorporate XR into their core, and we are particularly curious about the field of education. Because education has the ability to teach peoples' minds and souls for the better.

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REZUMAT

Educația a fost întotdeauna unul dintre stâlpii importanți ai societății. Fie că a avut loc în Egiptul antic, Roma sau Grecia antică, în perioada iluminismului sau în vremuri moderne, a fost în centrul preocupării oamenilor și a fost înconjurată de provocări și oportunități. În prezent, noile tehnologii care apar zilnic ridică o întrebare justificată, și anume dacă tehnologia poate ajuta educația și în ce fel. Odată cu trecerea la noile tehnologii din Industria 4.0, unul dintre mediile cele mai promițătoare pentru educație este realitatea extinsă (XR), care reprezintă o combinație de realitate virtuală, augmentată și mixtă. În acest scurt articol, analizăm asemănările și diferențele dintre tehnologiile menționate, precum și beneficiile și provocările ce țin de design și implementare. Totodată, arătăm provocările care apar în implementarea unor astfel de tehnologii la o scară largă – intimitatea, siguranța și accesibilitatea. Per ansamblu însă articolul este un manifest în favoarea utilizării acestor tehnologii în predare și învățare, de la grădinițe până la universități inclusiv, deoarece au toate ingredientele de care studenții au nevoie: sunt scalabile, ajută și motivează studenții, scad încărcătura cognitivă, pot fi utilizate de la distanță și au un impact minim asupra mediului.