Experiences with Extended Reality Use in Education During Pandemic

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Abstract. *The COVID-19 pandemic has impacted almost all sectors of society due to lockdown measures taken to contain the spread of the virus. The education sector had to adapt quickly to this scenario, in which regular teaching and learning process was disrupted by sanitary measures. This exploratory study aims to investigate what kinds of experiences have been developed with extended reality technology during these challenging times. We aim to discuss what applications were used, in what contexts and how they were used. 27 teachers that represented a broad cross-section across teaching levels and subjects answered an online survey in order to help us understand those issues. Results have shown that varied applications were used for different subjects and in different contexts. The main reason for use was to enhance students motivation and engagement.*

Resumo. *A pandemia do COVID-19 impactou quase todos os setores da sociedade devido às medidas de bloqueio adotadas para conter a propagação do vírus. O setor de educação teve que se adaptar rapidamente a esse cenário, em que o processo regular de ensino e aprendizagem foi interrompido por medidas sanitárias. Este estudo exploratório tem como objetivo investigar que tipos de experiências foram desenvolvidas com a tecnologia de realidade estendida durante esse período desafiador. Nosso objetivo é discutir quais aplicativos foram usados, em quais contextos e como eles foram usados. 27 professores que representavam uma ampla variedade de níveis de ensino e disciplinas responderam a uma pesquisa online para nos ajudar a entender essas questões. Os resultados mostraram que aplicações variadas foram utilizadas para diferentes assuntos e em diferentes contextos. O principal motivo do uso foi aumentar a motivação e o engajamento dos alunos.*

1. Introduction

Businesses and public bodies increasingly see the value that Extended reality (XR) can bring to their organizations, allowing for cheaper training costs, easier product development, better collaboration across complex projects and vastly improved visualization. Consumer XR may not have quite the same level of profitability yet but it is showing signs of major potential and key developments have been expected of this sector. From the likely dropping of the next generation of consoles into the consumer market, to decreasing headset costs, to the explosion of open-source development software, to the rash of AR integration on major platforms, the space is likely to evolve extremely rapidly and for the better [Hadwick 2019].

DOI: 10.5753/sbie.2022.225021

Research has shown that the global XR market has thrived during the pandemic and that it benefited many sectors during this period, such as retail, healthcare and other industries [Mathew and Pillai 2022]. The global education system has been hugely disrupted due to the ongoing pandemic which forced educational institutions worldwide to instantly switch to an unplanned and sudden online learning mode. Digital technologies stood as an alternative to mitigate the negative impact lockdowns would have otherwise caused. [Mathew and Pillai 2022] argue that the challenges faced because of remote learning could be handled by incorporating XR related technologies to enhance the collaborative learning experience for remote learners. They claim that XR has emerged to solve the issue of distance impediments, boost productivity, enhance remote learning experience, reduce errors and cost in almost every industry. Thus, this exploratory study aims to investigate the impact of those technologies in education during these challenging times.

2. Related Works

[Milgram et al. 1994] established a continuum that is helpful to explain different emerging technologies. This continuum covers the different possibilities of mixing real and virtual environments, as illustrated in Figure 1. In one of its extremes, we have the real environment and in the other end, the virtual environment. Between those extremes, there are Augmented Reality and Augmented Virtuality, which is a mostly virtual world with some real objects.

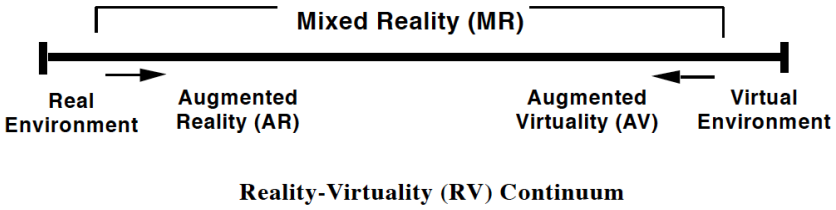

Figure 1. Reality-Virtuality Continuum.

As can be seen, the main difference between Augmented Reality (AR) and Virtual Reality (VR) is that in AR the real-world is enhanced with virtual objects, whereas in VR, the user is immersed in a complete virtual environment. Due to the rapidly-evolving characteristic of this field, discussions have been made concerning the definition of Mixed Reality (MR). [Speicher et al. 2019] have shown that there is no universally agreed definition of MR. They interviewed 10 experts and reviewed 68 academic papers and identified six existing notions of MR. The most popular definition and the one adopted in this work is the traditional notion of MR in accordance with the Reality-Virtuality Continuum [Azuma 1997] as exposed above. That means a mix of real and virtual objects on a spectrum between a fully real and a fully virtual world. In other words, everything that is between the real environment and VR is Mixed Reality, which includes AR and Augmented Virtuality [Azuma 1997].

Another term that has been increasingly popular in the area is Extended Reality or XR, which is an umbrella term bringing together emerging technologies, such as Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR)

[Mathew and Pillai 2022]. Studies have shown that these technologies can facilitate experiential learning, engage learners' leading to improved retention rates and help them in experiencing and understanding abstract scientific concepts by connecting them to the real world [Mathew and Pillai 2022, Donally 2018]. Students can visit and experience locations that are too far away without having to leave their place, remotely do their labs using virtual labs and perform experiments which otherwise is a concern due to lockdowns to curb COVID-19 spread [Mathew and Pillai 2022]. Several mechanisms can be used to enhance instruction, namely: storytelling, role play, skill building, 3D visualization, rich digital content, social emotional learning, laboratory, game based learning and research [Yang et al. 2020]. Among the benefits of incorporating these technologies into education are: learn by doing approach; and anytime, anywhere learning [Chard 2020]. Nevertheless, there are some barriers to XR adoption in remote learning reported in the literature, such as lack of required skills to use XR technologies, access to hardware or incompatibility with the existing pedagogical approaches. Staff training, management support as well as clear directives and training for learners are among the actions that could be taken to help overcome those barriers [Mathew and Pillai 2022].

3. Methodology

We applied an online structured survey to gather information about our research questions using a Google Form. The questions were related to (a) teacher's personal and background information, that is, gender, age, teaching time, education background, institution, school subject and teaching segment they teach; (b) frequency of XR use; (c) experiences with XR use, that is, technologies used, teaching segment in which they were used as well as description of the application(s) used, their practice with it and the motivations for using it; and (d) creation of XR content, that is, who created the content, what tools were used to create it as well as possible problems faced during the creation experience.

We aimed to recruit participants that represented a broad cross-section across teaching levels and subjects. Thus, this form was shared with English and Portuguese speaking teachers from different countries, levels and areas of expertise as well as to mailing lists and social media groups of teachers interested in innovation and XR use in education. Participants were requested to fill out the form and share it with their colleagues, a method known as snowball or chain sampling [Naderifar et al. 2017]. All the answers were provided in July and August, 2020.

To treat the qualitative data generated throughout the survey, we used the coding cycles proposed by [Saldaña 2013]. This data was treated using thematic analysis which "is a type of qualitative analysis. It is used to analyze classifications and present themes (patterns) that relate to the data" [Alhojailan 2012]. Phrases and sentences, called codes in the thematic analysis methodology, were created and grouped by themes. This step corresponded to what [Saldaña 2013] labels as "themeing the data". The unit of analysis was all teachers' responses considered together. In order to support the coding process as well as the visualization, retrieving and analyzing processes, we decided to use the software ATLAS.ti[1].

[1]Available at `https://rb.gy/lo6agb`.

4. Results and Discussion

27 teachers answered our survey. 19 answered the Portuguese survey and 8 answered the English one. Nevertheless, we found out that 12 respondent teachers actually used XR in their practices during the pandemic. 8 of them answered the Portuguese survey and 4 answered the English one. This is the sample considered in this analysis.

4.1. Participant's Background

Teachers were evenly distributed regarding gender. On average, they had 46 years old and had been teaching for 19 years. They are, thus, experienced professionals and highly qualified. Most of them have a master or a specialization degree as can be seen in Figure 2. Most of them teach high school groups, mostly in private schools as shown in Figure 3. The subjects taught varied widely from English (4) and Chinese (1), to technology (2), Edtech (1), Botanics (1) to Geography (1) and Math (1).

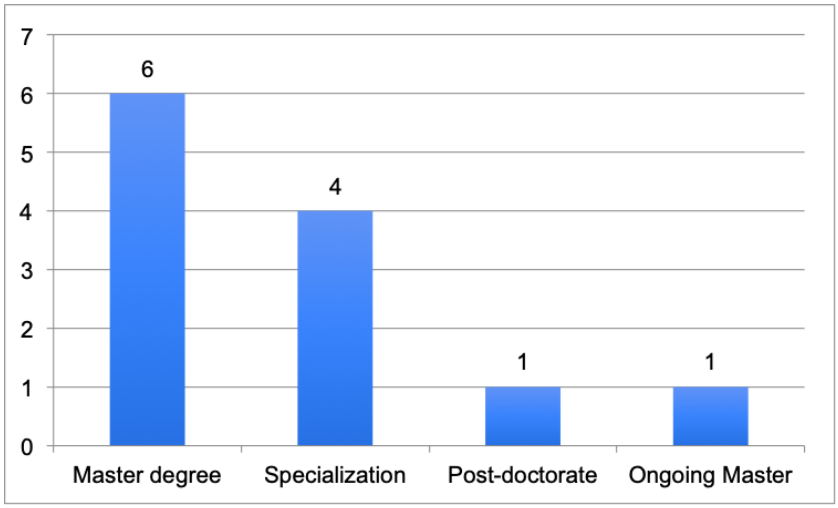

Figure 2. Teachers according to their educational background.

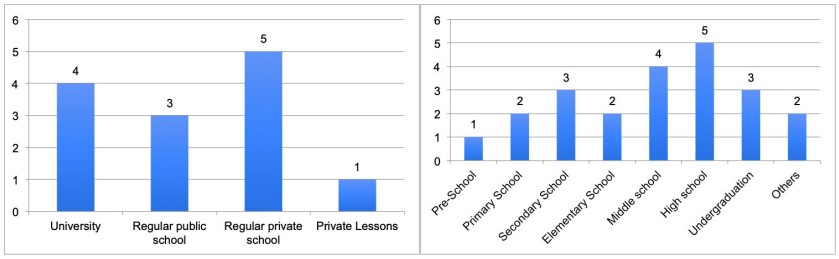

Figure 3. On the left, teachers according to what kind of institution they teach. On the right, teachers according to the segment they teach.

4.2. XR Use

50% of teachers used XR more than once, but not much as shown in Figure 4. Surprisingly, 17% reported never considering using XR in their classes, which might indicate a casual use not thoroughly planned. No teachers reported having used it only once. As regards to specific technologies, most of them used both AR and VR as displayed in Figure 5. Most teachers used XR in K-12 education as can be seen in Figure 6.

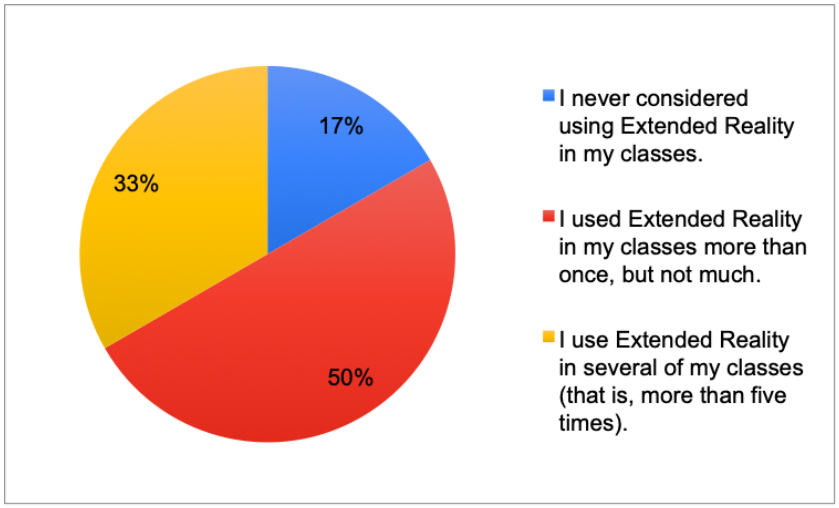

Figure 4. Frequency of XR Use.

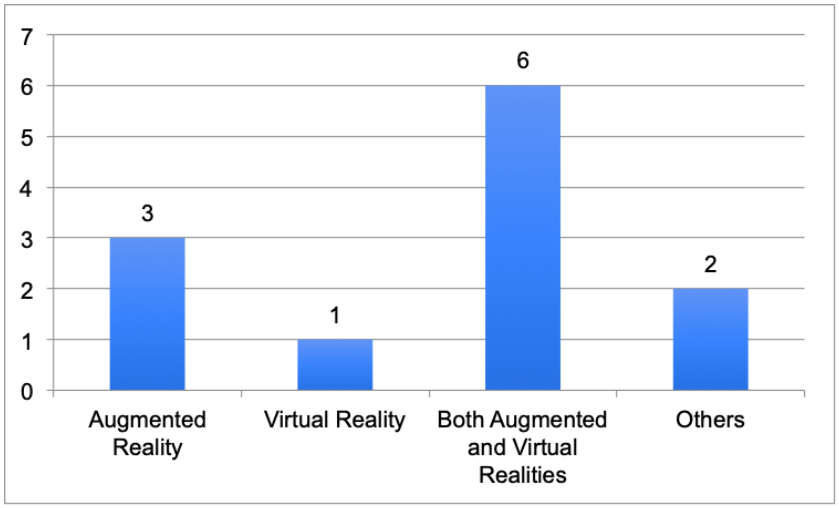

Figure 5. XR Technologies Used.

When asked about the applications used, teachers mentioned Google Expeditions[2], HP Reveal[3], Vuforia[4], QR Codes, 360º Immersive Experience with audio, Zapworks[5], Microsoft Hololens[6] and CoSpaces[7].

The main motivation for XR use was to provide variety for students during the pandemic (3 mentions) as well as to engage them in learning (2 mentions). Two teachers also mentioned reasons related to improving learning and preparing students for the future. AR was seen as an alternative to help students interact with content and understand it better as illustrated in this speech: "*In the regular Chinese classroom, teachers always use the physical objects to instruct the unique Chinese grammar structure, however, it's*

[2]Available at `https://rb.gy/msrxul`.
[3]Since late 2020, HP Reveal is no longer available.
[4]Available at `https://rb.gy/nqzviy`.
[5]Available at `https://rb.gy/aa8j6g`.
[6]Available at `https://rb.gy/9ki0ti`.
[7]Available at `https://rb.gy/qeyxen`.

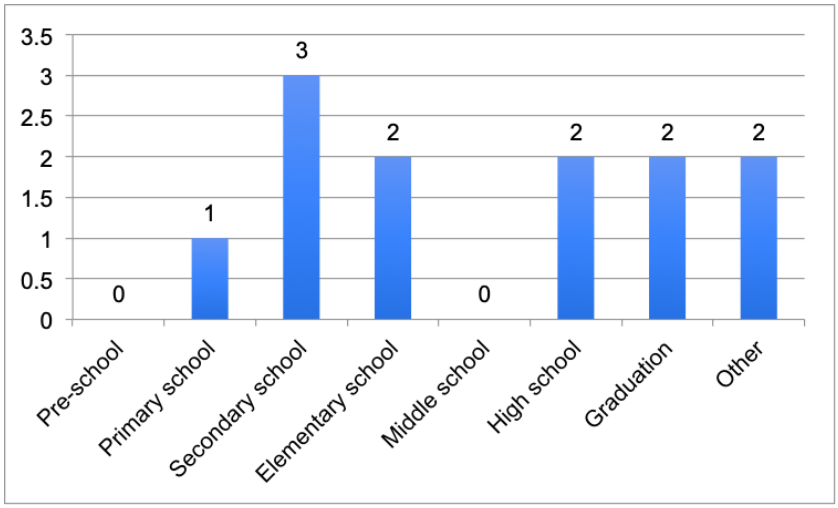

Figure 6. Teaching Segment of XR Use.

difficult in distance learning. I used the AR tech to present students the vivid 3D objects to help them understand the grammar and motivate them.". One teacher mentioned that his GEG (Google Educator Group) colleagues were the main motivation for XR use, which reveals the value of peer incentive.

As regards the practices conducted with XR technologies, we found out that among the goals for uses teachers mentioned: the work with diverse content, as a complement for students, to demystify AR and to implement games. Some teachers focused on describing the context for use, one of them mentioned that the results seen made clear the potential for interdisciplinarity as illustrated in this quote: "*It was interesting. It fostered a lot of conversation in the target language (English). The students found the experience very cool and rich. They were able to expand their vocabulary and also relate to other curricular components. Making clear the potential of the resource, in addition to bringing the possibility of interdisciplinarity.*". The results of the experiences varied. Most teachers reported positive results. One of them mentioned it was "*excellent*". Nevertheless, due to a limited database one teacher reported to feel frustrated. In Figure 7, we can see the relationships observed among the themes found related to XR use.

4.3. XR Content Creation

Most teachers did not need to create XR content as shown in Figure 8. As regards the tools used, teachers mentioned HP Reveal, Vuforia, and Zapworks. This suggests that most of them used content-design tools, that is, tools that do not require programming from the end-user; whereas one of them used Vuforia, which requires programming knowledge [Hampshire et al. 2006].

Not many problems were reported by the teachers. One teacher mentioned a problem regarding infrastructure, that is, some of the students did not have a good internet connection. Another one mentioned that "*sometimes it requires web scripting knowledge if designers want to make the AR content more interactive.*". Nevertheless, while describing their practices with the tools, teachers described some issues related to limited databases as can be seen in this quote: "*It was frustrating having limited content available on Hololens in 2016 .*".

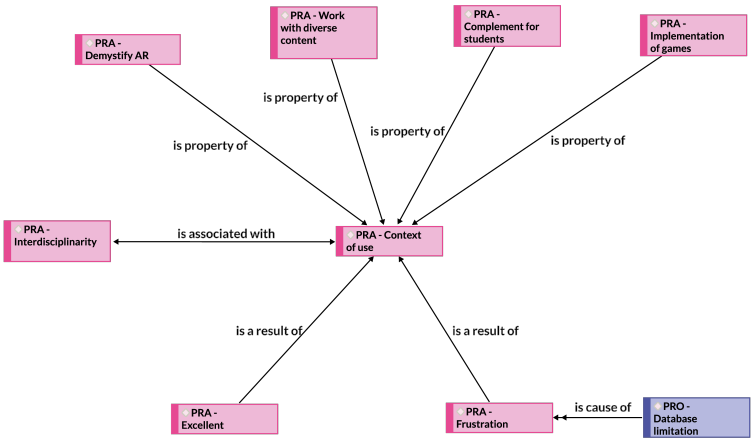

Figure 7. Network of relationships concerning practical use of XR. The code "PRA" refers to practice and "PRO" to problems.

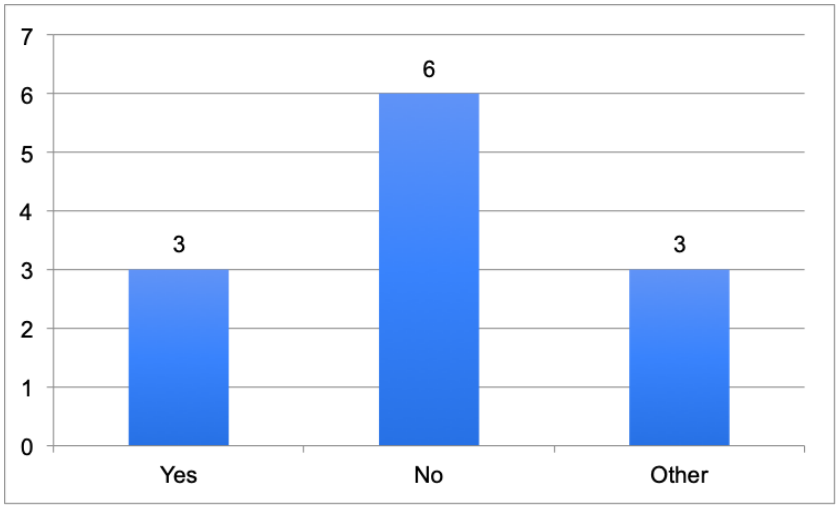

Figure 8. Did you need to create content for XR applications?

5. Conclusion

Results have shown that varied applications were used for different subjects and in different contexts yielding mostly positive results. Teachers were motivated to use XR mostly to add variety to their lessons as well as engage students in the learning process. On average, these teachers were older, experienced and highly qualified. Most of them teach in private schools. Nevertheless, some barriers to use were found related to the lack of infrastructure, limited database and knowledge to make contents more interactive. These barriers corroborate to what has been reported in the literature during and even before the pandemic [Mathew and Pillai 2022, Oliveira da Silva et al. 2019, Silva et al. 2018].

When we consider the uncertainties of the post-pandemic scenario, it is increasingly necessary to adopt innovative solutions that can mix the best of face-to-face and hybrid activities. XR stands out as a viable alternative for bringing immersion, something that is lost or hindered with remote teaching. Also, it is interesting to point out that the use of XR as reported in this research suggests teachers are moving forward to adapt their strategies as concerns the remote teaching during the pandemic. In his work,

[Silveira 2021] shows that the shift from long videoconference sessions to shorter ones and activities that require student's actions is a characteristic of phase 2 of the adapted remote teaching seen during the pandemic.

Thus, we conclude that efforts are needed in order to popularize the use of XR promoting equitable, diverse and meaningful experiences for our learners. These efforts might involve diverse stakeholders. For instance, teachers must have proper training as well as being encouraged to create content and share it with peers. Developers could also work in partnership with educators to develop a broader database of appropriate and reusable educational content.

As limitations of this study, we point out the number of answers received in the form. The teachers who used XR might be considered in a way pioneers in the use of technology and may not represent the general population. Therefore, this sample may not represent the entire teaching community.

6. Acknowledgements

The author would like to thank the teachers who contributed with this research as well as João Marcelo Teixeira and Daniel Perazzo for their insightful reviews.

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