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The possibilities of changes in learning experiences with Metaverse

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Abstract

This review aims to define the Metaverse, present the roles of AR, MR and VR, and also the concepts of digital twins and lifelogging. The evolution of applications for Metaverse in various sectors, especially gaming, has created the possibility of using Metaverse for education. We present the vast field of these applications and educational projects. The challenges that educators face are discussed and the potential and limitations of its educational applications are explained. It's suggested to embrace the Metaverse in classes but not in a full-time learning environment, instead, it should be used as a complement, when justified. Some of its limitations may be weaker social connections there are concerns for privacy and security. The big potential offered by Metaverse technologies is the immersive experience of content and social interactions.

Keywords: Metaverse; virtual reality; augmented reality; virtual worlds; learning experiences.

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1. Introduction

In this age of technology, many education researchers are interested in modifying the education system to improve learning experiences. Learning and teaching methods have been developed and expanded due to technological advances in recent years[1]. Different technologies were embraced by educators over time, and recent advances are getting included too. This article looks for the Metaverse as a possible tool for educators to use in their classes and summarizes the state of development of the Metaverse and presents the technical framework in section 2. In section 3, the link between the Metaverse and education is developed, presenting the projects and platforms as well as its potential and limits. Finally, we present our considerations.

2. Metaverse: concept

"So Hiro's not actually here at all. He's in a computer-generated universe that his computer is drawing onto his goggles and pumping into his earphones. In the lingo, this imaginary place is known as the Metaverse. Hiro spends a lot of time in the Metaverse"[2].

The word Metaverse originates from the novel Snow Crash first published in 1992, from which the above quote was taken and refers to a world where the virtual and the real interact through different social activities. The word is composed of meta and universe, where meta expresses the notion of transcendence and verse a hypothetical synthetic environment linked to the physical world[3]. The Metaverse presupposes a very wide range of new technologies, is connected to the internet, is a social form and provides an immersive experience through Augmented Reality (AR). This universe appears to be a replica of the real world, with an economic system based on blockchain technology and mixes both the real and virtual worlds in its economic, social and identity system where each user is invited to create content and edit their world[4]. Without leaving out cultural and political activities. So, we can see replicas of buildings, environments, spaces and objects from the real world, although, the Metaverse is not exactly a faithful replica, it presents its properties and functions.

Initially, the Metaverse focused on building its virtual world but quickly evolved into something more complex, more social, more like a medium that enables an exchange of interests and content-centred social interactions[5]. Despite this change, the development of the Metaverse is still taking its first steps, its architecture still does not present a constant definition, and neither the academy nor the industry can provide that answer. Duan et al[6] propose a three-layer architecture: infrastructure, interaction, and ecosystem (from bottom to top). These consider that architecture must cross the physical world to the virtual. The infrastructure layer contains the fundamental requirements to support the operation of the virtual world, including computing, communication, blockchain and storage; the interaction layer unites the real and virtual worlds, this layer has as components the immersive experience, digital twins (aka virtual replicas or mirror worlds) and content creation; the ecosystem can provide a parallel, living world at the service of all its inhabitants, in this way, people can have different real-world experiences and make friends with AI-operated characters; this last layer prioritized User-Generated Content (UGC), economics and AI.

It is also necessary to distinguish Metaverse from cyberspace, as the latter is a more inclusive concept that reflects the totality of shared online space in all dimensions of representation, whereas Metaverse refers more to a fully immersive three-dimensional digital environment.[7].

Still, in the field of virtual reality (VR), the Metaverse was conceived for the 3D Internet or Web 3.0, having been thought of as different virtual worlds or several virtual worlds between which avatars could travel and move from one to another without restrictions. What happened in Opensim's Hipergrid, however, Hipergrid brought with it an inconvenience: it was not compatible with other virtual worlds such as Second Life. Currently, in the construction of the second iteration of mixed reality (MR) of the Metaverse, social and immersive VR platforms will support massively multiplayer online video games, open game worlds and collaborative AR spaces. This will allow users to meet, socialize and interact without restrictions, embodied as 3D holograms or avatars in physical or virtual spaces. Currently, this is already possible with several limitations within the same platform. This will be the next step: cross-platform and cross-technology meetings and interactions, where some users are in VR and others in AR environments[8]. This premise to be reached meets some rules of the manifesto "The seven rules of the Metaverse" written by Parisi [9]: "Rule #1. There is only one Metaverse. Rule #2: The Metaverse is for everyone. Rule #3: Nobody controls the Metaverse. Rule #4: The Metaverse is open. Rule #5: The Metaverse is hardware independent. Rule #6:

The Metaverse is a Network. Rule #7: The Metaverse is the Internet". This author also recalls that these rules are already adopted by many, which are axiomatic and were born from the experience and knowledge of different professionals.

Despite this manifesto, there is still no single, unified entity, though there are several joint efforts where virtualization and 3D Web tools and objects are incorporated[10].

We are facing a concept, or rather a world, in constant change and there will be as many possibilities for evolution as there are users/contributors. In short, the Metaverse is a decentralized network of virtual spaces where you can socialize, learn, work and play. This will make use of other emerging technologies (5G, blockchain, artificial intelligence) and will be accessed through HMDs with 3D graphics, the Metaverse will contain an interactive and virtual equivalent of our physical world (in terms of people, places and things) that we will be able to explore for through extended reality (XR) platforms[11], Fig. 1 compares the technologies that XR embraces, differences about virtual contents, real contents and interactivity. As we can observe AR has low virtual and real content as opposed to VR; both have the same degree of interactivity; MR compared to AR and VR when analysed both virtual and real content is placed in the middle, but when evaluated the interactivity surpasses both; because XR embraces all of them, its virtual and real contents and interactivity are switchable[12].

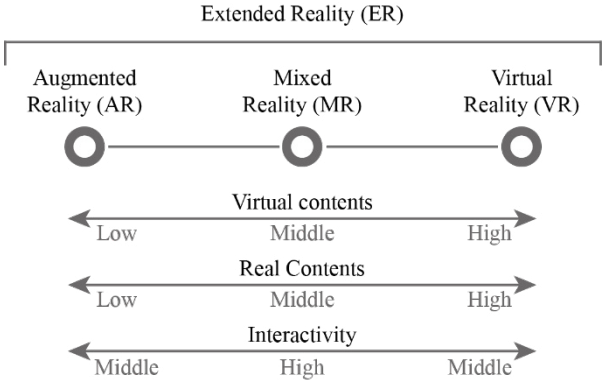

Fig. 1. Comparison of Virtual Reality, Augmented Reality and Mixed Reality [12].

3. Metaverse and education

The Metaverse already embraces different components of life, such as playful, social, economic and also related to learning. Education has always followed the advancement of technologies and forms of communication; we have examples that are about two hundred years old, as is the case, in the 19th century when the Magic Lantern began to be included in classes and in the late 1910s eight thousand Magic Lanterns circulated in the public school system in Chicago[13], it is still in the 19th century that the first forms of distance learning develop and no form of distance learning would be possible without the use of different forms of communication and new technologies it can be seen that these evolve alongside the evolution of communications /technologies. Distance learning started with correspondence teaching, it moved on to radio and television broadcasting, with cassettes/discs, correspondence teaching continued to provide its service, later with the computer and the internet b-learning and e-learning were disseminated[14]. However, it was not only distance learning that benefited from new technologies, traditional education has always been adopting technologies from things as simple as a photocopier or a video projector to interactive whiteboards, 3D visualization models and social networks.

Therefore, it is natural that teaching, once again, takes advantage of these new tools. VR, AR and 3D models are already used tools, the Metaverse encompasses all these tools and enables a more immersive experience, so it will not be the exception.

When compared to e-learning as we use now (throw platforms like Moodle, Zoom, Google Classroom, Meet), one of the clearest advantages that the Metaverse can bring is the sense of reality during virtual classes, this factor can be the solution to one of the e-learning weaknesses[15]. Nonetheless, it is not just in e-learning that the Metaverse can be

used as a tool to facilitate learning, it will also take place in traditional teaching since there is already considerable research in the field of virtual reality and its application in teaching. This research can be explained at two levels, at the practical level VR provides an opportunity to create learning experiences that students can benefit from without the constraints that come with planning and carrying out, for example, a study trip; psychologically, the immersive and interactive nature of VR is positively associated with feelings of satisfaction and commitment; in turn, these feelings lead to improved learning[16].

The same has happened with research on AR in education, many of these studies are in favour of learning and the use of training techniques with AR because AR increases student motivation, the ability to work in groups and the learning is lasting[1]. Templeton[17] describes that the most considerable and unique benefit that AR has in educational practices is its ability to use 3D images to illustrate complex concepts, concepts that can be easily explained or demonstrated through the use of AR resources such as Galactic Explorer for Merge. Cube, where you can manipulate holograms like the solar system, observe the comparative sizes of planets and the distance between them. This manipulation creates an immersive and realistic experience that increases the frequency and depth of connections made between the student, the contents, and the real world.

Knowing that AR and VR are further explored by STEAM disciplines (Science, Technology, Engineering and Mathematics)[15], in this article, no distinction is made between areas of application in teaching subjects in the Metaverse.

The concepts of digital twins, as well as VR and AR, have already been addressed, but there is another Metaverse concept that is lifelogging that could also have a great impact on the application of the Metaverse in teaching. Lifelogging is the use of augmented technology (e.g. black boxes and wearables) to capture, store, share information and everyday experiences with people and objects[18].

There is also the danger of fading, as happened with Second Life, initially the educators investigated, created projects, which they even implemented, but in a short time, it seems that there was a disenchantment, as with so many other educational fads†. But there is a considerably different and important factor so that this disenchantment does not also happen with the Metaverse as well, its interest has been increasing after a pandemic that favoured the very rapid implementation of e-learning worldwide, contributing, for example, to the fact that using a headset for a considerable amount of time was no longer intrusive[19].

3.1. Teaching and learning in the Metaverse

There are different educational projects that use different technologies, with VR being present in most and 3D being present in all. The table below shows some of these projects, applications, and tools whose use may have applications in teaching. This collection is incomplete, but it serves the purpose o identifying some of the different platforms used by students and educators and their purposes. Some of these projects are not yet operational (Women Rise NFT; Meta Immersive Learning) and some of these projects (Labster, Mozilla Hubs) cannot be considered a Metaverse experience, however, they have representation for their usefulness and for being able to serve as an initiation or even a gateway to the Metaverse, as they can be incorporated into it.

There are also projects focused on educators (Roblox Education, Eduverse) something very important because without the training of educators the Metaverse will not become a viable tool, these educator-centred projects allow them to learn and create their content. Likewise, there are also projects whose target audience is students (Roblox Studio and Roblox learn and explore). In table 1 we also have tools that can be used by educators “à la carte” (Project Lead the way; American High School, KaiXR, EduMetaverse, Labster, Dreamscape Learn, Engage), a content creation tool only (Driftspace), schools that already only have classes in the Metaverse (Optimal Classical Academy) and schools that use a hybrid model (Dallas Hybrid Prep).

† “Fad” is an idea that is enthusiastically embraced for a short time[32].

Table 1. Projects and platforms that can be used in learning.

Project/platforms	Brief Description	Web page
American High School	Virtual-reality offerings	https://www.americanhighschool.education/virtual-reality/
Dallas Hybrid Prep	A hybrid model of virtual and in-person learning, is one of the first schools in USA to implement a Metaverse platform.	https://www.dallasisd.org/hybridschool
Dreamscape Learn	Advanced motion capture techniques allow multiple users to be rendered simultaneously, fully in touch with their senses, in real time.	https://www.dreamscapelearn.com
Driftspace	Allows creators to make engaging and interactive content without knowing code; content creator.	https://www.driftspace.com/
EduMetaverse	A collection of virtual worlds for education.	https://www.eduMetaverse.com.au
Eduverse	Hub for educators	https://www.k20educators.com/
Engage	A virtual communications platform that simulates the way we interact in the physical world, but without physical limitations, allowing for multi-user events, collaboration, training, education	https://engagevr.io/
KaiXR	Virtual field trips	https://www.kaixr.com/
Labster	Virtual labs simulations	https://www.labster.com
Meta Immersive Learning	Immersive learning - in process	https://education.facebook.com
Mozilla Hubs	Meet, share and collaborate in private 3d virtual spaces.	https://hubs.mozilla.com/
Optima Classical Academy	Online charter school where scholars are able to have classes together as avatars	https://www.optimaclassical.org/
Project Lead The Way (PLTW)	Computer Science, Biomedical Science, and Engineering educational experiences on Roblox	https://www.pltw.org/
Roblox		https://www.roblox.com
Roblox Studio	Teach children how to code their own video games	https://developer.roblox.com/
Roblox learn and explore	Learn new skills in coding, building, and game design	
Roblox Education		
	Teacher Training	https://education.roblox.com
Women Rise NFT	Digital art by artist Maliha Abidi – in process to build a school in the Metaverse	https://womenrise.art/

As can be seen, there are many content development platforms, from this observation we can deduce that there is already a large number of educators and schools acquiring and implementing these tools in their classes, as there is no supply without demand. We also know that Roblox has created a $10 million fund to support the creation of learning experiences using their platform, Project Lead the Way is already a beneficiary of this fund[20]. About this fund, Rebecca Kantar (Head of Education and Director of the Roblox Community Fund at Roblox Corporation) says: “We're ready to find and reward developers and organizations who can figure out how to really lean into our great physics, strong immersive 3 -D capabilities, and multiplayer experiences to teach in a deeper way”[20].

Facebook, recently renamed Meta, invested $150 million in Meta Immersive Learning to “help develop and empower the next generation of creators, launch high-quality immersive experiences that transform the way we learn, and increase access to learning through technology”[21].

3.2. Potentialities and limits

Some of the potentialities and limits of the Metaverse and XR technology applied to education are similar to those of e-learning, e.g., the location: both the student and the educator can be located anywhere in the world. But we have others such as the availability of content 24/7, the offer of training, the possibility of offering personalized content,

ease of interaction, cost reduction, and respect for the pace of learning. We couldn't find any advantage from e-learning that didn't feat Metaverse. There are advantages of the Metaverse that overcome the shortcomings of e-learning because the learning environment is a 3-D environment it is more immersive and interactive. One of the downside of e-learning is the inequalities in accessing technology and this happens too in the Metaverse. Some of the potentials turn into limits when analysed in-depth, e.g., the costs, these can bring savings as they can turn into big costs, that is, we can have savings with spaces, materials and even personnel, but to access the Metaverse it is necessary to have a good internet connection and specific hardware, HMD (head-mounted display with controllers), however, we know that these devices are already more affordable and better[22]. This issue related to the cost of connection and equipment also raises equity and accessibility concerns. The social experience of the Metaverse is deeper when compared to a class taught through a platform such as Zoom or Google Classroom; or when we use the technologies that compose the Metaverse separately (AR and VR), however, the social experience in traditional education is superior, because social connections are weaker in the Metaverse, where an avatar is shown presented as what we intend to be and not what we are[23]. There are some studies that quantify some of these advantages and disadvantages, as is the case of a study carried out by PWC [24] which states that with VR the "learners train four times faster than in classroom, 275% are more confident to apply skills after train (40% improvement over classroom and 35% improvement over e-learn training), are 3.75 times more emotionally connected than classroom learners and four times more focused than e-learning peers, and users are significantly less distracted". In another study – "Virtual STEM class for nuclear safety education in metaverse" – learners should measure radioactivity in different scenarios showed that "all the students enjoyed the project, were excited by the avatar and the virtual three dimensional space very much, after the activity, students were hard to leave the classroom and continued to operate avatars in a pretty long time" and the authors agreed that "for such difficult educational materials the Metaverse could be an effective supplemental effect to get the educational outcome" but they conclude that "the mixture and blending of the lecture, lead and guidance in virtual Metaverse and the hands-on experiments in STEM education could be effective, using Metaverse and the virtual system as one of the components"[15]. So, they don't present a learning experience only focused on Metaverse, instead, we see a mixed approach that joins traditional classes with Metaverse. This is an important point, this research showed several platforms in table 1 that could function as a support tool in traditional classes but don't substitute them, this fact is brought too, because the health issues, like cybersickness, could become worst with the prolonged presence in Metaverse. "A prolonged time spent in virtual reality spaces could aggravate symptoms linked to digital eye strain, including blurry vision, headaches, and dry eyes (...) although research into the long-term consequences of VR use is still scarce [25]. Another study explains that some initial discomfort relative to simulator sickness gets overcome with time: "there was some indication that participants gradually overcame negative first impressions and initial discomfort[26]". This study was applied to working adults, not students.

In a ten-year review of educational virtual environments, some of the author's conclusions were: "Features of VR that contribute to learning (…), are first-order experiences mainly coming from free navigation and first-person point of view, natural semantics, size, transduction, reification, autonomy and presence. (...) Our findings show that both students and teachers share a positive attitude toward the use of virtual reality in educational settings (...) Characteristics of VR such as immersion and features, especially the sense of presence, are also important factors that contribute to learning and need further exploration"[27].

Table 2 presents a collection of advantages and disadvantages presented by different authors, some of which are mentioned only for VR, but are suitable for the Metaverse. We believe that one of the main advantages of the Metaverse is the degree of immersiveness combined with the social component that surpasses previous technologies.

Table 2. Advantages and disadvantages of Metaverse.

Advantages	Disadvantages
Increase Interest and Motivation to Learn[11]	Cognitive Load [11]
Visualization[11]	Time Constraints[11]
Active Learning[11]	Accessibility[11]
Game-Based Learning[11]	Affordability [11,28]
Virtual/Augmented Field Trips[11]	Lack of Educational Content [11]

Role-Play and Perspective-Taking [11]	Privacy and Safety (scammers, predators, commercialization) [11,19,20,23]
Immersive Storytelling [11]	Difficult to Assess Learning [11]
Novel Social Interactions [11]	Inequality[28]
Faster training[24]	Cybersickness[22]
More confident to apply skills learned after training [24]	Social connections in the Metaverse are weaker than interactions in the real[23]
More emotionally connected to content [24]	
More focusing than e-learning peers [24]	
Avoid the harm of reality experiment.[4]	
Humanity (could be an excellent approach for cultural communication and protection) [29].	
Immersive experiences make digital interactions feel more human[28,30]	
Flexible (time/place), accessibility[4,6,19,28]	
Equality[6,28]	
Effective Tool for Tough Topics[24,31]	
More immersive and social experience[19,23]	
A higher degree of freedom to create and share[23]	

4. Final considerations

This paper brings insights into some terms related to the Metaverse and also presents projects/platforms that can be used by educators and students, finishing with the presentation of the advantages/disadvantages of the Metaverse in a learning context.

The Metaverse provides experiences that are impossible, or extremely complicated to implement in traditional teaching, we can imagine that students have the opportunity to hear speakers from anywhere in the world, and simulate any type of experience in virtual laboratories, without constraints of materials or equipment, the possibilities of study visits are also endless, even learning new languages can benefit from cultural exchange[19]. We believe that all disciplines can benefit from the Metaverse. Its use will have to be an object of reflection, the lack of studies on the consequences of prolonged use of the Metaverse leads us to propose that its use be complemented with traditional classes.

We also have concerns about data privacy, cybersecurity, cyberbullying, scammers, and predators, but all these problems aren't new, and we're more aware of them and more prepared.

Regarding the advantages and disadvantages, XR offers a great sense of immersion when compared to other technologies, we still have a long way to work, need to improve the hardware (audio, speech, expressions) and equip schools. We guess that content won't be a problem, with more users, more specialized content producers will appear, and it can bring monetization opportunities for schools.

In future works, the authors would like to test different platforms/projects with different subjects and bring insight into which ones could be more helpful and catalogue the different platforms/projects for age/subjects correspondence with the concern of conveying impactful learning experiences. Another possibility is to approach the learning curve of these platforms/projects or construct a learning path to help educators initialise their experiences in metaverse in an easier way.

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