The Metaverse evolution: Toward Future Digital Twin Campuses

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***Abstract*—The term 'Metaverse' has been used to refer to the next generation Internet (NextG). New, developing, and recently innovation technologies have enabled the incorporation of digital twins into education's metaverse. This is a shared virtual area that combines all virtual worlds over the Internet. This will enable users represented by digital avatars to interact and cooperate as if they were in the physical world. While the metaverse may seem futuristic, it is accelerating because of emerging technologies such as AI and Extended Reality. This paper explores the technologies utilised to build the metaverse and practical applications on improving the educational experience and offer value by optimising how students are taught. Thus, we shall study in detail eight enabling technologies that are important for the Metaverse ecosystem: Virtual, Augmented, and Mixed Reality. Autonomy of Avatar, Computer Agent, and Digital Twin. Data Storage, Data sharing and Data interoperability. This article will discuss prospective metaverse technology and its difficulties. Finally, we have looked at societal acceptance, privacy, and security challenges.**

Index Terms - Metaverse, Extended Reality, Artificial Intelligence, Augmented Reality, Mixed Reality and Virtual Reality, Autonomy of Avatar, Computer Agent, and Digital Twin, Data Storage, Data sharing and Data interoperability.

I. Introduction

Despite the fact that the word Metaverse exists for over 3 decades, it was invented by *Neal Stephenson* in his 1992 science fiction book entitle *Snow Crash*. In this book, Stephenson defines the Metaverse as a vast virtual environment that coexists with the real world and in which individuals converse through digital avatars [1]. As a computer-generated world since its introduction, the Metaverse has been described by a plethora of notions, including lifelogging [2], shared virtual space [3], embodied internet [4], and a mirror world [5]. The Metaverse considers the use of a 3D VR along with its extension towards extended reality [8]. Everyday activities and economic life can be carried out via avatars that reflect the actual people who live in the real world [6]. Due to the rapid growth of 5G and mobile immersive mobile, the Metaverse has evolved in many verticals including education [7]. We are still in the early stages of developing the Metaverse. Furthermore, the Metaverse has the ability to extend beyond the fields of education and entertainment, is expected to impact our daily lives and the economy. It is impossible to overestimate the potential of the metaverse as a new forum for social discourse.

The following is the overall structure of the author's paper. Section II will cover the technological aspect of extended reality, which will consist of three subsections: Augmented Reality (a), Virtual Reality (b) and Mixed Reality (c). Section III will cover artificial intelligence, which is separated into three sequential stages, Digital Twin (a), Computer Agent (b), and Autonomy of Avatar (c). The following section is Section IV which will cover blockchain, which is separated into three sequential stages, Data Storage (a), Data Sharing (b), and Data Interoperability (c). Lastly, in Section V, the paper outlines many potential paths. A notable example would be that it can cause social relationships to suffer as well as the possibility of privacy invasion; it can also result in numerous crimes being committed because of the anonymity in the virtual environments, which may result in students struggling in the real world because their identities have not been formed.

II. Metaverse Explained

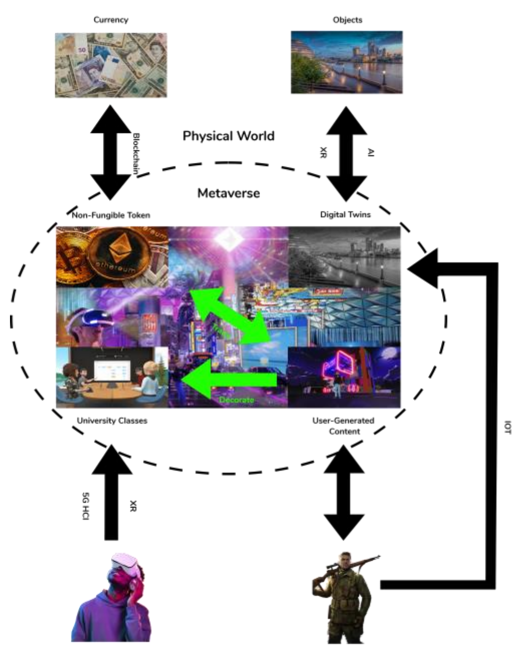

Figure 1 illustrates the Metaverse's essential characteristics and how they interact with the real world. Access to the Metaverse and participation in its numerous social activities is made possible using 5G and HCI technologies. The Metaverse allow users to decorate social gatherings with their 3D models. Additionally, Non-Fungible tokens may be used to exchange content on a blockchain network. An object's digital twin in the Metaverse is produced using 3D modelling and consumed using XR devices using artificial intelligence. Furthermore, the IoT will have sensors to get information, such as movements, to produce the digital twin.

It is critical to grasp the difference between AR and VR, with their respective positions on the continuum of real to virtual world established in [9]. The MR is a technology where the surrounding environment is genuine, and that natural environment is enhanced with augmentations. In contrast, in AR and VR, the surrounding environment is virtual. The real-to-virtual continuum is shown in Figure 2 and demonstrates which industry sectors use certain technologies.

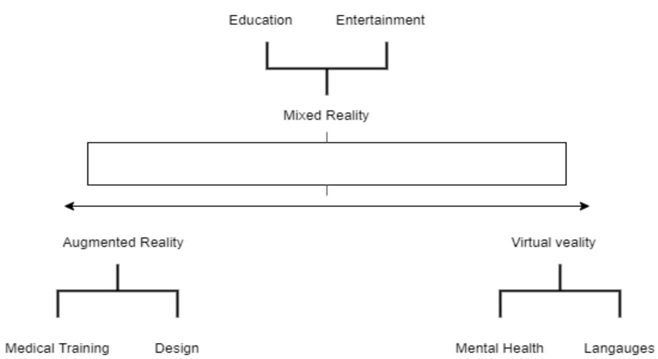

Figure 2: The real-to-virtual continuum

This article defines the Metaverse as a virtual environment that merges the physical and digital worlds, allowing for the delivery of education through it. Everyone in the Metaverse has their avatar, a virtual representation of their physical selves. To achieve this duality, the metaverse must evolve through 3 developments: digital twins (I), digital natives (II), and finally, co-existence of physical, virtual reality (III). Figure 3 shows the three phases linked. Our starting point is digital twins, where the natural surroundings are digitised and regular alterations to their fictitious counterparts take place. In the real world, digital twins create digital replicas of real-world environments, known as virtual worlds, where digital natives work on new designs. In the beginning, these unique digital environments have a restrained connection with the actual world, and a vast landscape will eventually unite them. At some point, the digitised actual and virtual worlds will blend, resembling surrealism in its last state. This linked physical-virtual universe demands an everlasting and 3D virtual cyberspace known as the metaverse.

Everyone in the Metaverse has their avatar, which is analogous to the user's physical person, allowing them to live an

Figure 1: The way metaverse elements connect with the environment around them.

alternative existence in virtual reality. Large-scale, high-fidelity digital models and creatures are referred to as digital twins in

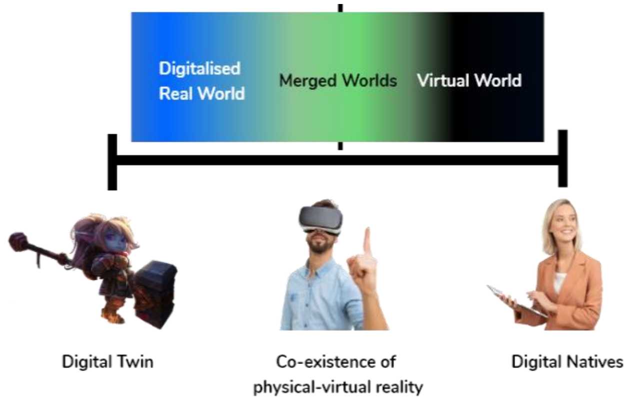

Figure 3: Digital Twin continuum

the context of virtual worlds. In digital twins, qualities such as motion, temperature, and even function are reflected from their physical counterparts [10]. Virtual and physical twins are linked via their shared data [11].

This article is the first attempt to provide a complete understanding of the Metaverse, considering both the technological and the sociological aspects. We will talk about the most recent technology and the problems and potential that the Metaverse offers.

III. Extended Reality (XR)

Extended reality encompasses both real and virtual integrated settings. The many categories within the continuum enable human users to experience the metaverse via various of alternating realities that exist in both the physical and digital realms [12]. Extended reality technologies supplement or replace our perception of real life, which are essential to the metaverse deployment [13]. Although we discussed a variety of realities, we focused on three basic categories of reality which range in the academic and industrial elements [14–16]. In this part, we begin with virtual reality and work our way to the burgeoning disciplines of augmented reality and its advanced variations, magnetic resonance technology. Furthermore, the section will be introductory to how virtual reality bridges the gap between virtual entities and actual settings.

A. Augmented Reality (AR)

Augmented reality goes beyond purely virtual settings to provide users with different experiences in their actual physical surroundings to improve the physical world itself. Location-aware systems and interfaces with additional and layered networked information on the areas we encounter regularly, extend the physical world outside of an individual [17]. In addition, glasses or lenses may be used to see both the actual environment and virtual visuals in real-time. A notable example, teachers may use AR to present virtual examples of subjects and include game aspects to supplement textbook content in the classroom. They may learn more quickly and better retain knowledge by using this method. Students may explore 3D ideas that can be rotated, zoomed, and more in AR. The effectiveness of AR in learning content is difficult to view directly or describe in language. This is because disciplines that need ongoing practise, expertise, and fields with high prices with great danger have all been assessed [18]. It's worth noting that students may study the human body's interior much as they would in an anatomy lab using Cruscope's Virtuali-Teep [19]. Moreover, simulation content can be linked to augmented reality as an educational example. Through simulation, the real-world and virtual worlds may be linked together to create more meaningful images. There are several instances of augmented reality technology being used in the medical industry nowadays. An augmented reality platform for spinal surgery has recently been developed by a research team at a Seoul hospital in collaboration with university laboratories [20]. Pedicle screws used for spinal fixation are projected onto a human body structure in real-time via augmented reality. It is also planned to establish a new educational system for spine surgery, based on this technology, that may be used in real surgeries. Augmented reality headsets benefit other techniques in refocusing the user's attention and occupying their hands. To begin with, users of various kinds of AR gadgets must juggle their focus between the actual world and digital information.

On the other hand, AR headsets allow AR overlays to be presented in front of the user's perception [21], [22]. A second advantage is that the users' hands will be free from the burden of holding and manipulating the actual gadgets. Virtual reality headsets allow users to see the Metaverse via an AR lens. Textbooks, tangible forms, posters, and printed brochures might be replaced with augmented reality. Using a mobile device to study also lowers the cost of educational resources and makes them more accessible to a broader audience. AR in education has several drawbacks or negative characteristics that must be considered before using it in the classroom. This is due to the complexity of the technology itself, as well as the cost or compatibility of the devices [23], the price of the applications and devices [24], design errors that cause the learning devices to run slowly [25], the difficulty of using it for students with visual needs [26] and the fact that teachers do not have the training to make materials [27].

B. Virtual Reality (VR)

There is a continuing search for new techniques to make information transmission easier, faster, and more effective. In the age of digital gadgets, we now have the chance to use technology to improve education. Another direction in education's progression will be virtual reality. This section explores how VR may revolutionise the way educational materials are provided. VR's application in teaching is by no means a breakthrough in technology. Using a head-mounted display linked to and included in a computer, fully immersive users may walk about in a 3D virtual environment or use a joystick to control their movements [28, 29]. 3D visuals, avatars, and instant messaging are just some of the features that make virtual reality so immersive. In this virtual environment, individuals feel as if they are completely immersed. It is common to think of virtual reality as the other end of a continuum that includes mixed and augmented reality [9]. Human perception function similarly to virtual reality, allowing individuals to view a flat picture in three dimensions [30]. Characters, places, and things in this virtual reality Metaverse are all built differently in the actual world. Figure 4 demonstrates a notable example of how VR can be incorporated into the class; students are invited to join classes to communicate with other students and learn [31].

Figure 4: Classroom via the Metaverse [31]

Users of VR headsets must devote their complete attention to the virtual worlds, so distancing themselves from actual reality [8]. As previously stated, people in the Metaverse will develop material for digital twins. VR will also enable students to be more hands-on rather than reading instructions from a textbook, improving their 'real-world' abilities. The authors have considered that virtual reality's capacity to imitate actual hands-on instruction might facilitate various learning methods. Users may also engage with one another in real-time due to the ability of 5G. The users’ perception to capture virtual items and multiuser cooperation in a virtual shared area will be crucial. Considering the Metaverse's ultimate stage, users in a virtual shared area should engage with other objects in the real world. The heart of constructing the Metaverse, via the composition of various virtual shared spaces, must blend the simultaneous activities of all surroundings, intentions and avatar behaviours. Virtual environments' dynamic states and events should be reflected in all involved processes' synchronisation and reflection [32]. When considering an infinite number of concurrent users may operate on virtual objects and communicate without any regard for latency, it becomes much more challenging to manage and sync the dynamic states and events at scale.

C. Mixed Reality (MR)

This section discussed about how the Metaverse, and MR are connected [30]. MR lies between AR and VR. When AR is combined with VR, you get MR, allowing an individual to interact with virtual items in the actual world. Despite this, there are several meanings of the term. Researchers think of MR as a bridge between AR and VR enabling users to engage with virtual things in real-world settings. A noteworthy example of how students' learning experiences might be improved by using mixed reality in education. As an example, students could explore historic places like the ruins of Ancient Greece or the battlefields of Vietnam without ever leaving the classroom. Students may benefit from a more engaging and successful learning experience via Mixed Reality (MR). Several papers [14], [33], [34], [35] argue that MR is a more potent form of AR because it draws more linked and collaborative linkages between the physical and virtual worlds.

In the author's opinion, the digital twins connected to the real world are the starting point of the Metaverse [36-40]. Following that, users begin to create material in the digital twins [41-45]. Human users anticipate that such digital things would integrate with their physical surroundings throughout space and time due to the ability of digitally produced contents to be mirrored in physical settings [46]. The current Metaverse prototypes, although not able to anticipate how the Metaverse will ultimately affect their physical surroundings, do have particular aims such as seeking scenes of realism [47], providing sensations of presence [48], and building sympathetic physical spaces [49], among others. These aims overlap with the Metaverse, promoting collaboration across virtual worlds. The downsides of MR include costly development expenses, additional expenditures for head-mounted displays, and a steep learning curve for daily usage. AR enables digital twins from the Metaverse to be superimposed over real-world objects, thus combining the two realms. MR enables people to interact with virtual items by connecting them.

IV. Artificial Intelligence

When considering the concept of a Metaverse, it is critical to keep artificial intelligence in mind. As a result of AI, robots may learn from their mistakes, recognise patterns in data, and synthesise new information based on the information they already have. AI may be used to free operators from tedious and difficult data processing jobs, such as monitoring and regulating, by using the enormous volumes of data available in the growing Metaverse.

There are three distinct types of AI applications in the Metaverse: digital twin, computer agent, and avatar autonomy. DL will have several advantages due to the massive volumes of complex data generated by the Metaverse. Digital twins, for example, may be used in the Metaverse as an intelligent healthcare tool. Using digital twins of patients, [50] developed a small surgical prototype. A robotic arm aided by Deep Learning will perform the same surgical procedures on the patient as were performed on their digital twin.

A. Digital Twin

Digital twins are digital clones of material things or systems that maintain high integrity and awareness and interact with the real environment [51]. These digital clones of their physical things may be utilised to offer classification [52], [53], recognition [54], [55], prediction [56], [57], and determination services [58], [59]. Interference from humans and manual feature selection are both times demanding. DL can automatically extract information from many complex data and expresses it in a range of applications without the need for human feature engineering. As a result, deep learning has tremendous promise for facilitating the deployment of digital twins. A digital Metaverse campus needs academics to respond quickly and accurately to students. As a result, the digital twin notion is inherently relevant to education.

Education may use learning algorithms to monitor and alert pupils who do not comprehend the assignment in real-time, allowing instructors to choose the amount of complexity with which they approach the issue with their digital twins. Nowadays, cities are implementing an increasing number of IoT sensors to monitor different data types and aid in city administration. Additionally, building information modelling (BIM) is becoming increasingly precise [60]. By merging IoT big data with BIM, we can develop high-quality digital twins for intelligent cities incorporated in education. For instance, we may study the effect of pollution in the air for people [61] or the effect of traffic signal intervals on urban traffic [62]. A similar strategy may be used to assess students' development and comprehension. Additionally, such a system might assist in solving the optimisation issue of solar panel location [63]. Additionally, data are heterogeneous, consisting of structured, unstructured, and semi-structured data, necessitating the use of a digital twin powered by deep learning [64]. The framework is built based on process and subject-matter expertise, and they then utilise existing data to train the AI algorithms for optimisation and prediction.

B. The Computer Agent

A computer agent, commonly known as a Non-Player Character (NPC), is a character in a video game whom the player themself does not control. This character is not a playable character in the game. As the difficulty of the level increases, the enemy's movement patterns will become more and more difficult to predict [65]. This is how NPCs started in games. NPCs' intelligence is shown in many ways, such as how they move, how well they look, how well their voices sound, and so on. The most common way for NPCs to react to what players do is to use finite state machines (FSMs) [66]. FSM thinks that an object goes through a set number of stages in its life. Each part of the FSM has a different name: the state, the action, and the next state. Conditions must be met for the object to do something new and change its state from where it is right now to where it needs to be due to the FSM algorithm [67], [68], [69], [70].

FSM is not very good at scaling when the game environment gets more complicated. A support vector machine allows for the control of NPCs in games. If a shooter game is played, SVMs could be used to control NPCs [71]. Left bullets, stamina, and enemies near you are part of the three-dimensional vector. Thus, this can be used in education when teachers are not online, but the lesson will continue to run. If you use this algorithm, the main problem is that it only has a limited number of states and behaviours, and it does not give you many options for making decisions. It also lets agents learn from their interactions with their surroundings. The agent's actions will be rewarded in the same way. People who do what they won't get more money for doing it. Because of its good results, re inforcement learning has been used in many schools. When DeepMind made AlphaGo in 2015, it was the most well-known game that used deep reinforcement learning as its foundation [72]. The AlphaGo uses neural networks to figure out which moves have the best chance of winning, and this can be used in education to figure out how well students will do on exams and assignments.

C. Autonomy of Avatar

Generally speaking, an avatar is a computer-generated representation of a player in a virtual world where the player interacts with the other players or computer-controlled entities [73]. Teacher models will be left behind when they are not currently online, which will be helpful in the educational setting. Examples include Forza Motorsport's Drivatar, which uses AI to learn the driving style of its users [74]. In the same way, professors may teach many modules simultaneously and their expertise and teaching style are retained, the same notion can be used. Improved efficiency will enable instructors to get more active with creative resources, increasing their work happiness. The technology captures specific instructional data from instructors, such as body posture, voice tone, and subject matter expertise. As a result of the data acquired, a digital campus metaverse can be built that will generate digital twin academics. Using neural networks, the authors in [75] create a quite comparable framework. Teaching methods such as reinforcement learning and neural networks may be used to train models, with the reinforcement learning model outperforming the neural network by a significant margin.

V. BLOCKCHAIN

Blockchain is widely regarded as a breakthrough technology that has the potential to link everything on the planet and in the Metaverse, according to its proponents [76]. Most things have been digitalised, including digital twins for real-world products. Blockchain is projected to open a plethora of possibilities in the Metaverse, as well as to spark a new wave of technical innovation and industrial revolution. Recent breakthroughs in AI, on the other hand, have provided potential answers for addressing the problems of Metaverse development, such as big data analytics, AI-enabled content production, and intelligence distribution. As a result, the combination of AI and Metaverse technologies has emerged as a potential trend for promoting the benign expansion of the blockchain & AI enabled metaverse ecosystem. Even though, the emergence of blockchain and artificial intelligence has created a significant number of new technologies and applications, the combination of blockchain and artificial intelligence with the Metaverse faces several new research hurdles. For example, because of the characteristics of digital items and marketplaces, transaction volumes in the Metaverse system, Figure 5 demonstrates the blockchain's architecture.

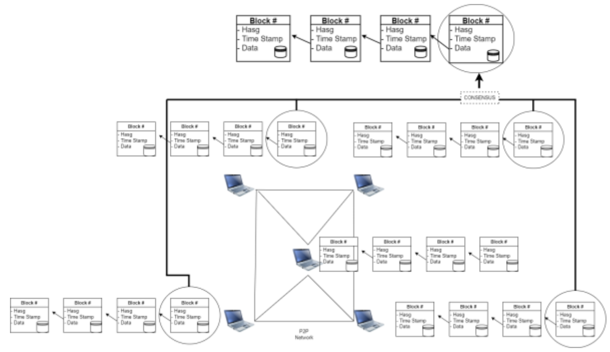

Figure 5: Blockchain architecture

A. Data Storage

A significant challenge is how to store vast amounts of data. Traditional data storage systems often use a centralised architecture, which necessitates the transfer of all data to a data centre on a regular basis. Due to the sheer volume of data, it is necessary to invest in relatively costly storage capacity. It is possible that such data contain personally identifiable information (PII), making it vulnerable to unauthorised access. Blockchain, being a distributed database, is more than capable of handling these problems. Students may take control of their academic identity via blockchain technology, providing them access to their personal information. Graduates looking for work now have an easier time establishing the veracity of the qualifications shown on their resumes. They have greater control over what an employer can see as a result. Educators now have additional tools at their disposal to keep tabs on their kids' progress because of the openness provided by blockchain data storage. Schools can provide students with a completely individualised learning experience by using smart contracts and the data they provide. The educational methods of the whole school district may be improved by accessing student performance data stored on a blockchain.

There are, however, a few difficulties in using blockchain in the educational setting. The verification process is the first hurdle to overcome. Students in blockchain-based educational systems present their student cards on the table to the instructor, who use them to register and verify them. However, this is challenging in the metaverse. With so much information on students and graduates at educational institutions, scaling the blockchain may be a problem. The number of blocks necessary to store the growing amount of data slows down the pace at which transactions can be completed on the blockchain, since each transaction necessitates peer-to-peer validation. This may be a huge stumbling block if implemented widely. The issue of anonymous exploitation is addressed by using shared algorithms and encrypted group signatures in blockchain applications [77]. The ability to store and validate data is important for the effective deployment of blockchain technology in higher education institutions [78], as massive amounts of diploma and degree certificate data are traded across institutions [79].

B. Data sharing

The scalability and versatility of blockchain-based data storage solutions are unparalleled. Blockchain are distributed ledgers that are built by the contributions of their users. Both data requesters and providers might be the same person. The data are also encrypted and stored on an anonymous node. In such scenario, students may benefit from adopting of blockchain technology to enhance the security and exchange of authentic digital certificates between them [80, 81]. There are a variety of smart contracts that may be used to facilitate learning, data exchange and documentation organisation while preserving privacy for the certification process [82]. Students and researchers alike expect to be able to study at their own pace, regardless of time or space constraints, while developing digital skills that will be useful in the workforce [83]. HEIs also have concerns about developing content delivery and improving educational quality, as well as replacing traditional educational services [84]. The data storage architecture, on the other hand, is incompatible with conventional data sharing mechanisms, since blockchains do not share data. Additionally, to facilitate the exchange of encrypted data, additional procedures for key management are required. An encrypted crucial is kept in a distributed ledger blockchain and, as an additional layer of protection, they use proxy encryption. Data security is ensured by Xia and co-workers using the tamper-proof method of blockchains, as well as access control mechanisms like smart contracts and tokens [85]. It is unsafe to store educational data on blockchain because of the possibility of faults in the application or platform or simply because participants fail to properly preserve their private keys [86].

C. Data interoperability

Data in the Metaverse must be kept private and secure at all times. Multiple parties will inevitably have access to and act on this data. In the end, this leads to misunderstandings and disagreements. Using a blockchain-based data platform, educational institutions from across the country may collaborate and exchange information. It's possible for banks and insurance firms to exchange the same client data using blockchain for interoperability; for example, Data interoperability in education is a common use case for blockchain technology. Previously, we said that students will be given digital twins based on their profile data so that they could better concentrate on their topic. Teachers may use these digital twins. Blockchain-based medical data management system is being created and being deployed by Azaria et al [87]. Authentication, interoperability, and secrecy are all supported by the system. This system's functionality is similar to that of Bitcoin, which allows for mining-based aggregate and anonymization. Financial institutions all around the world are working hard to reduce clearing and settlement times in order to improve transaction efficiency while also lowering risk mitigation costs. E-wallet architecture was designed by Singh et al. for safe payments between banks [88]. Table 1 demonstrates a technical review undergone for metaverse technologies that have undergone success in current game environments.

Metaverse Examples		Infrastructure	Interaction			Ecosystem		
		Blockchain	VR/AR	Digital twins	Creator	UGC	Economics	AI
Text-based Games	MUDs & MUSHs	✗	✗	✗	✓	✓	✗	✗
Virtual Open Worlds	Active World	✗	✗	✗	✓	✓	✓	✓
	Solipsis	✗	✗	✗	✓	✓	✗	✗
MMO Video Games	Second Life	✗	✗	✗	✓	✓	✓	✓
	Roblox	✗	✓	✗	✓	✓	✓	✓
	Minecraft	✗	✓	✗	✓	✓	✓	✓
	Grand Theft Auto Online	✗	✗	✓	✓	✓	✓	✓
	Pokémon Go	✗	✓	✓	✗	✗	✓	✓
	Super Mario Maker 2	✗	✗	✗	✓	✓	✓	✓
	Fortnite	✗	✗	✗	✓	✓	✓	✓
Virtual World	Decentraland	✓	✗	✗	✓	✓	✓	✓

Table 1: Technical Review of metaverse technologies [89]

VI. Conclusion

The Metaverse technologies will increasingly provide additional value and possible advantages to the educational sector by improving the quality of the user experience, and the introduction of digital twins will soon begin. Due to the availability of sophisticated computing devices and intelligent wearables, our digitised future shifts to more interactive, integrated part of daily living, easier embodied approach, and more multimodal than ever before. However, even though the Metaverse has had a recent year of hype and inflation of interest, there are still obstacles to overcome before the Metaverse can be fully normalised and accepted in education.
A comprehensive investigation must be conducted as a result of this. Our paper has discussed and touched on several topics, including Extended Reality, AI, Blockchain and Digital twins. A conclusion can be made to support the current technologies to be incorporated into the current educational system. We have contributed to the knowledge that will help the future undergoing research within Metaverse.

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