Review

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Metaverse for Education: Developments, Challenges and Future Direction

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Metaverse for Education: Developments, Challenges and Future Direction

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Abstract: Recent digital transformations have significantly impacted the current society, economy, and culture. This includes adoption of rapidly emerging technologies, such as artificial intelligence (AI), immersive technology (e.g., virtual, augmented, mixed and extended reality (VR/AR/MR/XR)), cloud services, and internet of things, in our day-to-day life. 'Metaverse' has emerged as a technology that incorporates many of these transforming technologies to deliver personalised immersive experience related to specific application areas. A potential major beneficiary of Metaverse is the educational ecosystem, where highly immersive learning experiences can be delivered to students, catering to their personal learning needs and train them on life skills such as empathy, ethical qualities, and communication skills. The present-day Metaverse allows physical engagement, enabling users to utilise limb movements to interact with the presented materials. However, ethical concerns and technical limitations impede the widespread implementation of the Metaverse in the real-world. This paper provides a comprehensive survey of the existing literature covering the architecture, type and components of Metaverse, followed by practical aspects of metaverse implementation. The paper is concluded by discussing on the open challenges and issues along with their mitigation strategies and future research directions after the detailed usecase of Metaverse in Education.

Keywords: Metaverse; education; Virtual Reality; Augmented Reality; Computer Assisted Learning; User Privacy; Smart Cities

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1. Introduction

Metaverse comprises two Greek words: Meta, meaning "after or beyond," and verse telling the universe. A post-reality universe, or Metaverse, is a multiuser environment that exists forever and mixes the virtuality of the digital world with the reality of the physical world. It is based on the convergence of technologies, such as Virtual Reality (VR), Mixed Reality (MR), Augmented Reality (AR) and Extended Reality (XR), that allow interactions on a wide scale with people, digital objects, and virtual surroundings [1]. The Metaverse, hereafter referred to as a socially networked and interconnected realm, constitutes a conglomeration of immersive encounters accessible to multiple individuals simultaneously. Within this virtual domain, individuals partake in seamless real-time exchanges, assuming anthropomorphic representations and engaging in dynamic interactions with digital entities. Notably, the most recent iteration of the Metaverse encompasses the capacity for avatars to traverse a network of virtual realms employing teleportation as a means of travel.

The most recent version of Metaverse has well-designed, captivating VR systems that can be customised to work with multiplayer video games, open game worlds, and AR collaborative experiences. 2021 is considered the seminal year of Metaverse [2]. Many research groups have claimed that Metaverse is a future education trend and have faith in the global Metaverse world.[3–7].

In three ways, the Metaverse differs from VR and AR [8]. For beginners, where most VR research relies on a physical approach and representation, Metaverse distinguishes itself as a service providing social interaction and content. Secondly, the Metaverse does not always use methods from Augmented Reality (AR) and Virtual Reality (VR). Applications used for operating Metaverse may use AR or VR technologies. The Metaverse must have a setting accommodating many individuals to encourage social interactions. Wide-scale Metaverse implementation demands advancement in hardware, a model that is good in recognition and expression and can use the powers of hardware parallelism [9], and availability of good content for people to enjoy and participate in the Metaverse [10].

Despite various technological developments, education remains one of the most critical subjects for the economy and society. Essential implementation techniques remain unchanging, focusing on content transmission to the newer generation through classroom learning and textbooks. A race has started around building the protocols, infrastructure, and standards governing the Metaverse. Openness and privacy support diverging systemic approaches and methods. This tech race will largely influence and decide privacy protections for users. It will also play a significant role in understanding whether Metaverse could be used for educational purposes for students and kids.

Sung et al. [11] explored the possibilities of a Metaverse in education. They gave the differences between Metaverse-based learning and old-style classroom-based learning and content delivery, primarily including live or video lectures. Students' attitudes toward learning, level of enjoyment, and success on knowledge-based tests are all considered when evaluating them. Through the use of extended reality (XR) technology, the economy, and marketplace are rejuvenated. Similarly to this, *Kemp et al.* [12] analysed the advantages and disadvantages of a virtual world, which be operated by multiple users simultaneously, in the field of education.

During the recent period, many countries utilised video conferencing software platforms to facilitate remote schooling. However, these platforms had limitations in providing an immersive and classroom-like experience. The emerging technology of the Metaverse addresses many of these limitations by offering integrated physical-digital environments [13].

Individual activities and production methods face increasing hurdles in the face of a complicated and changing global political and economic context and a global pandemic.
To maintain social distancing, lectures, for example, have been relocated online via Zoom, MS Teams, Google Meets, and more. However, present virtual learning content is primarily built on flat or liquid-crystal display (LCD) screens, requiring more involvement and participation than traditional classroom teaching. Students need to pay attention to the video lectures on their nets. In this situation, the use of Metaverse — a platform that combines cutting-edge technologies like AR, VR, cloud

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computing, and artificial intelligence (AI) — appears to be an intriguing solution that deserves more investigation.

1.1. Technologies for Improving Quality of Education

Additionally, we have discussed some advanced technologies that can improve the quality of education in daily life in the following subsections [14].

1.1.1. Computer-Assisted Learning

Conventional classroom-based education has encountered mounting challenges concerning the scarcity of practical teaching resources and the availability of high-quality learning materials in online settings. However, the utilisation of video conferencing devices for remote learning has enabled us to adapt and continue instruction while maintaining opportunities for interaction [15]. Secondly, a trend for remote learning is now emerging in society, in which students want to learn while having hands-on experience in the industry.

However, the Human-Computer Interaction (HCI) community discovered some issues associated with remote instruction. Students, for example, have been known through a survey conducted by Barnes & Noble Education [1], that they find it challenging to stay attentive for long durations of time because of multitasking, lack of social interactions and unforeseen interruptions. They have more impaired learning efficacy because of live-streaming learning's prolonged timeframe, and they support lower collaboration/engagement between students and teachers in light of the shift of the learning environment from a community-based public classroom, which enjoys the support of multiple facilities provided by the universities, to a private location, with restricted and limited resources.

Several solutions have been proposed to reduce inadequacies and vulnerabilities for teachers and students during a live-streaming session [15].

1.1.2. Virtual Reality in Education

Virtual reality has five principal components: 3D viewpoint, closed-loop interaction, dynamic rendering, increased sensory feedback, and inside-out perspective [16][17]. Due to the simple accessibility of many inexpensive Head-Mounted Displays (HMDs), greater computing power, and a range of uses, including STEM (science, technology, engineering, and mathematics) education, psychotherapy, and surgical procedures, VR has shown to be effective [18].

VR has the potential to improve education and training. However, there are still problems remaining. To begin with, most people think of VR as a game played for pleasure and leisure. The audience is more concerned with the victory in the game than with acquiring knowledge and improving critical thinking skills, contrary to the instructional purpose [19]. Secondly, from a psychological standpoint, VR is not perfect. Thirdly, the overhead cost that the educational institutions will incur for designing and creating VR resources for various teaching objectives will be very high, and the library department needs more optimal practices and interoperability standards for adopting the contents related to VR. These concerns justify the difficulty in sharing resources among different institutions [20].

1.1.3. Augmented Reality in Education

An information layer of context is added to the user's perception of physical effort in augmented reality, a three-dimensional technology. It has lately grown in popularity among academic studies as well [21].

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[1] https://www.businesswire.com/news/home/20200408005156/en/

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AR technology is popular because it does not need specialist equipment like HMDs or expensive, unique gear. AR may be used even with affordable mobile devices like smartphones and tablets [22].

AR in education has limitations, though. Usability is a prevalent complaint because most AR education settings are difficult for students. The quantity of content and challenging tasks in AR learning environments may increase student academic strain. Tech issues can also deter students. *Maccallum et al.* [23], in their research, showed that it was demanding to involve the students in the learning process with newly created virtual content and other fresh concepts. Further, some researchers claim that technology does not affect learners' and students' performance on knowledge-based assessments.

This paper contributes to these. First, we analyse the latest remote learning and interactive mediums like VR/AR [24]. We will also explore the potential of utilising the Metaverse for creating interactive and engaging study environments. Additionally, the current circumstances have heightened the possibility of implementing the Metaverse sooner, as discussed in Table 1. Some of the technical characteristics and their educational implications have been addressed in the Table 3.

We suggest a system in this study that blends the technologies of the Metaverse and VR into the classroom to compensate for the inadequacies of existing virtual teaching models. Consequently, we ascertain the notable challenges associated with building the Metaverse classroom, explore its various applications, and delve into the broader possibilities of utilising the Metaverse beyond this context [25]. This research aims to apply Metaverse and similar technologies to education. This paper details Metaverse's architecture and layers. The study examines the Metaverse's impact on critical learning, training, and skill development. The convergence of XR and IoE for Metaverse education application cases emphasises relevant theories and enabling technologies.

We also propose a VR and Metaverse immersive educational system that enables remote real-time engagement with others. By identifying the elements that need the research community's attention, we will analyse the research trends in the Metaverse sector.

This survey explores Metaverse education potential. The survey begins by discussing other research organisations and the need for this article. Discussed Metaverse architecture and kinds. Additionally, Metaverse components are detailed. The next few sections describe distance learning and its various forms, introduce the Metaverse in distance learning, discuss different approaches to the Metaverse, and discuss its role and application in education. This survey then covers the Metaverse's open-ended problems and technological answers. The study concludes with a list of research prospects.

1.2. Foundational Works for Metaverse

The idea of the Metaverse has been introduced previously. Its concept was initially presented in 1992 by American science fiction author Neal Stephenson in his book "Snow Crash." According to the authors of [1], Metaverse may be utilised to link social media platforms by employing reasonably priced AR and VR technology, and it can also be used to create immersive learning environments. In their survey on the Metaverse, the writers of [26] underlined the Metaverse's privacy and security characteristics. Additionally, they presented a Metaverse architecture in their study and covered its essential elements and contemporary examples. They also spoke about the security and privacy risks that the Metaverse poses. The authors of [27] discussed the architecture of the Metaverse and the current developments related to various technological advancements. They also discussed the importance of solving problems related to communication and networking, computation, and blockchain. The authors of [4] presented a "beyond a hype" perspective of the Metaverse, in which they discussed the benefits and challenges of Metaverse when it is implemented on a large scale and extensively adopted in society and how it will impact the daily life of people and its impact on business and society.

A recent study titled 'The Metaverse in 2040,' focuses on the Metaverse released by the Pew Research Centre. In a survey by the Pew Research Centre and Elon University of 624 technology innovators, developers, business and policy leaders, researchers, and activists about the trajectory of

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a Metaverse in 2040, 54% of the respondents predicted that the Metaverse would be a much more developed, truly fully-immersive, and functional part of daily life for more than half a billion people worldwide by 2040. The researchers were then invited to comment on their selections, which resulted in two main topics being thoroughly examined. It has been speculated that XR will mainly revolve around AR and MR technologies rather than a completely immersive VR setting, which many call the Metaverse at the moment. The respondents then spoke about how every human characteristic and propensity, excellent or terrible, may be massively magnified in these new realms [28].

This survey aims to collate the information available in the existing smaller surveys and present the information in a comprehensive and accessible way covering all features and characteristics of the Metaverse for the common masses.

The overview and organisation of this survey are presented in Figure 1. The main objective of this manuscript is to offer a comprehensive overview of the Metaverse in a clear and accessible manner while conducting a rigorous theoretical analysis of its advantages and disadvantages. Another goal is to explore the potential of the Metaverse as an educational tool in contemporary society, considering its benefits and limitations.

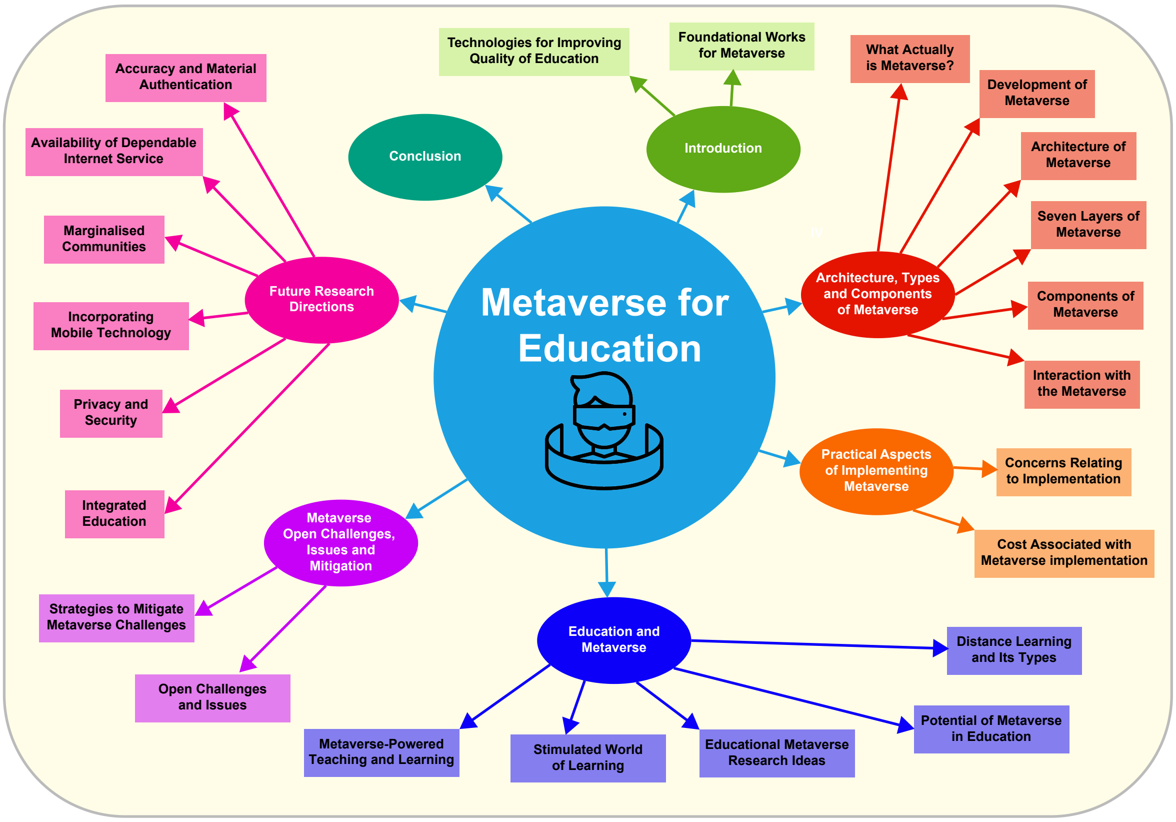

Figure 1. Organisation of the paper.

2. Architecture, Types and Components of Metaverse

The Metaverse represents an advanced technology with its wide design formats and techniques. Gaining a clear understanding of the Metaverse necessitates deeply exploring and studying its architecture, visually depicted in the accompanying Figure 2.

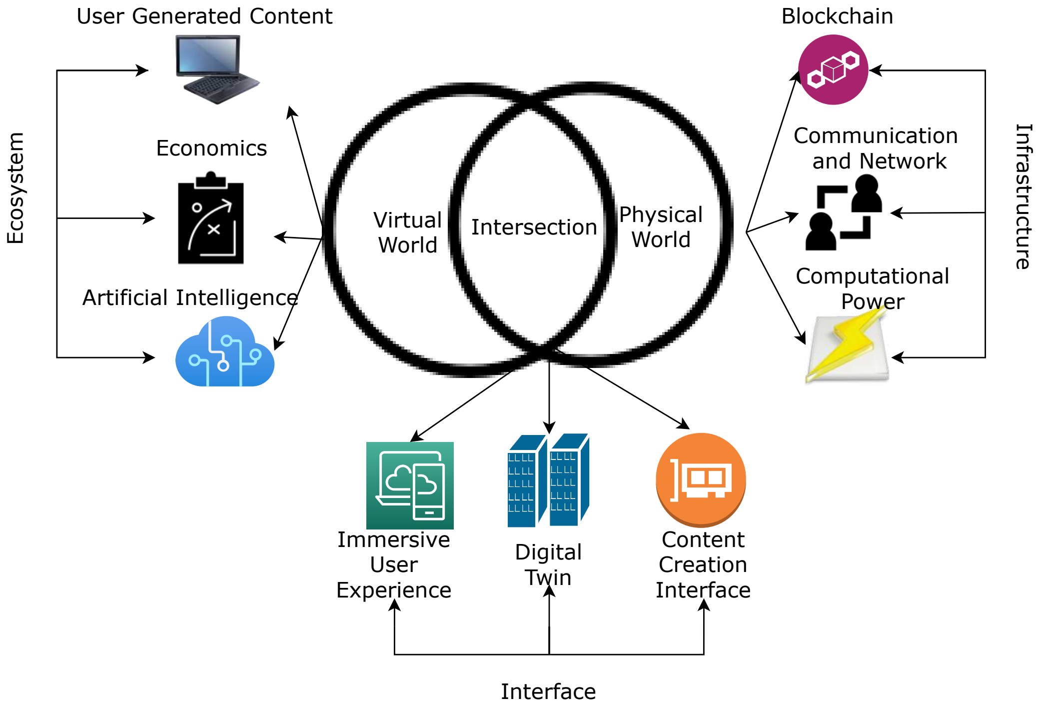

Figure 2. Architecture of Metaverse [29].

2.1. *What Actually is Metaverse?*

Metaverse, an immersive platform, blends multiple current technologies, such as VR/AR/MR/XR that delights consumers, digital twin that reflects reality, blockchain technology that integrates real and virtual worlds into social, economic, and secure systems. The Metaverse lets users create content and edit them in the virtual world. People are refining the Metaverse notion. Metaverse offers vast commercial prospects. Large firms are building Metaverse for capital export. Users' expectations of virtual world freedom, internet content, interaction methods, etc., are continually growing [30,31].

2.2. *Development of Metaverse*

Broadly, the evolution of the Metaverse can be divided into three stages.

2.2.1. Digital Twins

The first step in the evolution of the Metaverse involves the creation of a high-fidelity, mega-mirror world. This world replicates individuals, things, and virtual surroundings as digital twins of their real-world counterparts, aiming to reproduce actual reality vividly. The virtual world would have virtual actions and features like movement and user emotion, which would imitate their physical twin in the real world.

2.2.2. Digital Natives

Creating original content is the main focus of the second phase. The digital world could improve physical world output and expand reality-virtuality interactions. Digital inventions would eventually match physical ones.

2.2.3. Surreality

In this final stage, the Metaverse would become an autonomous surreal universe that consumed reality. This phase will merge the real and virtual worlds, with the virtual world having more areas and better means and types of living than the real one. [26].

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2.3. *Architecture of Metaverse*

Smart devices allow virtual identities to interact in the Metaverse. Avatars, virtual goods, and other computer-generated elements are included. The Metaverse combines physical, human, and digital dimensions.

2.3.1. Human Society

Metaverse considers humans. Humans, their minds, and their relationships dominate the world. People can interact with and manage avatars. These avatars can work, play, socialise, and engage with others in the Metaverse via HCI, XR, and novel wearable devices like VR/AR helmets.

2.3.2. Physical Infrastructures

Nature provides Metaverse infrastructure for sensing, controlling, communicating, processing, and storage. These infrastructures would enable multi-sensory data perception, processing, caching, transmission, and physical control, enabling virtual-physical interactions.

2.3.3. Interconnected Virtual Worlds

Each connected distributed virtual world would offer its users a unique set of virtual services (such as social dating, gaming, museums, and concerts) and environments (such as tournament settings and cities) for their digital avatars. The Metaverse has two primary information sources. The first is recorded data from physical spaces. The virtual environment would display this data. Virtual world output is mostly avatar documentation, digital items, and Metaverse services.

2.3.4. In-World Information Flow

Social media links people with similar interests and behaviours. First, natural and human-generated digital data is processed. Metaverse engines use processed data to create large-scale Metaverses and provide digital services.

2.3.5. Information Flow across Worlds

In the virtual world, users can interact with various physical items using the concept of human computer interaction (HCI). Using XR technology, they could virtually experience AR, such as holographic telepresence. The Internet would connect the physical and digital worlds. Users can engage and participate in the digital world for the production, sharing, and learning of information via cutting-edge devices like smartphones, sensors, and VR headgear [26].

2.4. *Seven Layers of Metaverse*

Metaverse consists of seven layers, extensively discussed in the following subsections and pictorially represented in Figure 3.

2.4.1. Experience

Metaverse offers most people a "third place" for thorough socialisation, social integration, e-sports, retail, and other activities through invention. Education Via Metaverses' investment hyped this Metaverse component. Social features in Metaverse's experience layer dematerialise space and objects.

2.4.2. Discovery

Instead of focusing on network users' needs, this layer visualises current behaviour. The Metaverse aids introspection and exploration. Inbound discovery uses search engines, real-time foresight, and community-driven content sharing. Outbound Metaverse findings use social media notifications, emails, blogs, and ads.

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2.4.3. Creator Economy

Content creators expect Metaverse economic growth. Businesses should exploit the Metaverse to create an endless economy. Creators are already contributing to the economy's monetisation and user experience through the facility-designed suite, infrastructure, networking, and discovery.

2.4.4. Spatial Computing

Metaverse PCs and devices can be moved around. Spatial computing, like XR, promises to accelerate the Metaverse's economic revolution.

2.4.5. Decentralisation

When a centralised system cedes decision-making power to a decentralised network, it happens. It may create a scalable Metaverse ecosystem without merging interoperable systems' back-end activities.

2.4.6. Human Interface

This Metaverse layer focuses on hardware devices that enable human-machine communication. Better human interface technology lets people encounter the Metaverse. Metaverse apps may become more interactive. For a compelling experience, Metaverse embedded AI technologies offer low-latency edge computing.

2.4.7. Infrastructure

A functional and interoperable Metaverse relies on the infrastructure layer. The Metaverse's infrastructure includes processing, communication, AI, blockchain, gaming, and display tools. 5G and 6G services may have high speeds and bandwidth. Metaverse infrastructure requires performance optimisation with low hardware and power requirements [32]. Metaverse is a massive technology, due to which it has a massive architectural structure. Implementing the Metaverse is a challenging task. To make Metaverse a success, many software and hardware components are also required, which are discussed in the following section, along with a detailed description of the cost associated with its implementation.

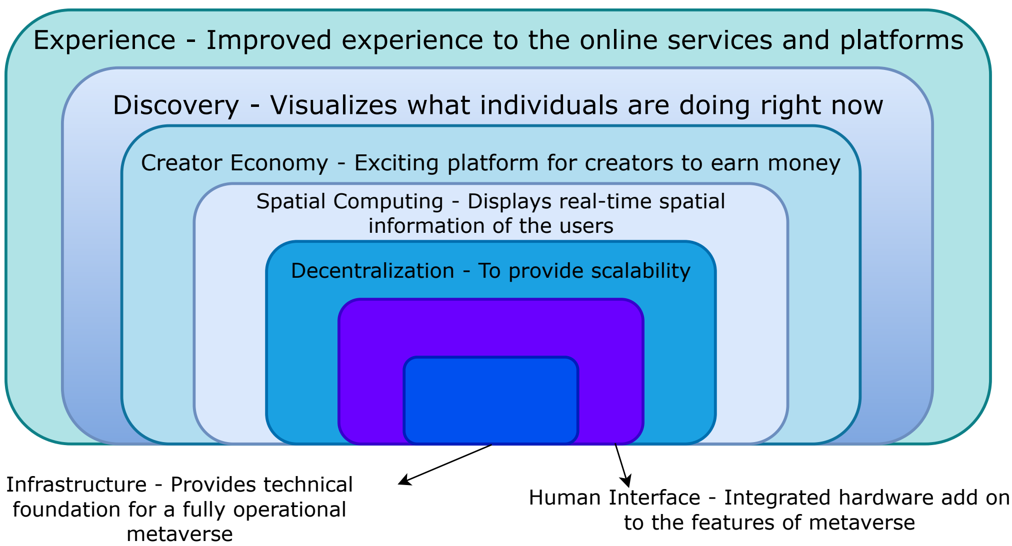

Figure 3. Seven Layers of Metaverse [33].

2.5. Components of Metaverse

Psychotherapy patients are immersed in the Metaverse. People are influenced but aware that stories and messages are unreal. User-interactive storytelling services may feel real, like the Metaverse. Two-way interactive games are great examples. Simultaneous, presence-based communication is needed to make the Metaverse work like the actual world. The Metaverse needs user interactions to sustain economic activity. Metaverse's hardware and software components, as well as the various interaction methods, are examined here.

2.5.1. Hardware Components

Hardware in the Metaverse can provide an interactive and high-quality experience, but it also poses technological obstacles. Since the Metaverse, hardware technology has advanced significantly, although it still needs refinement for real-world use. Metaverse immersion requires HMD. For a more accurate feeling of vision, *Birnie et al.*'s retina rendering approach keeps the core area in a high resolution equal to human eyesight. [34]. Physical devices and sensors need answers, range, and delay. Latency is the most important for multimodal interactions and should be planned with side effects and temporal gaps in mind.

Head Mounted Displays

Head Mounted Displays (HMD) displays an image and plays music through the speaker [3]. Non-see-through, optical, and video-see-through HMDs exist [35]. Metaverse uses HMD for input. It covers the screen to produce a virtual reality experience. AR's optical-see-through method requires powerful hardware. Video-see-through HMDs enhance this method. HMD's bulkiness, expense, and short battery life are issues. HMD tracks users' head movements and modifies the screen to match the virtual environment's perspective. HMD is less precise than external calculation methods for calculating motion, but it saves money and space.

Hand-Based Input Device

Hand-based input devices have numerous concentric synchronisations and input zones. Mobile phone grip prediction requires accurate user data modelling to give haptic perception. Passive and active haptics simulate coercion and real-world items. Passive haptic is used to study problems while providing presence, but active haptic changes and delivers in response to user input[36,37]. Attach the device to the hand or outside. It only affects material experiences (such as muscle strain).

Non-Hand Based Input Device

Voice, eye, head, and auxiliary input options are provided. Eye tracking predicts eye movement without head movement. This strategy allows users to determine the sort of object they are focusing on and creates high-quality images in the region where the user is trying to concentrate on a sophisticated approach, decreasing image processing workload and giving a significant advantage [38]. Voice input is helpful for long texts and debates while utilising a virtual keyboard with limited input.

Motion Input Device

Active and passive motion input devices are categorised. Active feedback depends on human activity, while passive feedback is based on a predetermined condition. It can be used for walking or 360-degree rotations to give realism. Due to user injury, treadmills waist-fixate.

Metaverse technology requires hardware components. Hardware technologies need more study and development.

2.5.2. Software Components

Cognitive illusions are needed to appropriately perceive the subjective and objective reality of the physical area. Dynamic and static cognition. Sight, hearing, and touch are static cognition, but sensory balance and movement are dynamic [39]. It's crucial to lessen the distortion of detection and recognition, especially in the Metaverse. Modifying the kernel's form, altering the expression, and increasing input are all ways to reduce distortion. Faces, stances, gestures, and body-related gazes are objects of object recognition. Sensing, recording, recognising, and tracking are all steps in this object identification process.

According to recurrent recognition, the absence or presence of a variation in the user's movement distinguishes between the senseless and reactive approaches. There are ways to process information instinctively, behaviourally, consciously, and emotionally. An essential component of the Metaverse is the avatar, which is formed and animated to mimic the activity. Models based on vision calculate human positions, identify hand movements, and forecast gaze, which requires the utilisation of iris, facial contour, and 3D gaze prediction.

Scene and Object Recognition

The technique of recognising an item at a distance based on its size, shape, position, brightness, and colours is known as object recognition. To identify scenes and objects, novel approaches (such as point clouds, scene graphs, cross-modal attention, and modal alignment) are used [39]. The process of aggregating item pairings into graphs by combining and exchanging representations is called sub-graph-based scene graph creation [40].

Along with scene recognition, object recognition is also crucial. Non-contact interaction, which includes gestures, looks, attitude, etc., and human-centred scene analysis must also be considered. An effort is made to lessen the computing burden by applying an abstraction idea because when several items are recognised, the number of computations increases when individual object detection is used, according to the number of objects.

Sound and Speech Recognition

Understanding the surroundings and engaging with other avatars is made easier through speech processing and sound recognition. The conversation acts as a direct line of communication for directing a non-player character (NPC) in the Metaverse as well as connecting with other users' avatars. For a realistic environment in the Metaverse, voice recognition technology that adjusts the volume based on distance and takes into consideration the surroundings is necessary.

Sound and Speech Synthesis

Contrary to vision, sound synthesis gives the user a sensation of immersion, although there needs to be more study in this field. It creates sound in the area to create a sense of presence and increase immersion. The metrics that the users can utilise to emphasise words or convey variability are the focus of the voice synthesis system Tacotron [41]. Prosody is the speech signal variation left after variation (such as phonetics and channel effects) has been considered. Prosody employs layering techniques to capture and transmit meaningful utterances. [42].

Motion Rendering

Real-time multi-party 3D motion tracking and pose estimation using CNNs and global context encoding to identify asymmetric relationships and context patterns between objects [43]. With a single-colour camera, it is feasible to isolate human body parts (such as shaking hands) and capture the real-time 3D motion of challenging scenarios, but it is still limited in its ability to capture close physical interactions.

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Scene and Object Generation

The two ways that the environment and items in Metaverse are generated are the methods for reflecting the natural world and inventing a brand-new made-up universe. A realistic plan for presenting the environment there is to replicate well-known destinations (such as museums and the Eiffel Tower) and places that people are acquainted with (such as their homes and schools) in the real world. As an alternative, it generates a difficult-to-reach setting (such as Mars or the deep sea) to offer a dreamlike experience. The main aims for object creation are people and stuff. It emphasises more on the use of facial emotions and organic joint movements to facilitate smooth multi-sensory conversation. While on the other hand, it creates lifelike objects that are sufficiently detailed to feel like real-world items.

Cost and practicality of the most of the currently available hardware and software pose one of the significant challenges in wider implementation of Metaverse. The paper calls for more research and development in software and hardware so that Metaverse technology comes out of the literature to the real world.

2.6. Interaction with the Metaverse

Metaverse is a massive technological idea. Metaverse has many smaller units, which range from interactions between various components of the Metaverse through sound, visuals, etc., to make the Metaverse an attractive business destination. All of these units must be addressed simultaneously to make the Metaverse a success.

2.6.1. User interaction

Natural interaction is a prerequisite to enhance the level of engagement within the Metaverse. It might mimic the faces of friends and celebrities to facilitate natural interactions and give users the impression that they are in well-known and well-liked locations. Hands are a vital contact component because the primary target population is humans. Two main categories of input devices are hand-held devices and non-hand-held devices. Because a 360-degree vision range is a responsive field for dimensionality detection, efficient video processing necessitates many pictures and distortion corrections.

2.6.2. Verbal Interaction

Through voice recognition, the conversation is a straightforward method of providing helpful information. In other words, speech is used frequently because it efficiently and indirectly clarifies complicated situations [44].

2.6.3. Multimodal Interaction

refers to a situation where the user is given various ways to interact with the system. Multimodal systems integrate the output of a multimedia system with the processing of two or more integrated user input modes, such as speech, touch, visual and learning [44]. Multimodal interaction is necessary because managing several complicated emotions using the method of each modality is challenging [45]. Multimodal generally contains more information than unimodal and is better for comprehending the scenario. When the meanings of visuals and words diverge, multimodal learning is the most successful one [46].

2.6.4. Multi-Task Interaction

A model that manages several jobs concurrently is useful in the complexity department because the Metaverse manages a variety of functions in the virtual world. By using the knowledge distillation approach, a compact model with a wide range of features and the capacity to handle different modal types is produced. *Hessel et al* shared that since multitasking models balance several activities in a

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confined expression, multitasking is more complicated than single-tasking [47]. Despite being very easy to use for comparable tasks, it overfits rapidly when the target domain's data is restricted and has a different distribution from the job at hand [48].

E2E techniques are also used to complete numerous tasks successfully. Most inputs in an E2E model may be utilised without resulting in any data loss. The project Metaverse revolves around providing users with a much better experience than the internet and its services by engaging every sense of users. Hence it becomes of utmost importance to design the interface accordingly.

3. Practical Aspects of Implementing Metaverse

The Metaverse concept is still relatively new and faces many opinions and contrasts when implementing Metaverse in the real world. Some of the aspects are discussed below.

3.1. Concerns Relating to Implementation

3.1.1. Technology Infrastructure

Metaverse requires a considerable infrastructure to support millions of users simultaneously. This includes high-speed internet connections, available everywhere, robust servers, and advanced network technologies. According to an Ookla report, the overall fixed median download speed in India is 50.02 Mbps, while the median mobile download speed is 29.85 Mbps,[2] which don't seem to fit the requirement of the Metaverse. Along with these things, the technology infrastructure should be highly scalable so that everyone can easily adapt to it and can be expanded easily.

3.1.2. User Interfaces

In this study, the usage of the Metaverse is discussed concerning education. Hence it is evident that the user interface should be easy to use and intuitive, which would allow the users to easily navigate and interact with the virtual world. The interface should be such that the users should not feel that using Metaverse as another science, which might be difficult for weak students. The usage of Metaverse should be as easy as the usage of search engines and the present-day internet. It should also be compatible to be used on any device, including mobile, tablets, PCs, laptops, etc.

3.1.3. Content Creation

Since the schools and colleges would be responsible for generating content for the students so that they can quickly learn from them, content creation should be easy for the teachers. Otherwise, they might not feel an impetus to use the Metaverse. Content creation should also be engaging and include virtual environments, avatars, objects, and interactive experiences. Secondly, content creation should be easy so people can quickly learn it and run their businesses on the Metaverse. If content creation is to be compared, then it should be as easy as content creation on platforms like YouTube, Instagram, Facebook, etc., so that more and more people could get attracted to using it.

3.1.4. Security and Privacy

Metaverse should be safe and secure for students. Parents should feel comfortable allowing their children to use Metaverse as a platform. Secondly, schools' and students' data should be protected on the Metaverse from getting hacked.

[2] https://www.speedtest.net/global-index

3.2. Cost Associated with Metaverse implementation

Implementing Metaverse would be a significant investment, requiring substantial expertise and resources. But, if Metaverse is successfully established, it would become a huge source of income, similar to or even greater than the present-day internet.

3.2.1. Development Cost

This would include the expenses related to building and designing the virtual world, including creating 3D models, programming the mechanics of games and various physics laws of this world, which would be present in the virtual world, designing the user interface and testing and debugging the model created. The cost would vary greatly depending on the size and complexity of the Metaverse desired.

3.2.2. Infrastructure Cost

This would include the cost of the hardware and software used to make a successful Metaverse. This would consist of hosting and running servers, network equipment and storage devices. The price will again depend upon the size of the Metaverse and the number of users who could simultaneously use it.

3.2.3. Content Creation Cost

This would include the cost of creating virtual assets such as buildings, avatars, parks, cities, objects, sea, etc., which would ultimately populate the Metaverse. The cost of it would depend upon the size of various things and the details of the objects, for example, in a park, what all types of trees, birds, animals, etc., should be present. The segments of a tree in the garden, for example, if it is a banyan tree, how big it should be, should it be growing on its own, at what rate it should grow and should be noticeable to people, etc.

The above two subsections discuss the practical aspect of implementing Metaverse. As indicated above, it would be more challenging to implement it, both economically and practically. This poses a challenge in engaging Metaverse technology in education, accessible to every class of students.

4. Education and Metaverse

Enhancing societal well-being stands as a pivotal criterion when evaluating any technological advancement's worth. Among the myriad approaches, education emerges as the paramount avenue due to its unparalleled capacity to impart knowledge to subsequent generations. This cascading effect of knowledge dissemination not only eases the lives of future cohorts but also cultivates an environment that fosters greater happiness, profound erudition, and heightened awareness, collectively contributing to advancing a more enlightened and harmonious global community.

With the advent of the recent pandemic, the society has increasingly become digitally aware and various novel ways of communication have emerged [49]. Distance education has been more widely practised during this period which is the best candidate to adopt the Metaverse.

4.1. Distance Learning and Its Types

Distance education, often known as distance learning, is an area of study that focuses on how to best employ technology, education, and instructional system design to provide students with education [50,51]. Distance education refers to service providers, participants, and media. The separation of teacher and student in time and/or space, the student's volitional control of learning, as opposed to the instructor's, from a distance, [52,53], and the non-contiguous communication between the teacher and student, which is mediated by print media or some other form of technology such as emails and social media, are some of its distinguishing features [54,55]. Distance learning has various components, represented in figure 4 for better clarity and understanding.

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4.1.1. Approaches for Distance Learning

Distance learning have been delivered in various modes and ways. The following paragraphs provide an overview of the approaches distance learning can be delivered at the present time.

E-Learning (Electronic Learning)

It is the form of learning in which educational material is delivered to the recipient in an electronic form primarily based on a computer and its networks and applications. It is done in such a way that allows active interaction of peers with the materials and features simultaneously in a synchronised way. It is costly to set up the computer infrastructure, create software, train professors and students in its usage, and create electronic scientific content. It provides educational opportunities for all segments of society, including homemakers and factory workers, so that work and education may coexist [56].

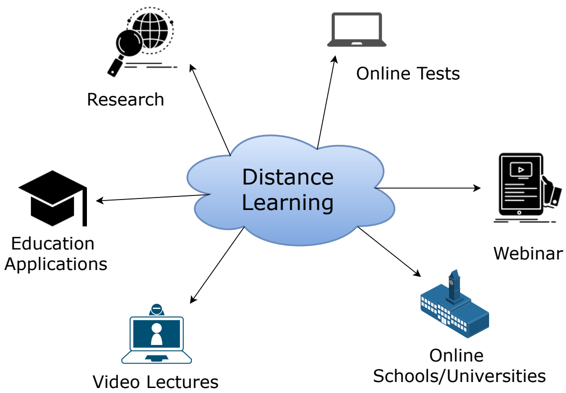

Figure 4. Components of Distance Learning [57].

M-Learning (Mobile Learning)

Mobile learning refers to any educational environment where mobile or palmtop devices are the sole or dominant technology. This definition includes mobile phones, cellphones, PDAs and their accessories, tablet PCs, and laptop PCs but excludes desktops on carts and other related devices. Perhaps the term should also include the growing number of experiments with specialised mobile devices like game consoles and iPods and both commonplace industrial and seldom experimental technology [58]. Mobile learning technologies remove geographic constraints and create a collaborative learning environment for international groups [59].

U-Learning (Ubiquitous Learning)

In the late 1980s, Mark Weiser invented "Ubiquitous Computing", which refers to the process by which computers seamlessly integrate with the physical world. As we go toward a more pervasive computing environment, computers' presence will become less noticeable and eventually mix homogeneously into our daily lives. The user's attention is usually drawn to the screen when utilising a computer. Ubiquitous computing, in addition to personal computers (PCs), incorporates computer-related technologies in mobile phones, microprocessors, digital cameras, and other such devices [60]. U-learning is an emerging paradigm that extends education in various settings by placing users in authentic learning situations to undergo immersive experiences to achieve meaningful learning [61].

The term "Digital Revolution" began developing quickly in the latter decades of the 20th century. Future educational systems will primarily use virtual learning environments. Adopting cutting-edge but complex technology is necessary to provide an enjoyable atmosphere for online learning. Additionally, it offers a comprehensive and successful educational approach. Therefore, academics and developers need to understand how the Metaverse functions and what unique

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technologies are included in it. The Metaverse is the most recent development. The Metaverse is transforming online education in the following four ways:

1. Building a fascinating and realistic online classroom,
2. Encouraging communication,
3. Encouraging immersive learning, and
4. Enriching gamification.

4.2. Potential of Metaverse in Education

The Metaverse holds tremendous potential as a transformative educational force. Its capabilities provide students with many remarkable opportunities to engage in collaborative endeavours actively, navigate novel learning environments, and even assume instructional roles within this virtual realm. Moreover, the Metaverse empowers learners by granting them access to educational scenarios surpassing physical constraints' boundaries, allowing for immersive experiences that foster deeper understanding and skill development. In this context, diverse domains such as nursing, clinical and healthcare education, scientific disciplines, military training, industrial sectors, and language acquisition can all reap the benefits of integrating the Metaverse into their educational practices, enabling enhanced learning outcomes and preparing individuals for the complexities of the modern world [62]. Some of the applications of the Metaverse have been demonstrated in Figure 5.

Table 2 showed changes in satisfaction among the students and the teachers when Metaverse was used in a class for educational purposes. Some of the reasons for adopting Metaverse for educational purposes are:

1. Instead of exposing students to potentially risky situations in the physical world, the Metaverse provides a secure and regulated environment for skill development. It serves as a unique platform for comprehensive training before real-world implementation. The Metaverse has practical implications, particularly in cultivating optimal driving abilities. While current software solutions have limitations, such as high costs and hardware requirements, the Metaverse offers an accessible and immersive virtual landscape replicating real-world driving conditions. It presents an effective avenue for individuals to enhance their driving skills.
2. By immersing students in simulated environments, they can delve into unique and extraordinary scenarios that are seldom accessible in their everyday lives. This enables them to broaden their horizons, gain novel perspectives, and acquire knowledge and experiences that transcend the limitations of the physical world.
3. Through the virtual realm, students are empowered to transcend the constraints of financial limitations and scarce resources, enabling them to embark on endeavours that would otherwise be unattainable in the real world. By encouraging them to explore, create, and discover without the burden of financial barriers, the virtual environment becomes a catalyst for unleashing their ingenuity and fostering resource-independent pursuits.
4. Giving students a chance to investigate, observe, or make observations from various angles or positions.
5. Granting students the opportunity to engage in virtual interactions with individuals who may not typically cross their paths in the physical realm, fostering communication and collaborative endeavours that would otherwise remain elusive.
6. By putting students to work on difficult, diversified, and real-world tasks, we may examine how much higher-order thinking is capable of being shown in our students [6].
7. The Metaverse revolutionises education by offering collaborative experiences, immersive learning environments, and efficient, practical knowledge testing. It transcends physical limitations, deepening understanding and skill development through immersive scenarios. It promotes virtual interactions, fosters higher-order thinking, and revolutionises education as we know it.

 doi:10.20944/preprints202308.1872.v1

4.3. Educational Metaverse Research Ideas

As the advancements in wearable technology, powerful computing, efficient networks, and sensing technology continue progressing, the integration of Metaverse technology in education is increasingly viable. In this regard, several research avenues hold promise for expanding educational applications in the Metaverse such as the list below:

1. Creating instructional models or execution frameworks based on the Metaverse,
2. Examining how Metaverse-based learning environments affect students' perceptions and performance in the classroom,
3. Using the Metaverse as a method of evaluation,
4. Investigating the cognitive abilities and perspectives of learners with various personal characteristics in Metaverse-based situations,
5. Evaluating behavioural or interaction characteristics of students with varying levels of achievement in the Metaverse
6. Designing Metaverse boot camps that are complicated in real-world environments
7. Developing ethical guidelines for using the Metaverse in academic settings,
8. Investigating the ethical implications of Metaverse integration in education, including privacy concerns and digital citizenship,
9. Examining the effectiveness of Metaverse-based simulations and virtual reality experiences in enhancing practical skills acquisition and training,
10. Exploring the potential of Metaverse in addressing accessibility and inclusivity challenges in education, particularly for **students with disabilities**,
11. Analysing the impact of Metaverse on teacher-student relationships and instructional strategies in virtual learning environments,
12. Investigating the scalability and sustainability of Metaverse implementation in educational institutions, considering infrastructure requirements, cost-effectiveness, and long-term viability.

Advancements in technology enable Metaverse integration in education, offering diverse research avenues. Topics include instructional models, student perceptions, ethical implications, Metaverse simulations, scalability, teacher-student relationships, accessibility, and inclusivity.

4.4. Stimulated World of Learning

The five identified virtual worlds promote students' learning by providing a game-like experience based on the core framework of gamification [63].

4.4.1. Sustenance Realm

The sustenance realm follows strict game rules. In this game, the user competes for knowledge with several other users until the last one standing is declared the winner. Users who have gathered knowledge from around the globe or increased their level of logical thought must compete with other players for expertise in the educational survival scenario. In contrast, if any player offers the incorrect answer or makes the wrong choice, that user is ejected from the game and cannot play further.

4.4.2. Maze World

In the realm of the labyrinth, puzzles pervade the environment, occupying over half of the landscape. Users are transported to the starting point and tasked with uncovering the intricacies of the world to find a way out of the maze. Exploration takes centre stage in this labyrinthine realm, where communication predominantly revolves around obstacles and objects, as the necessary guidance for maze navigation is embedded within the world itself. As a result, interactions with barriers and elements within the maze surpass those with fellow users.

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4.4.3. Alternative Worldscape

Users may participate directly in the multi-choice virtual world by putting game rules and elements into place. Users acquire knowledge by identifying right and wrong answers while deciding how to approach the quiz moderator for new information or to exit the maze. A user may try again even if they choose the bad option in a multiple-choice game since there is no such thing as "failure" in this context.

4.4.4. Racing/Jump World

The player wins by bringing their avatar to the finish line first in the virtual arena known as the racing/jump world. Users are encouraged to compete with one another in the racing/jumping realm. Users may encounter challenges, including starting the game under the same circumstances, buying items to advance more quickly, or breaking the laws in the racing/jumping environment. The passive learning hypothesis from the advertising industry is used in this information transfer approach. The world designer purposefully repeats the facts.

4.4.5. Escape Room World

The escape room world is a virtual environment where one or more players search for hidden clues in one area of the game, move on to the next area, and compete to reach the final point first. The student is trapped in a certain space, and hints are buried throughout the space's equipment. The student exits the room after entering the final correct response they arrive at after completing all the issues by locating the hints buried throughout the room. The learner's capacity to solve problems creatively, as well as soft skills like leadership and communication, are all improved by the escape room game. The advice obtained includes pointers on how to complete job application forms or interview techniques [63].

These five virtual worlds offer gamified learning experiences for students, promoting competition, exploration, decision-making, problem-solving, and the development of soft skills. From knowledge competitions to maze navigation, multi-choice quizzes, racing challenges, and escape room puzzles, these worlds provide diverse and engaging educational opportunities.

4.5. Metaverse-Powered Teaching and Learning

Through the establishment of intricate digital connections bridging the realms of the virtual and physical, the Metaverse presents an unprecedented opportunity to harness its significant advantages that surpass those of conventional educational platforms.

 doi:10.20944/preprints202308.1872.v1

Table 1. Types of Metaverse [64]

Type	Definition	Features	Use cases
Augmented Reality	AR is a digitally improved representation of the world using digital visual elements, audio, or other sensory stimulation.	Utilising location-based technology and networks to build a smart environment	AR helps teachers to aid students in understanding abstract ideas. By using the interaction and experimentation that AR technology offers, educators may improve educational experiences.
Lifelogging	The ability to acquire, store, and exchange information about items and people in everyday life.	Using AR technology to record data about objects and people	allows teachers and students to capture their educational experiences using snaps, audio recordings, videos, location information, and sensor data.
Mirror World	Mirror World, also known as the Metaverse, is a blockchain-based virtual world that aims to integrate the mirror world with various games and experiences.	Using GPS technology, it creates virtual maps and models	Mirror world based virtual camps
Virtual Reality	A virtual environment with realistic-appearing images and objects. The spectator gets the sense that they are engrossed in their surroundings. To see this environment, use a headset or helmet that provides VR.	Expanding knowledge and providing an active experience, It has also proven immensely useful in understanding and learning complex concepts.	The use of VR may enhance learning and student engagement. The creation of a virtual environment, whether actual or made up, and enabling users to view and engage themselves in it, are two different ways which prove the potential of VR.

4.5.1. The Metaverse Classroom

The advent of XR technology has revolutionised the accessibility of educational services for students and learners situated in remote locations, mitigating the necessity for extensive travel and emphasising the implementation of interactive and collaborative approaches in distance learning. By leveraging the immersive capabilities of XR, individuals can now effortlessly partake in educational experiences that transcend physical boundaries, fostering a rich and engaging learning environment that transcends geographical constraints. This transformative shift in educational delivery enhances convenience and inclusivity and empowers learners to actively participate in dynamic and interactive educational experiences, thereby promoting knowledge acquisition and skill development regardless of their geographical location.

Table 2. Changes in satisfaction with interaction in the class utilising Metaverse

Reason	Had difficulty pre-survey	Difficult	Easy
Lack of interaction with teacher and other students	72 %	5%	67%
Difficulty in performing various tasks	65%	10%	55%
Ease of learning utilising Metaverse	-	15%	85%

4.5.2. Advantages of Metaverse Integration in Education

The Metaverse and its supporting technologies can transform traditional educational methods, such as classrooms and online learning environments, into virtual environments [65]. This can assist in directing educational institutions' attention toward Metaverse-based education [66]. Regardless of their actual location, students can benefit from a mesmerising learning experience and feel the

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physical presence in the collective classroom setting using such a platform. Metaverse has been used as an educational tool in the digital form by integrating various information and communications technology (ICT) tools and technologies for boosting education and learning through collaborative platforms abilities [67].
Furthermore, by combining spatial sound with XR-capable video streaming services, the audio Metaverse through virtual mainstreaming, allows the creation of inter-operable experiences. [68]. The students can thoroughly examine various historical and architectural locations thanks to technology. *Gaafar et al.*, for example, read the possibilities of the Metaverse in architecture education by giving students and instructors a chance to examine historical places using virtual replicas of historic structures and their interactive 3D models [69].

4.5.3. Metaverse for Teachers

Teachers can benefit from the Metaverse in a variety of ways. For instance, using the Virbela platform, a Metaverse environment is employed to improve the teaching abilities of pre-service teachers. In the experiment, pre-service teachers' virtual avatars were used to evaluate micro-teaching for a group of participants. A thorough review of the teachers' skills in responding to questions and comments was conducted. By immersing teachers more fully in their profession while providing instruction and skill-building activities for the students, these approaches aid teachers in honing their teaching [70]. Secondly, teachers can use games, as mentioned earlier, to teach students efficiently and quickly. Teachers can also use Metaverse to conduct examinations, more specifically practical assessments, such as driving tests of complex vehicles such as aeroplanes.

4.5.4. Metaverse for Industrial Training

The Metaverse and accompanying technologies have improved employee training in industries, allowing workers to gain practical experience in various activities in a risk-averse setting [71]. The Metaverse enables the sharing of workspace with numerous robots that greatly simplify tasks in industrial sectors with IoE-enabled technology and digital humans [72]. Logistics use robots to enhance the flow of material in the production process since they are essential to the current industrial system. Domain randomisation has the potential to provide an endless number of permutations of photo-realistic objects, texturing, lighting conditions, and orientations [73]. It is the perfect framework for creating real-world pictures and objects for the Metaverse., whether for detection, segmentation, or depth perception. Furthermore, digital twins could make virtual factory visits possible, which the Metaverse environment would provide. Digital twins are powered by Metaverse technologies, which allow industries to advance constantly as well as interact, learn, and teach the supply chain to be more innovative. As a result, planning duration will be reduced, while flexibility and precision will improve, resulting in an optimal design process.

4.5.5. Aircraft and Maritime Training

The possibilities of AR technology have been heavily used for a long time in the aviation, automotive, and astronautics sectors for a range of tasks such as environment monitoring, control, and learning [74]. XR and other Metaverse techniques have also been utilised for training workers for the aviation industry's maintenance and inspection processes [75]. The literature reports on the technology's demonstrated effectiveness in the task. According to another research [76], AR is effective for supporting, training, and maintaining aircraft. The technological review substantially reduces mistakes made during training and, as a consequence, process breaches. These results bring down the need for the current Metaverse to enhance the functionality of the learning system while cutting back training time [77].

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4.5.6. Military Training

Training troops is critical in the defence industry since sending military officers to active battle zones is not usually possible for training. XR technology may be used to provide troops with more realistic training scenarios. It may aid in preparing soldiers for dynamic adaptation by enabling them to exercise in a comparable environment. Additionally, it lowers the expense of relocating and travelling for army training. Additionally, using virtual things helps troops practice with specific military equipment without putting them at risk. The combination of IoE and Metaverse technology may make military training even better, even if cutting-edge strategies are utilised to replace it entirely with XR. Due to the immense variety it offers compared to real-world military training, technology has changed the emphasis away from conventional training approaches and toward immersive instruction via a virtual environment.

4.5.7. Cultural and Historical Exploration

The Metaverse allows students to explore museums, historical sites, and cultural landmarks virtually, enhancing their understanding of diverse cultures and historical events. Through immersive experiences, students can closely examine artefacts from various civilisations and periods. Additionally, they can participate virtually in cultural festivals, gaining insights into different traditions and customs. The Metaverse also allows for simulated time travel, transporting students to significant historical periods such as ancient Egypt, Rome, and Greece, enabling them to experience those eras firsthand.

4.5.8. Personalised Education

Using the Metaverse, educators can personalise educational content and activities based on student's abilities and preferences. Interactive learning environments offer personalised adjustments in difficulty, pace, and content, ensuring inclusivity [78,79]. Students can pursue their interests and interact with peers and experts, fostering engagement. The Metaverse revolutionises education, empowering teachers, enhancing training, and promoting innovative and inclusive approaches to skill development and knowledge acquisition.

The Metaverse revolutionises education, transcending physical boundaries to provide immersive, collaborative learning experiences. It empowers teachers, enhances industrial and military training, and fosters inclusive and innovative skills development and knowledge acquisition approaches.

5. Metaverse Open Challenges, Issues and Mitigation

This section highlights the open challenges and issues related to Metaverse and possible strategies to mitigate them.

5.1. Open Challenges and Issues

No technological advancement is without its inherent challenges and drawbacks, and it is crucial to acknowledge them in any comprehensive research. This survey highlights and presents several pertinent issues as thought-provoking, open-ended questions, inviting the research community to contribute their insights and propose innovative solutions.

5.1.1. Effects of Metaverse on Health

Imbalance in visual information within the Metaverse can lead to virtual motion sickness, accompanied by issues like physical exhaustion, headset weight, mobility injuries, and hygiene concerns. Negative effects such as mild motion sickness, vector convulsions, dizziness, and eye fatigue can also arise. Achieving effective service in the Metaverse relies on maintaining cognitive equilibrium and stability. Recent advancements have expanded the Metaverse to incorporate taste and smell perception for heightened realism. Users can structure their experiences as detailed plots or concise summaries, utilising techniques like modal and density transform to calculate scenario

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depth and length. Metaverse scenarios employ clustering, planning-based conditional branching, and time-dependent indexing to organise events and effectively summarise main ideas.

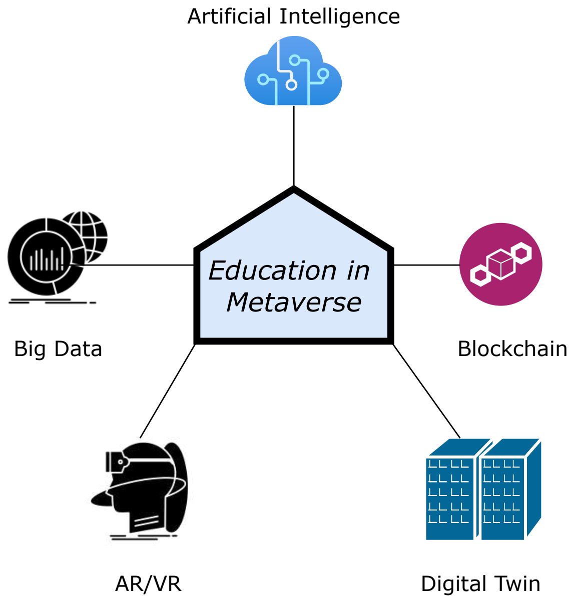

Figure 5. Technological Contributors to the Metaverse

5.1.2. Barriers to the Adoption of Metaverse in Educational Services

Virtual Mainstreaming

To ensure the optimal functioning of XR and IoE frameworks, it is essential to address the critical elements of the virtual world that render it comparable to reality, as well as the trust factors vital for interpersonal interactions and organisational efficacy. Establishing standards in these areas is fundamental to shaping legal systems' creation, evaluation, and utilisation. Instances of online bullying, abuse, infidelity, and dishonesty in relationships can exacerbate due to users mistakenly perceiving virtual connections and information exchanges as genuine. However, as society's appreciation for the virtual realm deepens, certain groups may exploit this trend for personal gain. Researchers are actively developing infrastructure, including virtual resource streaming, to combat cybercrimes such as phishing, online fraud, virus dissemination, and ransomware attacks [80].

Simulating Reality

Simulating and mixing the virtual and real world is not a novel idea. The idea of distinguishing between reality and a dream or discriminating between reality and illusion may be traced back to many different ideologies, such as idealism, scepticism, objectivism, etc. The ray-tracing simulation defines images' appearance, which enables 3D graphics for real-time visuals by adequately utilising the physics of light energy [81]. The usage of realistic graphics and pre-rendered content for the Metaverse requires higher processing power from the IoT devices employed for these operations. On the other hand, real-time ray tracing, a technique to create realistic images, may solve these issues via enhanced AI models that can imitate machines and provide a captivating Metaverse experience through virtual objects, people, places, and machines. Using AI and predictive analysis, real-time data visualisation could then be provided. Additionally, these characteristics bring another level of immersion to the Metaverse and can make the next-generation education system and framework more dynamic and effective by providing learners and educators with a better platform for engagement.

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Ethical Considerations and Potential Pitfalls

The Metaverse's interoperability and openness pose the issue of the future Internet's ethics and values. The moral decisions based on the philosophical nature of the techniques taught in the Metaverse must be used to determine who is accountable for building this infrastructure. [82]. Privacy and security are critical factors since Metaverse collects activity data that is far more detailed than user interactions and internet browsing history. We must be more vigilant about possible criminal activities in the Metaverse and protect transferred data with two-factor authentication for avatars [7]. Some morally upright people in the real world have been known to commit crimes due to their online anonymity in the Metaverse. Figure 6 shows various ethical issues which are faced by society.

Figure 6. Ethical issues in Metaverse Education.

Some of the potential ethical issues related to Metaverse can be summarised as follows:

- Privacy Issues - The brain-computer interfaces (BCI) and XR devices may be able to give users access to Metaverse applications that can track their cognitive processes. The privacy rules of Metaverse applications should be studied and acknowledged to comprehend the repercussions of data breaches, data misuse, and personal data hacking [83]. Privacy and security attack nodes are utilised in social VR learning settings, and stochastic timed automata representations are used for statistical model checking. [84].
- Digital Citizenship - Digital citizenship is the term used to describe how to behave responsibly and safely when online. It encourages the user to think critically and not to believe everything they see. It guarantees information security and connection to the intended parties. Users of the Metaverse are guaranteed by digital citizenship to act responsibly in communication and behaviour [85].
- Network security - Attacks against Head-mounted display (HMD) systems may provide attackers with the opportunity to briefly render victims helpless while overlaying or modifying the images in their range of view. As a result, security concerns in immersive educational platforms increase. The fact that the Metaverse requires specific hardware to function is another problem. The Metaverse is focused on external digital devices like VR headsets that, if left unguarded, are vulnerable to hackers [86][87]. These headsets' data collection capabilities—or those of any other wearable technology that will undoubtedly be unveiled in the future—can yield extremely delicate information. Furthermore, it may be more challenging to protect intellectual property when people and organisations are active in both the real world and the Metaverse.

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- Copyrights - It is difficult to monitor digital rights on educational content against infringement of copyrights of learning resources given the extensive appearance of several online educational platforms [88]. By using both private and public blockchains, the current digital copyright management system allows the sharing of multimedia instructional materials. It protects the privacy of instructional materials, making it a useful option for Metaverse platforms as well [89].
- Netiquettes - Digital manners are often referred to as "Netiquette," where good communication is essential for asking questions and providing respectful and protective answers. Being an ethical online citizen is essential in the Metaverse-based educational programs in high schools, colleges, and businesses. In online learning contexts where information and communication technology (ICT) has changed social interaction and communication norms, netiquette is essential. Students and teachers should be properly educated and guided in correct netiquette, which will help in stopping cyberbullying and digital fraud in social media [86].
- Acceptable Use Guidelines - It is a set of regulations/guidelines that the educational system's owner, author, or manager has implemented to limit how the resource may be used. It is an essential component of the security policy framework that grants potential users access to the resources by having them sign the policy [90]. Before granting them a network ID to get access, the investors of academic institutions may require students as well as teachers to sign this policy before granting them access to the Metaverse-based educational content [91].

Various ethical issues arise in the Metaverse, including privacy concerns related to data tracking and breaches, the importance of digital citizenship to ensure responsible behaviour online, network security risks and vulnerabilities, copyright infringement challenges, the need for proper netiquette to prevent cyberbullying and fraud, and the implementation of acceptable use guidelines to regulate resource utilisation. Addressing these issues is crucial for the safe and ethical use of Metaverse-based educational platforms.

5.1.3. Other challenges and Limitations

In addition to the above mentioned challenges, there are other uncategorised challenges which might pose some limitations for Metaverse. They are discussed in the following paragraphs.

Medium Selection

AR employs portable, lightweight equipment for brief experiences, while VR often calls for bulkier, more costly equipment. A single piece of gear may switch between AR and VR using specific techniques that combine the advantages of both technologies. This technology is more expensive and complicated despite using AR and VR in various ways than a single-model gadget. In contrast, holograms are a relatively new technology, but they have the potential to be valid. Another kind of input in the Metaverse is eyewear. The lens analyses the user's data by analysing the direction of eye movements, focus, winks, and blinks.

Metaverse Sustainability

Life monitoring emphasises social connections over individual activities and tasks. It requires maintaining continuous contact on a low-spec mobile device. Intermittent memory effectively manages user data, enabling long-term use of the Metaverse. However, research is needed to efficiently identify and reuse relevant episodes while considering usage and capacity limitations. Latecomer platforms should prioritise import/export methods for a seamless user experience.

Hardware and Software Limitations

While the Metaverse closely replicates the real world in terms of sensors, certain sensations like daylight and sunlight are best experienced in reality. Achieving a high degree of interoperability in the Metaverse relies on non-coded apps developed within the Metaverse. As software advances, it

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becomes more complex and versatile across different applications. Humans have multiple identities that manifest differently depending on the situation, emphasising the need for detailed persona modelling.

Generation Gap

The generation gap poses a challenge as young users readily embrace new options. AR offers lightweight, portable equipment for short experiences, while VR requires bulkier and costlier gear. However, techniques exist to switch between AR and VR on a single device, combining their benefits. Holograms, a promising technology, may leave older individuals behind and raise concerns about potential risks for younger users. Customised design and built-in controls from technology providers and software companies can help address these issues. Research communities must engage in healthy discussions and dedicate efforts to solving these challenges in their work.

The challenges in implementing the Metaverse for educational services involve various ethical issues such as privacy, digital citizenship, network security, copyrights, netiquettes, and acceptable use guidelines. Considerations include medium selection, Metaverse sustainability, hardware and software limitations, and addressing the generation gap. Research communities must address these challenges through comprehensive solutions, responsible practices, and open discussions to ensure a safe and inclusive Metaverse environment for education.

5.2. Strategies to Mitigate Metaverse Challenges

Metaverse poses many challenges. Some countermeasures, as mentioned below, have been proposed to overcome these challenges.

- To reduce health-related issues on Metaverse, some of the measures could be adopted, such as the research community should be prompted to provide some solution for heavily weighted headsets, etc. Along with it, some restrictions could also be introduced in Metaverse such that Metaverse could not be used simultaneously for more than a particular amount of time in a particular device, and some break has to be given, which can be used to prevent consequences such as virtual motion sickness, mild motion sickness, vector convulsions, dizziness, etc.
- Intelligent cloud computing services and quantum computing could be used to successfully handle multimodal medical data optimisation in healthcare education.
- Students and teachers should be appropriately trained and educated in various potential cyber threats possible in the Metaverse, and they should be taught about how to avoid them.
- Research in finding various solutions to the possible cyber threats in the Metaverse should be encouraged. A deep study should also be conducted to find out various possible ways of committing crimes on Metaverse. It will help the developers to find a solution to these threats and help them develop a much more robust Metaverse.
- With the implementation of the Metaverse, a team would have to be set up which would monitor and keep checks on various cyber threats, listen to people's complaints, and try to rectify them.
- Immersive cooperation and interactions in online education could be secured with the right combination of XR programs and IoE devices. Another kind of input in the Metaverse is eyewear. The lens analyses the user's data by analysing the direction of eye movements, focus, winks, and blinks.

Table 3. Technical Characteristics and their Education Implications [64]

Type	Technological Characteristics	Educational Implications
Augmented Reality	Combine virtual things with actual ones to give them a 3D, realistic appearance. Incorporating a mystical element into the conversation. Promoting convenience and powerfully highlighting information.	Utilise virtual digital data to solve problems by understanding invisible parts visually and in three dimensions. Learners can develop knowledge through experiences and gain an in-depth comprehension of difficult topics to see or express in writing. Reading, writing, and speaking are among the interactive activities that may be had while fully engaged in the learning environment.
Lifelogging	Social media, and SNS are used to produce content and share one's daily life and thoughts. Network technology allows people to create online relationships, communicate swiftly, and record various social activities. Wearable technology and other Internet of things sensors collect and analyse personal activity data to add value.	A person's ability to represent and utilise information correctly is aided by reviewing and reflecting on their daily actions and feedback obtained from others on various social networking platforms, providing reinforcement and incentives. Investigate varied facts on the lifelogging platform critically and creatively through collective intelligence. Teachers encourage learning along a personalised route based on data from the learning logs of their pupils, provide the required assistance, and stop withdrawals.
Mirror World	By merging GPS and networking technology, the real world is expanding. Real-world elements are incorporated into virtual environments with a specific goal, like a mirror image. Though, it does not include everything. In other words, it successfully widens the real world to promote joy and play, management and operation flexibility, and collective intelligence.	Learning occurs in the Metaverse of the mirror world, where the physical or spatial constraints of teaching and learning do not constrain it. Online real-time classrooms can be held using video conferencing and collaborative tools representing mirror worlds. Students can actualise "learning by doing" by using the mirror world. Users can interact with their digital legacy and learn more about history and culture.
Virtual Reality	Users can enjoy a variety of games via a flawlessly integrated interface thanks to advanced computer graphics work, particularly in a virtual environment built with 3D technology. They function as avatars rather than their true selves and have many personalities in a space, era, society, and characters built differently from reality. VR includes chat and communication facilities for communicating and collaborating with AI characters and others.	Virtual simulation may be used to practice in unsafe and expensive scenarios. Simulations on a virtual platform can be used to practice situations which seem to be impossible to build in the real world due to the serious danger and infrastructure cost involved. - Users can develop their comprehensive and coherent thinking and problem-solving abilities and learn real-world skills by playing 3D virtual world-based games.

- To achieve proper design, production, and supply chain management, industrial personnel's skill enhancement for managing problematic parts could be deployed using Metaverse-driven collaborative robots.
- The elimination of cybersecurity difficulties in the marine sector via the Metaverse allows the provision of robust systems to protect against threats.
- Precise object handling and identification in the Metaverse may drive artistic advancement and gameplay skill improvement.

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5.2.1. Technological Solutions to Overcome Challenge for Metaverse

Some technological solutions can be used to overcome challenges faced by the Metaverse. These are briefly discussed in the subsequent paragraphs.

XR Technologies for Metaverse

The influence of Metaverse on XR has significantly aided in the education and skill-building of the workforce. XR technology, at its heart, is intimately related to choosing suitable stacks of software and hardware for the creation and deployment of a variety of applications of Metaverse. In addition to IoE, XR is also in charge of creating a user-friendly Metaverse experience. The changes by XR may offer chances for critical thinking, improved conveyance, cooperation, and a higher level of creativity for instructors and students to impart adaptive and sustainable education. Such multifaceted learning components give educational benefits for an increased learning experience.

IoE Technologies for Metaverse

The Metaverse's impact on the IoE technology will improve far-off real-world practices by enabling sharper and better organisation for real-life commodities via the virtual world. From a research and application standpoint, the contribution of IoE and Metaverse in this field has grown crucial since digital twins serve as the software model of natural systems and assets. In these circumstances, IoT devices and other data processing tools enable edge processing of learning content driven by AI for the Metaverse. These might be used in mobile towers, IoT devices, or data-gathering stations. To be used in the Metaverse, the constellation of adjacent IoT devices and data-gathering sources for education must also be coordinated.

Big Data and Predictive Analytics for Metaverse

Social networking sites, corporations, the healthcare industry, and individuals using smart gadgets collect vast amounts of data on a range of personal topics, including preferences and hobbies. Real-time data analytics are required to forecast future results in businesses driven by Metaverse that use applications like marketing, sales, and advertising. The ability of Metaverse's predictive algorithms to derive highly beneficial insights from acquired data would be highly appreciated. The data may be presented more comprehensibly and engagingly with the aid of Metaverse. Given the apparent advantages of advanced analytics on XR and IoE data, applying advanced analytics in the Metaverse for various prospective educational applications is crucial.

Machine Intelligence

With the help of Metaverse, machine intelligence, when applied along with XR and IoE, adds significantly to the innovation in educational services. Teaching by gestures interpreted by the teacher's eye glances, mood, and conveying cues could be part of sophisticated facilitators in the education system via the Metaverse. In actuality, AI serves as a design consultant for the Metaverse. It is compatible with low-code and no-code systems as a fundamental component of the service architecture. Furthermore, AI-based architecture for the Metaverse chip is needed when virtual avatars populate the virtual world more densely, which could help programmers generate code.

Blockchain Adoption

Blockchain may be able to offer a potential answer in the security area because of its special qualities of decentralisation, stability, and lucidity. Data is stored in a decentralised manner in blockchain, which means, that it would be difficult for cyber bullies to access the data of an individual or a group easily. Secondly, in the Metaverse, the security feature of blockchain could be even more highlighted, by using more complex cipher functions, to encrypt data, which would make the Metaverse much more robust [92]. Blockchain is immutable, which means, once a transaction is

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recorded, it can not be modified or deleted. It means if a person is trying to do mischievous transactions or activities, then it will be properly recorded, which could be used by law-enforcing agencies to find out the bully. Blockchain uses a consensus mechanism to validate any transaction or to add any new blocks on the chain. It has the potential to prevent threats as any wrong activity have to go through validations and any of the miners could track it and report it as well. Blockchain is a transparent network as it allows all its users to view their data and it increases accountability and reduces the risk of malicious activities [93–97]. [98] provides a brief history of blockchain and has explained how Metaverse and blockchain could be integrated and could achieve industrial accuracy. Its use in Metaverse applications is possible by blockchain's programmability, which might generate educational content by connecting smart contracts across decentralised locales.

Through blockchain adoption for the Metaverse, trust and authority are enhanced, allowing more IoT devices to engage and aid in generating instructional material ranging from active gameplay to the integration of financial services into the content, however, as the social scalability of educational facilities powered by the Metaverse may take some time, it may be possible to develop trust-based educational components, materials, and contracts. To create on-chain educational data streams, we might take advantage of early blockchain usage, as well as the rise of virtual commodities.

Low-Code Platforms

The use of low-code and no-code application platforms (LCAP), which have replaced direct developer coding of processes, has sped up the development of higher-level abstractions in XR-based apps during the last several years. It enables non-programmers to accomplish a variety of tasks that would normally require programming knowledge. A diverse collection of creator tools is also accessible to produce Metaverse content with advanced features and to provide improved sustenance for the commercial and educational sectors. Even if it is difficult for corporations to scale down technology to individual educational institutions, there are several situations where IoE-enabled devices in people's hands could force firms to the most cost-effective solution. With various data endpoints, more LCAP support may be catered for in virtual educational platforms, ensuring scalable and secure solutions.

Accelerating Distributed Networks

This acceleration promotes the creation of more engaging educational apps by letting users exchange educational information in real time. It also aids in the maintenance of the Metaverse. Because data-heavy networks are critical resources in Metaverse applications, their connection to distributed networks must be tightly coupled and accelerated. Additionally, to deliver a rich educational experience, the Metaverse frameworks must be optimised end-to-end, and the processing and communication must be promising. The IoE-based implementation of the Metaverse educational systems means they could gain the most from edge computing.

Furthermore, it allows virtual user-generated instructional information to be distributed using low-cost data transmission protocols. Instructors and students may transmit transparent details thanks to a decentralised, hacker-free solution for edge-enabled educational institutions in a Metaverse framework.

6. Future Research Directions

Multi-domain design research with many dimensions is the foundation for an implementation analysis of the Metaverse. The study's main conclusions are outlined in this section, along with information on how the Metaverse's frameworks, methodology, and architecture connect to applications for learning, training, and developing skills.

These applications' frameworks should optimise speed while considering extra IoE and XR device restrictions, such as size, power, memory, and other resource limits for instructors and students. These limitations are especially significant in Metaverse-enabled classrooms since students and instructors utilise XR and IoT devices more frequently and with more influence. Therefore, in these applications, high throughput and high-speed connectivity are given preference over an immersive experience.

6.1. Accuracy and Material Authentication

High-quality content must be available to provide immersive and high-quality education using Metaverse. The accuracy and legitimacy of the instructional contents are further impacted by the use of subpar and severely incompatible XR and IoT devices. To supply accurate and top-notch instructions, efforts must be made to design a uniform authentication system. However, this project must make a broad range of cross-border auxiliary technologies interoperable to create a solid instructional platform.

6.2. Availability of dependable Internet service

Access to dependable internet services is a crucial component of seamless Internet connectivity for Metaverse-driven education. A platform that guarantees high capacity and includes features like trustworthy video streaming and the exchange of excellent immersive instructional content has already been laid through optical communication and 5G/6G services [99]. However, given the availability of broadband connections, adopting various radio technologies, depending on their availability, usually weakens confidence in the communication services supplied for educational services. [100].

6.3. Marginalised Communities

The Metaverse platform should include the educational needs of students with physical and cognitive limitations and make it possible for fairness policies to treat such people [101]. Explainable Artificial Intelligence (XAI) frameworks often integrate attribution-based learning models with the Shapley variables to comprehend explanations from deep neural networks. This makes it possible for the under-represented group to offer experiential education. Additionally, these XAI models help identify susceptible populations and examine how the algorithms' judgments are reached. The research community must be aware of the risks posed by educational resources and contextual exploration in general, particularly for Metaverse-based educational services [102].

6.4. Incorporating mobile technology

As more pedagogical strategies create interactive mobile apps, the utilisation of these apps for streamlining instruction toward immersive and engaging techniques grows with the acceptance of the Metaverse. Because individuals are connected through their high-tech devices, especially with IoE and XR modules, even though they may be at separate places geographically, mobile technologies are crucial [103].

The apps also offer opportunities for setting user-defined restrictions and exchanging instructional content. The effect of acknowledged trust and intellectual faith on trainers and instructors considerably grows with the introduction of AI-based goods and services [104]. Using cellular technology, discrete event simulations driven by Metaverse platforms may trigger XR's impending user-focused activities. This, in turn, greatly promotes the adoption of VR/AR technology and immersive XR applications by educational services for high-quality, learner-centred educational services [105].

6.5. Privacy and Security

Metaverse comes with many advantages, but its most prominent disadvantage is its exploitation by cyberbullies. Metaverse, by architecture, would collect much more data of the users as compared to normal internet. Hence, it becomes more important to strengthen the Metaverse with much more strong security protocols. The research community is expected to work more on finding out ways of ensuring privacy on Metaverse. Secondly, it is also necessary to find out various ways of privacy breaches and cyber crimes, which could be done beforehand so that developers of Metaverse could

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keep them in mind and implement Metaverse accordingly, making Metaverse much more robust and invincible.

6.6. Integrated Education

Integrating educational themes through video games and narratives is made possible by using Metaverse technology in integrated learning through XR and IoE modules [32]. The potential of a Metaverse in integrated learning might be realised with cutting-edge enabling technologies and high-speed connections, provided challenges like device size, power distribution, planning, and control are addressed across the integrated learning platform. IoT devices and VR/AR technologies are regularly misused despite secure connection support and its values. Each technology supporting the development of the Metaverse has distinct qualities that make it stand out from the rest. However, in addition to strongly emphasising security and privacy through effective encryption systems, end users and developers must support responsible technology use with their values [106]. The responsibility for delivering top-notch educational services via the Metaverse and its supporting technologies should fall on learners and teachers. Educational service providers play a significant role, and the difficulties they face must be given top priority by the academic community [107].

7. Conclusion

The advent of XR applications has given rise to a growing focus on Metaverse systems incorporating IoE devices, garnering significant attention from commercial entities and the scientific community. Within education, Metaverse platforms allow schools to access and evaluate raw data. In contrast, utilising IoE applications within the Metaverse facilitates exploring XR solutions and challenges pertaining to education, training, and upskilling across diverse industries. Integrating immersive education becomes paramount in delivering XR-based instruction through IoE devices, allowing for practical hands-on learning experiences that seamlessly merge with field education via remote learning methodologies. Furthermore, this comprehensive survey delves into utilising the Metaverse to enhance traditional classroom education by actively soliciting feedback from students and instructors, ensuring a collaborative and iterative approach to instruction. A detailed case study on education is presented, illuminating the innovative implementation of distance learning by leveraging virtual space and the Metaverse to foster talent development and embrace digital innovation within the context of convergence field education and practical hands-on learning. As we navigate the dynamic landscape of the post-pandemic era, it becomes increasingly evident that the Metaverse serves as an indispensable tool, facilitating the monitoring of student satisfaction, enabling effective instructor-student communication, and empowering the deployment of impactful instructional strategies. Furthermore, this paper offers a glimpse into the future, outlining potential avenues for research within this multifaceted domain, encompassing intriguing aspects that continue to shape and redefine the educational landscape.

Author Contribution

The authors, Chamola V., Hassija V., Singh A., Mittal U., Pareel R., Mangal P., Devika, Mahmud, M. and Brown, D.J. contributed equally to this paper, i.e., conceived, designed, analysed the data and wrote the paper. All authors have read and agreed to the submitted version of the manuscript.

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Data Availability

No new data were created or analysed in this study. Therefore, data sharing is not applicable.

Conflict of Interest

The authors declare no conflict of interest.

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