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SURVEY

# METAEDUCATION: State-of-the-Art Methodology for Empowering Feature Education

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**ABSTRACT** Education has become the most essential endeavor in our lives. There are many ways to learn, but only a few capture my interest. However, education has grown more interesting and attractive with the aid of technology. A fascinating step forward in education is merging the real and digital worlds through Virtual Reality (VR) and Augmented Reality (AR). The term used to denote the digital world is the "Metaverse." Metaverse enables us to engage in virtual conversations with others by utilizing avatars that mirror ourselves. Using Metaverse technology, readers of certain books have discovered ways to study rather than focusing on their screens. Several advanced technologies, such as Blockchain, Big Data, Artificial Intelligence (AI), game design, Internet computing, and the Internet of Things (IoT), are integrated into the Metaverse, an innovative idea in social work. The integration of the Metaverse is expected to contribute significantly to the advancement of education. On the other hand, it is important to acknowledge that the development of educational Metaverse concepts is still in its early stages. Addressing issues related to the Metaverse's objective in the classroom is critical. This research aims to conduct a comprehensive literature review on integrating the Metaverse in educational environments. We will start by giving a general overview of the Metaverse, its educational uses, and some background on the motivations behind its use. Moving on to the educational aspect, we examine the Metaverse, identifying its defining characteristics, including educational environments, Integrated technologies, and customized instructions. Following this, we suggested an essential structure for how teachers and students could connect in the Metaverse classroom. In addition, we investigate the most recent case studies of Metaverse in education, including investigations conducted by academic institutions and technology enterprises. Finally, this paper thoroughly analyzes the Metaverse in education, covering its current technological state, challenges, opportunities, prospects, and feature directions. The findings of our research indicate that the Metaverse is a valuable resource for educational purposes.

**INDEX TERMS** Metaverse, artificial intelligence, blockchain, big data, avatar, internet computing, virtual reality, argument reality, metaverse education, internet computing, game design, digital twin.

## I. INTRODUCTION

Nowadays, education is the most crucial aspect of our life. Continuous learning is a lifelong process, extending even into our later years. Since we were young children, we have been required to engage in learning activities. When we were younger, we went to school and learned various things. There is a wide variety of techniques to acquire knowledge. Some learning methods are enjoyable, while others are tedious. Our primary source of information is books, which mostly include written content with limited visual representation. This improves our perception of learning, making it more enjoyable. Nowadays, technological advancements are happening at an incredible pace. While technological advancements have affected nearly every industry, the educational system has been the most profoundly affected [1]. Nowadays, there are numerous learning tools available. For example, before the COVID-19 Pandemic, teachers used a screen to demonstrate to students what they were studying [2]. However, it should be noted that education is currently being conducted via videoconferencing. Nevertheless, there are specific constraints when using videoconferencing for

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educational purposes, such as the inability to communicate with students or teachers directly. This requires us to continuously seek the most efficient approach to utilizing technology to enhance the standard of education. VR and AR are two advanced technologies that have generated significant excitement in the field of education [3], [4]. VR is a technological innovation that enables individuals to connect their physical reality with a computer-generated virtual environment [151]. Virtual reality has been employed in several applications, including Google Earth, enabling users to participate actively in a simulated Earth representation. Augmented reality is a technical innovation that seamlessly integrates digital elements into the physical world [152]. Furthermore, augmented reality is utilized in practical situations, such as overseeing and controlling information on social networking platforms and gaming applications like Pokémon Go. Connecting the digital and physical worlds through technologies such as AR and VR is now possible. "Metaverse" refers to the virtual realm [5].

### A. THE METAVERSE'S HISTORICAL BEGINNINGS AND DEVELOPMENT

Neal Stephenson introduced the Metaverse in his 1992 novel. He portrayed it as shared virtual reality. The term "Metaverse" is derived from the noun "universe" and the prefix "meta," meaning "with, behind, beyond, after" [3]. This creates The Metaverse. Metaverse concept is not new [4]. Nevertheless, the "Metaverse" concept does not start to take shape with any clarity until thirty years have passed. Mark Zuckerberg's 2021 shift from Facebook to Meta revived widespread interest in the word and notion of the "Metaverse" [6]. Advancements in VR and AR have boosted interest in the Metaverse [6]. Metaverse mixes video, VR, and AR to create an immersive digital world [7], [152]. Users access the Metaverse by engaging in real-time virtual experiences and utilizing 3D viewers. Users can create realistic avatars, engage in social interactions, construct virtual residences and objects, participate in virtual concerts, conferences, and holidays, and engage in numerous other activities [7]. Second Life, Sandbox, Decentral, Stageverse, and others are only a few entry points to the Metaverse [8], [9], [10]. Thanks to recent VR advancements, the Metaverse is now within reach. Facebook, Google, and Microsoft are just a few of the top tech corporations that have poured a lot of money into creating VR and AR technology [10]. Currently, the Metaverse holds the capacity to revolutionize interactions, education, employment, and leisure, making it a captivating domain for internet technologies [11]. Integrating aspects of AR/VR with the web creates an immersive, collaborative, and interactive setting [12].

### B. THE METAVERSE'S UNDERLYING SUPPORT TECHNOLOGIES

The most essential tools for making and running virtual worlds are Metaverse technologies. These are a few examples of Bitcoin, cloud computing, VR and AR, and AI [14]. The use of these technologies enables individuals to connect with and experience virtual worlds, as well as to create digital assets, operate virtual worlds, and enhance their experiences through the utilization of motion tracking and intelligent tactile feedback [13]. AR blends digital components into the real world, unlike VR. At the same time, the latter replicates a whole digital world to produce an immersive experience [152]. The technology behind blockchain can also secure activities that take place in the Metaverse and make them more transparent. People who have access to the internet can access Metaverse experiences through cloud computing [14], and artificial intelligence (AI) can help make simulated worlds feel more natural and responsive [18]. The Metaverse is still being built, but many businesses are already looking into what it could do. Big companies like Microsoft, Nvidia, and Meta are making these efforts. As technology improves, we will see changes in these virtual places [15]. As the Metaverse continues to grow and improve, these tools must keep getting better [16]. AR, VR, AI, and blockchain technology are expected to be utilized in conjunction with one another in the Metaverse to create realistic simulated worlds and scalable [17].

### C. INVESTIGATING THE POSSIBILITIES OFFERED BY THE METAVERSE

A lot of different types of technology are already using the Metaverse. In medicine, for instance, it is used to mimic surgeries and give doctors training [18]. With AI, medical teams worldwide can work together to make better decisions [19]. AI is thought to help healthcare facilities quickly find up-to-date and correct information about their patient's health. It will be possible to get the most out of the available tools, boosting efficiency and improving clinical and operational workflow. In the business world, it's used for online meetings and talks and even for online trade shows and installations [20]. By providing a space for virtual shopping, ads, and business deals, the Metaverse could open up new business opportunities [21]. This could also lead to new job opportunities in areas like virtual reality creation and development, which would help the digital economy grow [22]. The Metaverse has the potential to transform how people work entirely, enabling effortless collaboration in remote environments, conducting virtual meetings, and improving skill acquisition [23].

### D. OBJECTIVE OF METAEDUCATION

The primary aim of metaeducation research is to create and apply an advanced approach to enhance the capabilities of future education systems. This methodology encompasses multiple facets of educational practices, such as the development of curriculum, pedagogical approaches, assessment methods, and teacher training. Its primary objective is to improve learning outcomes and equip individuals with the necessary skills to thrive in a progressively intricate and ever-changing global landscape. Metaeducation is an innovative educational strategy that provides learners with the required information, abilities, and attitudes to succeed in a constantly evolving world. Metaeducation can fundamentally transform the trajectory of education and foster a society characterized by fairness, sustainability, and prosperity through innovative approaches, collaborative efforts, and a steadfast dedication to continuous learning.

### E. SCOPE AND CONTRIBUTION OF METAEDUCATION

The comprehensive approach of an advanced methodology for enhancing future education involves numerous aspects to revolutionize educational methods to address the requirements of learners and society more effectively. Below is an analysis of the extent of paedagogical Methods, Curriculum Design, Evaluation Methods, Teacher Training, Integration of Technology, Continuous Learning and Metacognition, Global Citizenship and Ethical Leadership, Research, and Evaluation Policy Implications and Systemic Transformation, Community Involvement, and Cooperation By incorporating these characteristics into the technique, educators and researchers can strive to equip learners to excel in a dynamic and evolving world and make meaningful contributions to societal progress.

### F. STUDY MOTIVATION AND RESEARCH GAP

The Metaverse offers many options in various areas based on what has been said thus far. Despite this, little scientific research demonstrates what the Metaverse will look like in the next few years. Notably, there is currently a scarcity of systematic literature studies on the Metaverse. According to a search conducted on Scopus in April 2023, there are 35 reviews spanning the years 2021 to 2023 [24], [25]. One of these reviews began in 2021, sixteen in 2022, and eighteen are still being worked on in 2023. The articles cover various research topics, including work on blockchain technology, augmented reality, medical research, and digital technology. A few of them contain information regarding education and training. Therefore, the objective of this study is to endeavor to address this deficiency. This research endeavor aims to conduct a preliminary investigation to analyze the primary advantages, disadvantages, and possibilities related to education and training the Metaverse. This study focuses on the Metaverse's potential as a teaching tool because it is becoming more challenging. The aim is to examine the relationship between education and the Metaverse by weighing the benefits and drawbacks of this emerging technology. Even though the Metaverse is becoming more popular in education, there is still a lack of study on how to use it and how well it works [26]. Extensive research is required to determine the best strategies for utilizing Metaverse technology in education and to uncover its limitations [27]. This study aims to collect and assess existing knowledge about the benefits and drawbacks of using Metaverse technology in educational settings [28]. The research examined the connections between Metaverse education, which focuses on knowledge transfer, and developing specialized, vertical skills relevant to the workplace or industrial environment. This review can assist teachers, academics, and policymakers interested in using Metaverse technology in the classroom [27], [28], [29].

### G. THE STRUCTURE OF RESEARCH

This research examines a novel and challenging topic. As a result, a comprehensive investigation was conducted to produce a detailed analysis that would set the research route. Section II includes the literature survey. Section III explores the impact of the metaverse on schooling. Section IV presents the metaverse framework specifically tailored for educational use. Section V analyzes the utilization of the metaverse in the realms of education and training. Section VI examines the function of technology in facilitating the metaverse in education. Section VII explores the benefits and drawbacks of metaverse schooling while analyzing several associated challenges and problems. Section VIII highlights prospective directions for research in metaverse education. The paper finishes by providing an in-depth summary section. Figure 1 represents the overall organization of this research article.

## II. LITERATURE SURVEY:

An essential step in building a new theory or conceptual framework is conducting a literature review to trace the historical progression of a specific topic. Research has shown that using systematic procedures in a literature review can decrease bias and generate reliable findings for decision-making [24]. Systematic literature reviews are the focus of specialized publications and special issues. Because academics have recognized systematic reviews' potential benefits, we can classify systematic reviews into four types. Meta-analytic, method-based, domain-based, and theory-based reviews are included. Each of these categories is important in its own right. Various educational institutions and universities conducted many studies, with the Metaverse as the central focus of these investigations [5], [6], [7], [8], [9]. Using a problem-based approach, researchers implemented the Metaverse into a classroom setting where students and teachers may engage in simulated problem-solving in a three-dimensional virtual environment [9], [10]. The method employed was problem-based. By leveraging Metaverse-related technologies that integrate virtual and physical learning elements, building a new educational environment that takes advantage of Metaverse's existence is feasible. This new educational environment could be seen as an improvement on the current educational backdrop [30]. Wearable technology allows students to access the learning environment regardless of location or the time of day [31], [32].

Akour et al. [4] sought to examine Gulf region high school students' perceptions of the Metaverse as an instructional tool using the technology adoption strategy. Practically speaking, this study was beneficial as it enabled educational authorities to comprehend the value of each element. Consequently,

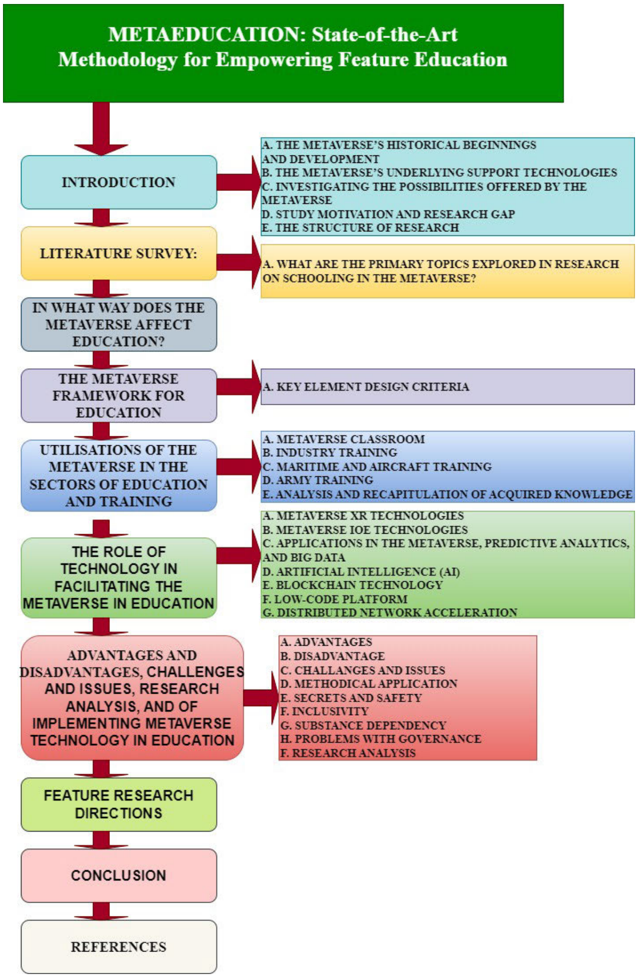


**FIGURE 1.** Overall general organizational structure.

they were able to develop policies and initiatives that prioritized the significance of these components sequentially. Minchev [150] improved the Unified Theory of Acceptance and Use of Technology (UTAUT) model to study student acceptance of an educational Metaverse platform.

The model considered the learners' sentiments towards the potential hazards of the technology. Dwivedi et al. [72] depth analysis of the difficulties by employing a well-informed narrative and a methodology that considers multiple points of view. Using this method, they investigate the Metaverse and its influence on the metamorphosis process. In their study [86], Tlili and colleagues conducted an exhaustive review of the previous research that had been conducted on the topic of education in the Metaverse. According to [17], an engineering curriculum incorporating advanced elements such as student-centered active and e-learning, visualization/Metaverse, and gamification characteristics is recommended. The data also demonstrate the progressive development of the educational Metaverse's design, wherein technologies employing artificial intelligence specifically cater to Generation Z rather than Generation X or Generation Petrigna and Musumeci [88] conducted a literature review and identified papers that discussed the interactions between the Metaverse and contexts related to training and education, research, and prevention and treatment. Zhao et al. [60] have an exhaustive study investigating the widespread applications of VR technology in nursing education. There will be a simultaneous increase in the number of research examining the application of VR in healthcare, as well as an improvement in the quality of those studies, as a result of the popularity of the Metaverse idea. Based on their review of nineteen articles, Ng [131] concludes the current state of the Metaverse trend, the potential technologies, and the historical and contemporary understandings of the term among scholars. The results give a solid theoretical foundation that may help us comprehend the future of online learning on these popular technology platforms. The results also cover the leading technical platforms of the Metaverse trials. Kye et al. [85] provided a comprehensive description of the four distinct forms of the Metaverse, together with their potential and limitations, specifically for teaching purposes. Initially, educators ought to examine students' understanding of the Metaverse. Subsequently, they should develop instructional strategies that promote collaborative problem-solving and creative thinking. Lastly, it is imperative to construct educational Metaverse platforms with robust safeguards to prevent the misuse of student data. Exercise utmost caution when engaging in any of these activities. Previous literature reviews have made it abundantly clear that a dearth of research investigates the use of the Metaverse in education [30]. To achieve the goals of immersive learning, it is possible to combine technology with mental immersion based on narratives and challenges within the educational Metaverse [22]. In their study, Khalil et al. [83] discovered that educators and students expressed a keen interest in investigating the possible uses of the educational Metaverse. The institution's management was also requested to construct infrastructure, provide training for staff and students, and offer technical support to facilitate the utilization of the educational Metaverse. In their study [9], Arpaci and colleagues established crucial factors for accurately forecasting the educational longevity of the Metaverse. The results showed that the time available for schooling in the Metaverse was greatly affected by the need for freedom and the urge to feel pleasure. Table 1 displays the study's review and the research gap it fills. Nursing and healthcare education-related studies are summarised in the review article. New technological advancements are now changing the world in profound ways. A change in the educational system results from one of these trends. Online learning activities have also been mandated due to the COVID-19 pandemic [31]. Video conferencing, email, and voicemail are among the distant means of online learning [34]. While there are many benefits to participating in educational activities online, we must not overlook their drawbacks [32]. The Metaverse is one technology that has the potential to be used in the field of education [35]. While this pandemic was underway, many students learned using non-face-to-face (NFF) methods. One solution to the many issues with NFF learning, including difficulties with interactions and general educational problems, is the virtual reality class format offered by the Metaverse platform [36]. It is reasonable to assume that the Metaverse enables us to move virtually and will replace traditional internet infrastructure shortly [36]. "Metaverse" refers to a space where physical and digital elements coexist. Metaverse features mainly consist of permanency, corporeity, and interactivity. The essence of interaction is two-way communication. By "corporeal," we mean our avatars, and by "perseverance," we imply our ability to grow both online and off [37]. One distinguishing feature of virtual worlds is that they are based on avatars rather than physical locations [38], [39]. Through this virtual world, we can participate in a wide range of social activities reminiscent of real life [40], and it unquestionably paves the way for new approaches to education and learning [41].

Metaverse users utilize XR (Extended Reality) technologies, encompassing VR, AR, and MR (Mixed Reality) [42]. The Metaverse can be categorized into four main types: VR, AR, Mixed Reality/Lifelogging (MR/lifelogging), and Mirror Worlds. Virtual reality is the predominant type of Metaverse utilized in education [43]. Virtual reality technology employs volumetric 2D/3D projection to create 360-degree and 3D films [44]. Virtual reality will have an even more significant impact on education in the future [44]. As an example of a gamified learning tool, it employs virtual reality. This gamified VR aids students in visualizing course materials and enhances player-to-player communication [45]. Students' emotions and physiology are also impacted by VR-based learning. The emotional well-being of pupils and their ability to study can be negatively affected by certain virtual reality lessons [46]. VR learning is only applicable to a limited range of academic disciplines. The current state of VR learning is adequate for procedural and declarative practical knowledge [46]. Augmented reality has also influenced several areas within the field of education [48]. With augmented reality technology, virtual items can move around in the physical world [47]. Anyone in a classroom can benefit from augmented reality. Several educators are considering ways to include augmented reality applications in their lessons [49]. Teachers can save time and effort by using an AR authoring tool application to develop AR content without learning programming [50]. Some topics, like geometry, can be better learn by pupils using AR. To tackle geometry issues, it aids students in visualizing the contents, increasing their enthusiasm and interest, and developing their creative thinking skills [51].

Nevertheless, there are a few drawbacks to utilizing this augmented reality technology for learning, namely that it isn't free and the limited language options it provides [51]. Teachers and students alike benefit from AR learning, according to another study by Jurmey et al. Students with trouble using computers or smartphones face some obstacles, [52] However, AR learning outperforms traditional learning methods due to AR's ability to boost creativity and enrich educational learning and instruction [53]. Using the Metaverse, augmented and virtual reality in academic settings can potentially bring a revolutionary change in education [54]. A new Metaverse classroom platform was developed through the research of Wang Yang et al. [144] to facilitate more participatory learning in the classroom. The metaverse can establish a captivating educational setting that is interactive and tailored to the student's needs. However, diligent supervision is necessary to avoid detrimental consequences [144].

Furthermore, as stated by Suh et al. [128], students perceive learning in the Metaverse as pleasurable, and educators can enhance their enthusiasm for learning by utilizing it effectively [128]. Education in medicine and clinical practice can potentially benefit from Metaverse technology. For online clinical case studies and training with several users, this platform provides a solution that requires many visualization scenes and characteristics. That way, students can get a feel for working in a hospital setting while benefiting from all the medical education-related virtual properties [55]. The Metaverse is now in its nascent phase of advancement; hence, its usage is not yet widespread [56], [57]. This approach aims to ensure that individuals with physical and environmental disabilities have equal opportunities by overcoming time and space limitations [58].

### A. WHAT ARE THE PRIMARY TOPICS EXPLORED IN RESEARCH ON SCHOOLING IN THE METAVERSE?

The significance of the research, the crucial subject matter, and the primary focus were comprehended through theme analysis. Metaverse-related technologies that blend real and virtual learning have improved education. The first curriculum includes nursing, medical, engineering, mathematics, and science. Metaverse technology could enable immersive and personalized patient experiences in healthcare [151]. It may allow doctors and patients to interact more closely. Metaverse simulations give pupils interactive feedback and help them learn. Metaverse simulations of intravenous drug infusion and administration assist nursing students in administering pharmaceuticals safely [59]. Visitors can use avatars to consult with doctors at the virtual Metaverse hospital. Doctors can consult, evaluate, and remotely monitor patients here. Professional growth and new research methods are also available [28]. There are medical consultation rooms, a cardiac MRI room, a virtual operation room, and a virtual laboratory at the hospital where patients can experience simulated heart attacks. Virtual reality in medical teaching allows students to practice surgical procedures at a cheaper cost [60]. Virtual reality during cadaver training can increase surgical trainees' accuracy and decision-making [61], [62]. Engineering studies involve fundamental knowledge and lab or experimentation experience [63]. Metaverse immersive labs and virtual education are available to students.

The primary concern in engineering education is insufficient time and resources for students to conduct experiments [64], [65]. This can be fixed using Metaverse labs. Other issues with online learning included a lack of interaction and engagement [66]. To overcome this, the Metaverse offers a stunning 3D environment. All of these elements will boost the engineering curriculum. COVID research comprises three sub-disciplines: pre-COVID-19 [37], [62], [63], [64], [65], COVID-19 [6], [21], [38], [40], [54], [66], [67], and post-COVID-19 [7], [8], [10], [11], [13], [14], [15], [16]. Virtual and blended learning superseded traditional classrooms before and during COVID-19 [67]. Students wear virtual reality headsets to learn, explore, and socialize in the Metaverse.

This allows them to experience a virtual campus or institution. Within this digital realm, students can engage with one another and access libraries, breakout areas, mentors, and advisors. In response to the 2020 pandemic, schools and students must engage in online learning. The pandemic has afflicted everyone, even schoolchildren [68]. Remote learning and online classes were common for those who couldn't attend, and the user's text was empty. Aside from devoting extensive time to Zoom classes, students also allocated the rest of their days to engage in online gaming or conversations with their peers. Following the resumption of in-person attendance at schools in 2022, these advances persistently continued to be made [1], [69]. There is widespread apprehension regarding the future of online education due to emerging technologies [13], [70]. Many individuals believe that the Metaverse will assume the role of the predominant educational tool in the future. This feature will allow students to connect physically within virtual classrooms, overcoming the primary drawback of learning in the Zoom era, which is the perception of physical isolation [3], [71]. Metaverse adoption for learning and education is the third discipline. This discipline has several subfields, including adoption among school students [8], [42], [71], [73] university students [6], [7], [13], [38], [40], [54], [55], [58], [67], [72], [76], [80], [81] and adoption teachers/professors [20], [21], [58], [68]. Businesses and industries need a workforce prepared to address Metaverse issues, which requires new management and organizational leadership paradigms [72]. Table 2 compares major education metaverse research topics. The application of Metaverse technology has started to be implemented in several different institutions, including business offices, charitable organizations, and the headquarters of some of the largest technological corporations in the world, like Facebook [73]. Facebook is becoming increasingly interested in advancing and integrating Metaverse technology in its applications and subsidiaries in the future. This interest is a direct result of Metaverse continuously gaining popularity [74]. Metaverse technology is advantageous in education for several reasons, including the fact that it helps raise educational standards and makes it possible to take a more modern approach to the teaching process [75]. There is more than one learner capable of understanding a theory; even one student is not the only one. On the other hand, he is also capable of experiencing the phenomenon in its entirety. By physically visiting and interacting with the objects, they learn about them through virtual reality [76]. Major corporations worldwide are beginning to take notice of the technology known as the metaverse. People will have an increasing demand for the use of technology that is associated with the Metaverse in the future. Technology that utilizes the Metaverse will bring about a transformation in the world. Up to this point, the two-dimensional environment we have been familiar with is beginning to give way to a technologically advanced three-dimensional atmosphere [77]. This technology is starting to become a more contemporary educational environment. In this era of millennials, the impact technology like Metaverse will have on education will be significant because of its potential. This will likely transform the ways, approaches, methods, and learning systems utilized in education [78]. Table 3 shows that several previous research has been conducted on the Metaverse in the context of education.

However, advancements in Metaverse technology are too much for humanity to resist. In the field of education, several colleges throughout the world have begun implementing the Metaverse technology. Some universities that fall into this category include Aman Arab University, Brainstem University, CEU University, Khon Kaen University, University of Nigeria, and University of Nicosia. While this happens, universities in Indonesia, such as Muhammadiyah University Prof. Dr. Hamka (UHAMKA), have begun implementing Metaverse technology. On the other hand, the development of Metaverse technology at several colleges in Indonesia necessitates extremely high development expenditures, and there is a possibility that it could have both beneficial and lousy effects [79].

## III. IN WHAT WAY DOES THE METAVERSE AFFECT EDUCATION?

The education system has evolved throughout the ages to adapt to new methods. We compare three instructional methods in Table 4. We should welcome and prepare for a new educational paradigm revolution, not just scholars and educators [80]. Generation Z is now open to the idea of attending education online. The digital world is just as important to them as the real world. Since birth, they have been surrounded by computers, smartphones, and the Internet [81]. In the educational system, the digital natives of Generation Z must contend with difficulties. Metaverse is a massive framework with numerous future digital elements [82]. Metaverse features include engagement, authenticity, and portability. Thus, the new educational system must be revised to remain accessible and viable [83]. In Figures. 2 and Figure 3, we list three education industry Metaverse implementations and seven ways it can benefit. In Table 5 describes distinctions between Metaverse technology and standard approaches in education.

### 1) IMMERSIVE INTERACTIVE EXPERIENCE:

Metaverse education transcends Web 2.0-based instruction. Studies [84], [85], [86] suggest that students love teaching classes and learn better in realistic environments.

**TABLE 1.** Metaverse education Review paper and research gap summary.

| Ref | Research Aim | Results | Lack of research or knowledge gap |
|---|---|---|---|
| Kye et al. [85] | This study demonstrates the difficulties in its implementation in the educational sectors. | The significance of the Metaverse is recognized in this research, and an effort is made to bring it to the students' attention. Furthermore, it highlighted the significance of actively creating educational Metaverse systems that effectively safeguard against the misuse of student data. | The only thing this study did was outline the difficulties and potential future directions of the Metaverse. |
| Tlili et al. [86] | Through the use of bibliometric analysis, this study provided an examination of the educational settings. | With the help of this study, new perspectives were discovered, and a road map for the Metaverse in education was provided. | This study examined the integration of the Metaverse into educational environments. However, it did not present any framework for implementing this concept. |
| Tan et al. [130] | The Metaverse of ophthalmology was thoroughly covered in this paper. | This study examines the advantages and disadvantages of utilizing a Metaverse in ophthalmology. | Only a general overview of a Metaverse in educational settings linked to ophthalmology was intended to be provided by this study and its findings. |
| Wu and Ho [132] | Articles about the Metaverse in emergency medicine were reviewed for this study, and its uses were found. | The results can provide a clearer understanding of a Metaverse's features, applications, development, and potential in alternative medicine. This study will enhance emergency medical services' capacity to manage future emergencies effectively. | This study covers emergency medicine, and its applicability was the only use case provided. |
| Petrigna and Musumeci [88] | For the objective of this study, a literature review on recent publications was to be carried out, and articles that establish a relationship between the Metaverse and research settings, education and training, and prevention and therapy were to be sought out. | The results of this study suggest a connection between online learning environments and health, wellness, disease prevention, and clinical diagnosis and treatment. | The relevant study was this one. Examined the difficulties that a Metaverse presents in the field of healthcare education. |
| T.K.-Ng [131] | With only 19 articles to draw from, this evaluation offered a comprehensive summary of the Metaverse system. | Insight into the future of online learning on these popular technical platforms may be possible thanks to the results, which offer a solid theoretical foundation. The leading technological platforms used in the Metaverse experiments are also detailed in the results. | The only thing this study did was present a perspective of the Metaverse in online education about the future. |

**TABLE 1.** *(Continued.)* Metaverse education Review paper and research gap summary.

| | | | |
|---|---|---|---|
| K.Topraklı-koglu and G.Öztürk [76] | A general summary of the Metaverse, as it relates to mathematics education, was presented in this paper. | According to the findings, the Metaverse and its applications can be conceptualized as a framework. Mathematical study and study. | Every aspect of mathematics was the exclusive focus of our investigation. |
| Kaddoura et al. [77] | In this particular research project, PRISMA was used to emphasize the Metaverse's role in education. | Based on the research, the Metaverse can emerge as the future of education and instruction. | Establishing a framework for the future is not included in this evaluation. |
| Chen et al. [19] | A bibliometric investigation of the application of the Metaverse in educational settings is brought to light in this paper. | The result of the investigation demonstrated the significance of the Metaverse and how it might be utilized in educational settings. | It was only possible to focus on learning surroundings and attitudes in this study. |
| Beck et al. [14] | Within the scope of this study, 47 studies were identified as exhibiting the tactics of a Metaverse in the field of education. | According to this study, there were 45 methods and 21 practices. | Greater emphasis was placed on strategies in this study. A greater emphasis was placed on strategies in this study. |
| Onggirawan et al. [108] | Within the scope of this study, 47 studies were identified as exhibiting the tactics of a Metaverse in the field of education. | According to the findings of this study, learning through the Metaverse is more easily understood than learning through traditional methods. | All that was discussed in this study were online educational environments. |

### 2) VISUALISATION:

Digital technologies allow the Metaverse to microscopically show learners chemicals and biological cells [87]. Additionally, it can replicate perfect physics circumstances, making abstract notions like Einstein's relativity theory concrete [88].

### 3) LOW COSTS AND HAZARDS ASSOCIATED WITH LEARNING:

Chemistry and Physics require experiments. Digitization, part of Metaverse education, can imitate all these experiments. This conserves resources. Learners' operational risk is low whether they train with high-risk chemicals or air crash simulations [89].

### 4) NO TIME OR SPACE CONSTRAINTS

Metaverse schooling can be used without time constraints. Students can imitate historical events instead of imagining or watching books or movies. It breaks geographical barriers [90]. For instance, temperate students desire to study tropical locations. With digital tropical simulations, students can use the Metaverse for this.

**TABLE 2.** Major education Metaverse research topics.

| Discipline | Sub discipline | Focus Area | References |
|---|---|---|---|
| Educational Courses | Nursing | Metaverse allows real-time virtual learning for nursing education. | [19] |
| Educational Courses | Medical | Metaverse can increase immersive and interactive learning in medical education. | [13], [18], [21], [27], [28], [53] |
| Educational Courses | Engineering | Metaverse examples in engineering education are real-time. | [17], [37], [38], [54], [55] |
| Educational Courses | Mathematics | Metaverse maths can be gamified to improve understanding. | [56] |
| Educational Courses | Science | Virtual spaces like Metaverse enable students to learn, communicate, and comprehend science education concepts. | [7], [8], [17], [20], [39], [53], [57], [58] |
| COVID-19 | Pre-COVID | Most learning facilities were offline before COVID. Therefore, Metaverse had limited potential. | [37], [62]–[65] |
| COVID-19 | COVID | Online learning increased during COVID because students couldn't attend classrooms, making it ideal for Metaverse education. | [6], [21], [38], [40], [54], [66], [67] |
| COVID-19 | Pre-COVID | This Metaverse-based online class lasted post-pandemic due to its reach. | [7], [8], [10], [11], [13]–[16], [18], [27], [28], [39], [41], [42], [54], [66]–[74] |
| Adopting Metaverse | Among School Students | Metaverse can help early technology adopters like schoolchildren learn more efficiently. | [8], [42], [71], [73], [74] |
| Adoption of Metaverse | Among College/University Students | TMetaverse technology enables global university and college lectures and labs. | [6], [7], [13], [38], [40], [54], [55], [67], [72], [76], [80], [81] |
| Adopting Metaverse | Among Teachers | TMetaverse, technologies simplify lecture delivery for professors. | [20], [21], [58], [68] |

### 5) ENSURING ACADEMIC INTEGRITY

Metaverse employs blockchain technology to identify instances of academic misconduct [91]. Blockchain necessitates assigning a timestamp to each instance of generating, releasing, and transmitting information in a chronological record. This function [93] can be utilized by copyright protection to track and monitor the publication, distribution, and dissemination of academic work [92]. Furthermore, smart contracts are only operational when all parties complete their obligations. Following an author's manuscript submission, our system generates a new block, which is subsequently used to distribute and oversee the maintenance of transaction information within that block [94]. In this particular instance, the author's submission conduct is ensured to be distinctive, and academic dishonesty, such as numerous submissions and disclosures, is avoided to the greatest extent possible [93].

**TABLE 3.** Several studies have already been done on Metaverse in Education.

| S.NO | Author | The Results of the Research Review |
|---|---|---|
| 1 | Jeon & Jung (2021) | The Metaverse connects the actual and virtual worlds. This article investigates the potential applications of the Metaverse for educational purposes. The platform based on the Metaverse was designed to be used in the context of online education. Therefore, it includes many educational activities, including learning, communication, and empathy. On this Metaverse platform, learners can experience learning and be motivated and immersed. Self-directed learning based on spatial mobility autonomy is possible. The Metaverse platform has limitations in terms of technology and ethics; nonetheless, we should emphasize learner interaction more than having unrealistic expectations. |
| 2 | Kye et al. (2021) | It is predicted or anticipated in this article that The Metaverse has the potential to change our economy and day-to-day lives, spreading its influence far beyond the domains of gaming and entertainment [85]. The Metaverse, being a nascent social network, possesses boundless potential. Teachers must conduct thorough studies on how students will perceive the Metaverse in the future, create courses that foster creative problem-solving and project completion, and design educational Metaverse platforms that prevent data abuse [85]. |
| 3 | Indarta et al. (2022) | The Metaverse technology has been gaining popularity over the past few months, and the adoption of this technology in educational settings has been accelerated by digital learning material based on augmented and virtual reality. The Epidemic's limited class size, distance, and time to attend class are stated to be overcome by the Metaverse. Virtual environments facilitate enhanced engagement in online learning while maintaining the integrity of student education. Over the next 10-15 years, the Metaverse will penetrate all elements of human life. |
| 4 | Hwang & Chien (2022) | According to this article, Metaverse is a promising technology. However, instructional use of the Metaverse is rare. This evolving technology's Metaverse properties and uses may be unknown to most educators. They intend to describe the Metaverse precisely in their position paper. The educational uses of the Metaverse, along with the corresponding research difficulties, are also addressed. Artificial intelligence's Metaverse roles and educational applications are being studied. Computer science and educational technology scholars must understand the Metaverse and its educational uses. |
| 5 | Suh & Ahn (2022) | This constructivist essay describes learners' Metaverse experiences and attitudes to show how closely this virtual environment affects elementary school youngsters. This study examined how new educational technologies increasingly focus on pupils. A poll of 336 Korean primary school children included 18 questionnaires to quantify each Metaverse characteristic. The Metaverse has been experienced by 97.9 percent of elementary school students, and 95.5 percent believe it impacts their day-to-day lives. |
| 6 | Hwang (2021) | This study suggests that gamification and edutainment may be successful when Metaverse students use avatars to interact with the learning process and surroundings. Utilizing a Metaverse environment enables individuals to have meaningful interactions and engage in practical activities, enhancing immersion in 3D learning. It can address the limitations of two-dimensional internet live broadcasting technologies like Zoom and Webex. |

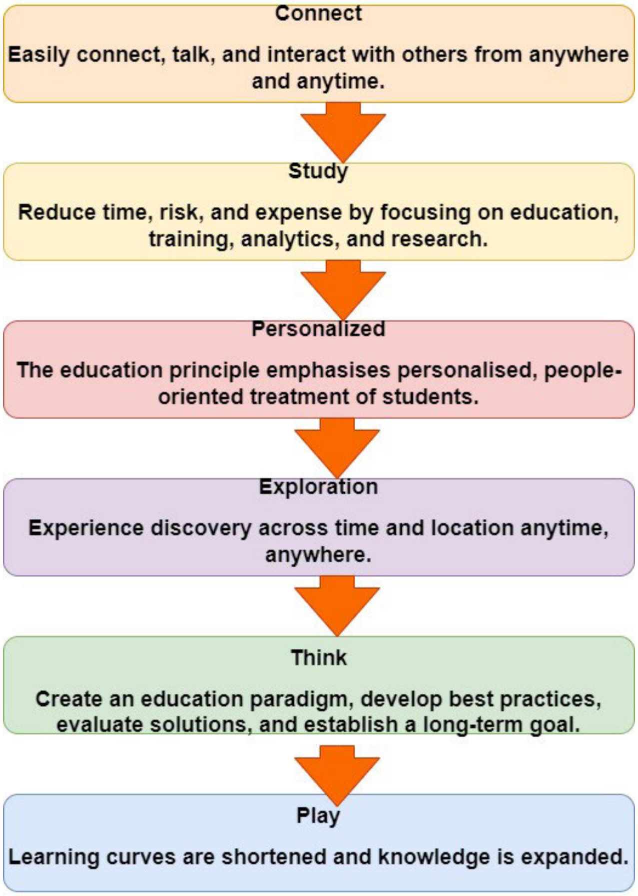


**FIGURE 2.** The transformation that metaverse brings to education.

**TABLE 4.** Evaluation of three distinct forms of education.

| | Traditional Education | Online Education | Metaverse Education |
|---|---|---|---|
| Place | school | school, home | school, home |
| Apparatus | notebook, writing implement, whiteboard | portable electronic device | gadgets worn by the user's body, brain-computer interface |
| Teaching methodology | one-to-many | one-to-many, one-to-one | one-to-many, one-to-one |
| Teacher | teacher | disseminator of information | information disseminator |
| Well-informed | student | learner | learner |
| Teaching things | fields of research in the natural and social | scientific, social, and interested | Making changes |
| Objective of Education | fitness programmes | wellness programmes, improve quality of life | knowledge in every are |
| Assistance with Technology | none | Web 2.0 | Web 3.0 |

### 6) PERSONALISATION

Like Metahkust 7 students, learners can create customized avatars utilizing digital twin generators or simulators, increasing self-assurance and involvement. Once users grant authorization for their data, the education system can generate lawful instructional content and courses [95].

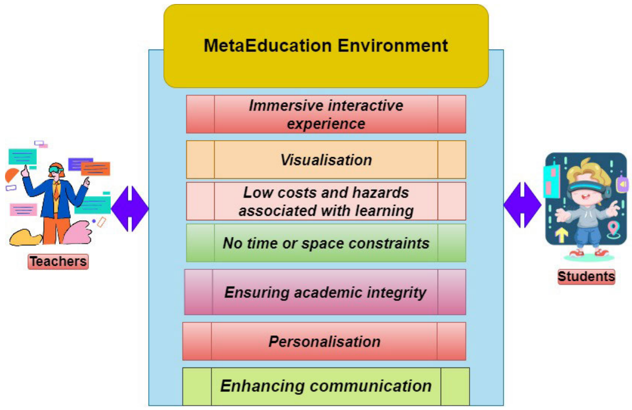


**FIGURE 3.** Overall general organizational structure.

### 7) ENHANCING COMMUNICATION

Physical distance impedes participation and communication in online classrooms [96]. Learners are inevitably subjected to distractions, whereas teachers cannot control the timing of their reactions, such as facial expressions and bodily movements. Metaverse enables educators to create virtual meeting spaces. Additionally, students can construct collaborative study rooms where they can study and socialize. Everyone can watch, share, and play games using their avatars [97].

These features increase relationships between students and teachers and bonds between classmates. As a result, we envision a bold future for education in the Metaverse [98]. The peak of the Metaverse needs to be decentralized, but the network environment already in place (for example, Web 2.0) cannot meet its requirements. Web 3.0 has the potential to serve as the basis for the Metaverse, which gives machines the ability to comprehend information akin to that of people. Given these circumstances, the paradigm shift toward creative education may have the following advantages:

1) At a low end: The Internet of Everything simplifies information retrieval and knowledge acquisition, reducing the overall education cost for all individuals [99].
2) AI search: AI search will only surface results that are considered to be urgent. The search system automatically marks all conversations, and users are reminded of topics and resources that are pertinent to their searches [100].
3) Revolution in the classroom: Big data and educational behavior technologies allow teachers to provide students with complex and individualized homework assignments that assist students in becoming more self-sufficient [100].
4) Learning: When it comes to learning, students should not spend a significant amount of time structuring major learning elements. They can study or review whenever and wherever they choose [99], [100].
5) Personal learning: The personal learning agent is tasked with autonomously gathering and documenting the user's learning objectives inside the personal learning network [101].

6) A system for the management of personal education: The personal education management system will generate study plans for each user, who can modify these plans at any time and in any location according to their requirements [102]. Considering the subversive alternative of the Metaverse to schooling will eventually advance the Metaverse. Metaverse-based education will benefit many students and help promote the Metaverse. Young people educated through Metaverse will be better familiar with all its components. This makes Metaverse development more plausible [100], [101], [101], [102].

### A. METAVERSE EDUCATIONAL TECHNOLOGY VS. TRADITIONAL EDUCATIONAL TECHNIQUES

The integration of modern technology in education, through the concept of the Metaverse, signifies a significant departure from conventional approaches, aiming to augment the learning process. Here are some crucial factors that emphasize the superiority and distinctions between Metaverse technology and conventional approaches in education: Although Metaverse technology presents intriguing educational prospects, it is crucial to acknowledge that combining both methods may be the most advantageous. Combining the advantages of the Metaverse with conventional approaches has the potential to offer a comprehensive and efficient educational experience.

## IV. THE METAVERSE FRAMEWORK FOR EDUCATION

The Education Metaverse must adhere to the overall Metaverse's construction paradigm and incorporate the necessities and traits of education. The study lays out a five-layer Education Metaverse structure with two methods and ethical standards that center on the building and interaction of human resources, scenes, and learning activities. Figure 4 illustrates the Education Metaverse Architecture, which consists of five layers. This architecture facilitates system expansion, updates, and maintenance by effectively distinguishing the data, compute, interface, and application layers while minimizing contact between various components. The management mechanism uses blockchain technology to classify users and allocate resources to ensure the system's long-term viability. An incentive mechanism is implemented to increase engagement and system dynamics in the Education Metaverse, drawing inspiration from the social psychology paradigm.

1) Physical Layer: Physical Sublayer Everything in the network, including hardware and other infrastructure, is part of the physical layer. Additional bandwidth is necessary for 360 video, immersive scenes, and many concurrent users to maintain minimal latency in the Metaverse. The hardware includes servers, sensors, VR headsets, and displays. Cameras and somatosensory devices are examples of sensors that can transmit data about changes in the real world to an online environment. Input data, like cameras, can serve two purposes: first, they reveal the user's actions in real-time; second, they provide multi-modal engagement, such as gestures. Holographic devices, VR goggles, AR headsets, and other portable terminals allow Metaverse access.
2) Data layer: The Data Layer serves as the foundation for the Education Metaverse. User-generated content and real-world aspects coexist within the Education Metaverse. In addition to fundamental user and system operational data, educational resources and repositories of information are crucial for online instruction, intelligent teaching aids, and customized learning programs.
3) Computing Layer: What sets the Education Metaverse platform apart from other immersive learning systems is its computational layer. Although conventional virtual humans depend on manual modeling, virtual avatars have the potential to provide an immersive experience. Generating virtual avatars with real-time sensory synchronization is now feasible using computer vision-based 3D reconstruction technologies. There are a lot of artificial intelligence technologies that could make the Education Metaverse's interaction modes much better. Speech recognition, natural language processing, and gesture recognition are all examples of technology that fall under this category. A fully immersive Metaverse experience can be created by utilizing information scheduling, photorealistic rendering, and simulated special effects, all of which add to the overall capability.
4) Interactions Layer: Interacting with virtual avatars may lead to intrinsic motivation and embodied experience [43]. Interactions between humans, between humans and learning resources, and between humans and the teaching scene are the three primary kinds of interactions that we propose exist in the education metauniverse. Communicating verbally, in writing, or through physical contact is all part of the human-to-human connection in the classroom. When a user interacts with a learning resource via a mouse, keyboard, handle, gestures, or other physical means, this is called human-to-learning resource interaction. Users can freely move around the scene and even switch between scenes as part of the human-to-teaching scene interaction. Aside from the most basic written and spoken communication types, the Education Metaverse calls for more natural multimodal interaction strategies like eye-tracking, tactile involvement, and gestures.
5) Applications Layer: By allowing the execution of infeasible educational activities on conventional teaching platforms, the Education Metaverse can cover a broader range of instructional scenarios than conventional immersive teaching systems. Even in a lecture-based classroom, students will still have a unique educational experience with the Education Metaverse. The capacity to transition between various content-based instructional situations is also a part of this, as is access to dynamic representations of process concepts

and figurative representations of abstract ideas using 3D virtual resources. The Education Metaverse system suits experimental teaching and collaborative learning due to its 360-degree sensory capabilities, multiuser cooperation, and 3D simulation. Thanks to apps like intelligent assessment and intelligent tutor, the Education Metaverse can complete the learning, teaching, management, and evaluation process from data to knowledge and iterative feedback on instruction.

6) Ethical Regulations: Code of Ethics Protecting users' personal information and data in the Education Metaverse is an essential responsibility of ethical regulations [48]. These rules address issues with trustworthiness, privacy, security, and accessibility through governing data and user authentication, which includes privacy protection and reliable algorithms. Biometric identification is one of the methods that can be used for secure user access in the Education Metaverse, which differs from the standard method of account and password authentication. Data management relies heavily on OAT, or ownership, accountability, and transparency. The proliferation of digital footprints and behavioral data in online classrooms poses new privacy concerns not seen in traditional classrooms. Classifying and grading data types according to sensitivity and hazards is essential to a user-centric privacy protection process. The Education Metaverse places a significant emphasis on Human-Computer Interaction (HCI) as a means of preventing users from being misled and providing them with inaccurate feedback. It is for this reason that it is necessary to have evaluation standards for AI algorithms that are reliable and rigorous.

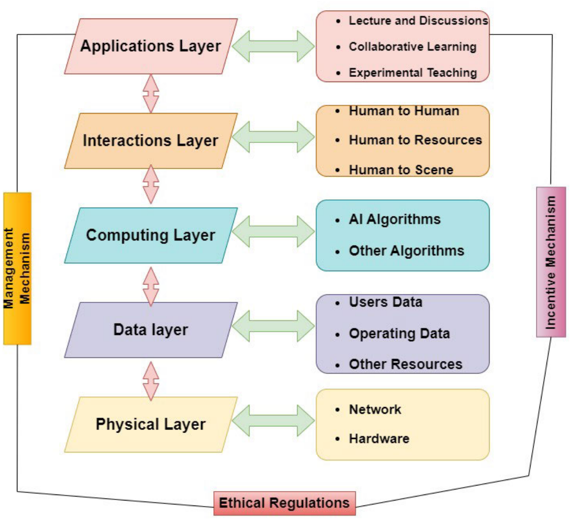


**FIGURE 4.** 5 layered education metaverse architecture.

## A. KEY ELEMENT DESIGN CRITERIA

Regarding educational and learning goals, the Education Metaverse comprises vital components such as virtual teaching environments, virtual learning resources, and virtual avatars. No aspect of teaching and learning does not involve these three components. Virtual humans will affect user experiences in various ways, including configurability, realism, operability, and other characteristics. The Education Metaverse platform can receive content from a wide variety of technologies, grow successfully, and construct an ecosystem with the assistance of a standardized definition.

**TABLE 5.** Distinctions between Metaverse technology and conventional approaches in education.

| S.No | Factors | Metaverse Technology | traditional Techniques |
|---|---|---|---|
| 1 | Immersive Learning Environments | Metaverse Technology offers immersive and interactive 3D environments that enable users to connect with content and one another more authentically and captivatingly. Virtual reality (VR) and augmented reality (AR) can generate authentic simulations and immersive experiences. | Conventional approaches generally depend on textbooks, lectures, and two-dimensional materials, providing a less engaging and dynamic learning encounter. |
| 2 | Individualized Education | Metaverse technology enables the implementation of adaptive learning routes and personalized experiences specifically tuned to meet the unique needs of individuals. Artificial intelligence systems can monitor and analyze user actions to provide tailored information and evaluations. | Conventional approaches often employ a standardized method, in which the teacher and predetermined curriculum dictate the speed and manner of learning. |
| 3 | Cooperation and interpersonal communication | Metaverse Technology enables seamless real-time cooperation and social interaction between students and educators, regardless of physical location. Collaborative work and group activities are facilitated by virtual classrooms and shared venues. | Conventional approaches usually need direct personal connections, which may be restricted by geographical distance and time availability. |
| 4 | Enhancing accessibility and inclusivity | Metaverse technology can enhance education by catering to diverse learning styles and addressing accessibility requirements. Virtual worlds can be tailored to accommodate diverse preferences and needs. | Conventional approaches may encounter difficulties ensuring equal educational opportunities for everyone, particularly persons with physical limitations or residing in rural regions. |
| 5 | Experiential Learning | Metaverse Technology facilitates immersive and practical learning by utilizing simulations and virtual labs, allowing students to hone their skills in a safe and controlled setting. | Conventional approaches frequently depend on theoretical teaching, offering limited chances for hands-on, practical implementation in real-life situations. |
| 6 | Cost, resource efficiency | Metaverse technology can decrease physical infrastructure, transportation, and materials expenses. It has the potential to scale, enabling more students to access instructional resources. | Conventional approaches entail costs associated with actual classrooms, textbooks, and travel, which may impede access to education for certain persons. |
| 7 | Worldwide Scope | Metaverse technology facilitates students' and instructors' seamless connection and collaboration worldwide by eliminating geographical limitations. | Conventional approaches may face limitations due to geographical constraints, posing difficulties for those residing in rural places to obtain high-quality education. |

1) Virtual Avatars: Teachers and students play a crucial role in education. Therefore, enhancing the virtual teaching platform by creating virtual avatars of teachers with emotions can strengthen learning and make the teaching environment more authentic [49], [50]. To replicate authentic educational experiences, the Education Metaverse necessitates the presence of virtual instructors and learners. Current Metaverse platforms employ anthropomorphic cartoon avatars. However, research suggests that realistic avatars, which closely match genuine images of human faces, enhance learning and create similar spaces. Therefore, the Education Metaverse should have realistic avatars. Anonymous avatars can potentially foster user non-compliance. The Education Metaverse offers both identity-specific and identity-agnostic avatars. Virtual avatars tied to your identity accurately resemble your physical look and vocal characteristics. Teaching activities can be classified into various virtual avatar categories. Identity-connected avatars are better for integrated online/offline classrooms, whereas identity-free avatars are better for exploring. Personal avatars improve user psychology by increasing body ownership, presence, and power. Realistic, configurable, and interactive avatars are needed to simulate virtual body ownership.
These design dimensions affect virtual avatar adoption and efficacy by affecting user identity. Realism is the avatar's physical resemblance to the user, whereas customization is how much users can adjust avatar attributes. The avatar reacts to user expressions, gestures, and voices. We offer five indicators: look, customizability, expression, action, and voice. Skeletal animation, Blendshape, and advanced computer vision and graphics technologies synchronize avatar behavior indicators with the lowest latency, improving user behavior synchronization. Table 6 illustrates how these requirements support the representation of user behavior and the delivery of an immersive experience via handcrafted and AI-generated Education Metaverse avatars. The Education Metaverse avatars' attitudes, movements, and speech must match the natural person. This is vital to increase user presence and provide data for intelligent educational analysis. This is true regardless of whether or not the avatars are connected to the user's identity.
2) Online Learning Resources: Three-dimensional virtual learning aids let students convey abstract topics figuratively and procedurally, lowering spatial cognitive load and improving learning results. The popularity of immersive educational applications is also due to their 3D learning resources and process simulation. The Education Metaverse has observational and experimental 3D virtual learning resources. Magnetism is taught using observational materials like 3D magnets' magnetic poles and magnetic field lines. Virtual simulation experiments address the issues of expensive equipment, risky processes, and particular experimental conditions that cannot guarantee student independence. Most 3D virtual learning tools are created using manual modeling techniques, which restrict their scope and usefulness. There will be widespread adoption of 3D reconstruction technology as a digital resource inside the Education Metaverse, increasing the level of engagement and intuitiveness of the learning process.

**TABLE 6. Characteristics enable handcrafted and AI-Generated education metaverse avatars.**

| Indicator | Connected to Identity | Independence of Identity |
|---|---|---|
| Appearance | Matching the photographs that users have submitted | Pick the one that suits you best |
| Adjustable properties | Dress code Coiffure | Apparel, hairstyle, and facial features (e.g., ears, eyes, lips, nose, eyebrow) |
| Expression | Blendshape motion should be brought [55]. Maintain the mobility of the facial bones [56], Produce expressions that are driven by the voice [57], and Generate expressions from videos [58]. | Blendshape motion should be brought [55]. Maintain the mobility of the facial bones [56], Produce expressions that are driven by the voice [57], and Generate expressions from videos [58]. |
| Action | Allow bone animation Help videos inspire action Support dynamic capture gear Actions generated by depth camera | Allow bone animation Help videos inspire action Support dynamic capture gear Actions generated by depth camera |
| Voice | Real-time voice Personal-sounding synthetic voice [59] | Real-time voice Artificial voice |

3) Virtual Teaching Scenes: According to contextual cognitive theory, applying knowledge deepens learning. [60]. The Education Metaverse needs virtual reality technology to provide realistic contextual educational settings to motivate students and improve instruction. Education Metaverse virtual teaching situations incorporate real-world twins and created settings. This paper emphasizes imagined virtual scenes over real-world twin scenes because they can be customized to the educational circumstance and content. A good virtual teaching scene has these traits: 1) Lecture, resource display, experiment, and roaming areas are designed. 2) Background and decoration are closely tied to educational material to minimize cognitive strain. 3) Dynamic linkages between scenes allow swift content switching, such as cultural courses from Western to Eastern countries. Adding photorealistic rendering and dynamic scene changes can further enhance immersion. A scene network based on location or semantics must combine virtual avatars, learning resources, and instructional scenarios.
4) Interactivity Mode: Virtual education systems still rely on voice and text, whereas immersive apps provide handling. However, the Education Metaverse needs more natural interactions. Table 7 categorizes Education

Metaverse interaction modalities and devices into three interaction categories. Creating a semantic knowledge base and semantic-based interactions in the Education Metaverse will improve its intelligence and usability. The instructor displayed a three-dimensional earth model to the virtual avatar during earth movement, mentioning that the tropic line triggered the model's appearance. Speech manipulation is used in this human-to-resource interaction, but automating it requires knowledge of speech semantics and contextual linkages.

**TABLE 7. Criteria for the design of interactive modes.**

| Type | Mode | Device |
|---|---|---|
| Human to Human | Speech Text, Action, Gesture | Microphone, Mouse, Keyboard, Camera Somatosensory device |
| Human-to-Resource | Speech, Gesture, Operational via mouse or handle Visual monitoring | Microphone, Mouse, Somatosensory camera device |
| Human-to-Scene | Gesture, Control by mouse | Mouse, Somatosensory camera device |

## V. UTILISATIONS OF THE METAVERSE IN THE SECTORS OF EDUCATION AND TRAINING

This section will examine several critical domains of education, training, and skill enhancement in which the Metaverse's accessibility can be advantageous [103]. It is possible to manually design the critical advantages of the Metaverse in comparison to traditional online educational platforms. Establishing digital links between physical and virtual environments achieves this goal [32]. IoE, XR, and other technologies aid education and training. The Metaverse digitally links the physical and virtual worlds, attaining this goal [32]. Figure 5 shows how the metaverse is used in education and training.

### A. METAVERSE CLASSROOM

The provision of educational services to distant pupils and learners is facilitated by implementing XR technology. The need to travel is reduced, and the emphasis is placed on interactive and collaborative methods of teaching that may be delivered remotely [32]. By utilizing interactive VR services and providing an immersive learning environment with virtual meeting locations and digital avatars of both instructors and students, the authors of [27] demonstrated the efficacy of solar system education [104]. The Metaverse and the technology that supports it can transform conventional education methods in learning environments such as classrooms and online platforms into virtual environments [105]. Recent works have used information technology services, including big data, cloud service, and artificial intelligence, to investigate educational, training, and learning activities using Metaverse-based platforms. This has the potential to assist in transferring educational institutions' attention towards education based on the Metaverse [106]. Using this platform, students can engage in an interactive learning environment and feel as if they are physically there in the collaborative classroom, regardless of their actual location. Even though it presents technological and moral challenges, the Metaverse encourages greater contact and collaboration among students, ultimately resulting in a more positive educational experience [107].

The immersive Metaverse platforms have effectively utilized humans' inherent visual cognitive abilities to enhance the interactivity and immersion of education across diverse cultural contexts [108]. There are instances of this in the literature. Metaverse has been implemented as a digital educational instrument to enhance instruction and knowledge acquisition via a collaborative platform. This has been achieved using various technological and information and communications technology (ICT) instruments. The findings of [109] demonstrated that its influence was supported by the fact that students' enthusiasm and collaboration were witnessed outside of the classroom setting. In addition, educators can derive numerous advantages from the Metaverse. To provide an example, the researchers in [110] examined the capacity of AR technologies to enhance teachers' experiences before and during their professional development. This was done because deploying the Metaverse through AR could benefit educators [111].

Another study [112] used a Metaverse environment and Virbela platform to enhance preservice teachers' teaching skills. In the experiment, pre-service instructors used their digital avatars to analyze micro-teaching. The writers assessed teachers' responses to inquiries and suggestions. By actively involving educators in their field in a more immersive and realistic fashion, these practices aid instructors in improving their pedagogical abilities. This is accomplished by providing students with training and activities that enhance their skills when taught [113]. Virtual mainstreaming allows the audio Metaverse to render spatial sound with XR-capable video streaming services for interoperable experiences [114]. Technology enables students to examine historical and architectural locations thoroughly. Gaafar et al. [44] employed virtual representations of historic structures and their interactive three-dimensional models to enable students and instructors to evaluate architectural sites of cultural significance in educational contexts [115]. This was done to assess Metaverse's potential in architecture education. The authors found that interactive cultural heritage models allow students to observe minute details in a fully immersive experience [116].

### B. INDUSTRY TRAINING

Sustainable industrial infrastructure design and training are crucial after the fourth industrial revolution [116]. With the help of the Metaverse and the technologies that are linked with it, the training of employees in industries has also been improved [117]. This has enabled workers to gain practical experience in various activities in a setting without any potential danger. In addition, training based on augmented

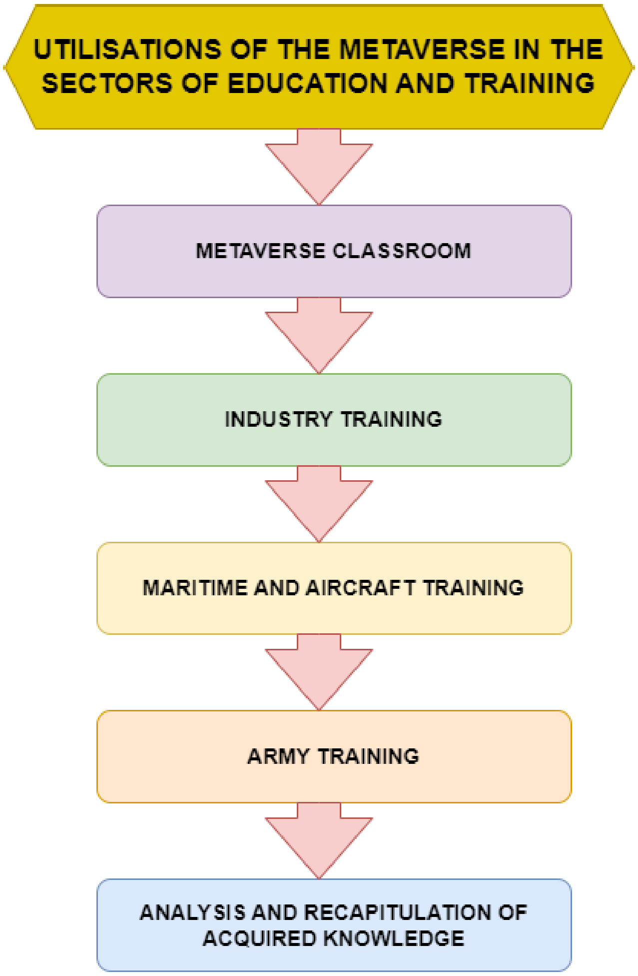


**FIGURE 5. Applications of the metaverse in the fields of education and training.**

reality can be utilized by businesses to assist in the study of consumer expectations, the classification of requirements within industries, and the utilization of approaches for the formulation of sustainable value propositions [117]. We can view the entirety of the factory through simulations in the industrial assembly system, which is brought to life by Metaverse. Collaboratively designing and strategizing the facility's building in real-time can be accomplished by international teams using CATIA, Revit, and point clouds [118]. These software packages allow global teams to work together to function in synchronization. For example, the planning process at BMW automobile manufacturing plants has been completely transformed due to the capability to function in a flawless simulation allowed by 3D technology. Their factories undergo regular reconfigurations, and their personnel receive training to accommodate the introduction of new vehicles [119]. Using a Metaverse, planning professionals residing in various regions of the world might be educated and allowed to participate in testing new designs. The Metaverse simplifies work in industries with IoE-enabled machines and digital humans by allowing robots to share workspace [120]. Because robots are crucial to modern industry, they are used in logistics to improve material flow. This versatility is crucial as modern industries require extensive effort, and clients prefer customized designs for their products [121]. In addition to the Internet of Everything data, Metaverse frameworks could use synthetic data. Robots are trained using millions of synthetic pictures from varied environments [122]. Domain randomization has the potential to produce an endless number of permutations of photorealistic objects, along with their texturing, orientation, and lighting conditions [123]. Irrespective of its intended purpose for detecting, segmenting, or perceiving depth on the Metaverse platform, it is suitable for generating accurate images and objects. Furthermore, it is a highly effective instrument for generating accurate photos of the actual state of the ground [124]. In addition, the digital twins could make it possible to conduct virtual factory visits made possible by the Metaverse. Metaverse systems that drive digital twins enable industries to create, interact, learn, and train the production network [125].

Consequently, this will help reduce the time spent planning and improve flexibility and precision, ultimately leading to a more effective planning process. To a similar extent, the fashion industry has profited from the Metaverse since it has enabled designers to create outfits tailored to the customers' needs by allowing them to create trails over digital avatars and customize the outfits to the customers' preferences for the best fit. With the help of Metaverse, you can select an appropriate outfit for your gender, age, body type, and ethnicity [126]. It is because of this that the designers can learn the wants of the clients in an automatic manner, which in turn motivates them to create revolutionary designs for the customers [127].

### *C. MARITIME AND AIRCRAFT TRAINING*

Augmented reality technology has been successfully employed in the aviation, automotive, and astronautics industries for various activities such as environmental monitoring, management, and education over a significant period [128]. An aeronautical training platform was presented and tested by [129], who developed augmented scenes through AR with cutting-edge machine vision and computer graphics technology throughout their research. Similarly, XR and other Metaverse technologies have also been used to train aviation professionals to perform maintenance and inspection procedures. It has been demonstrated that the technology can complete the work, as the published research indicates. Reference [130] showed that using XR technology for training reduces the likelihood of errors, requires less effort, and takes less time. Yet another study [131] reveals that AR is effective in aviation assistance, training, and maintenance operations. This study was undertaken to demonstrate the efficacy of AR. Examining the technology shows a notable decrease in errors during training, resulting in fewer violations of established procedures [47].

The findings of this research weaken the motivation to transition to the contemporary Metaverse, which seeks to enhance the efficiency of the learning platform by substantially lowering training time and offering practical and cost-effective solutions. There are already some accounts of efforts in this regard in the literature. For example, [132] built a simulator to educate staff to perform effective maintenance on Boeing-737 airplanes by utilizing Metaverse in conjunction with 3D models of the aircraft. The amount of technical help and directives offered to field experts is considered when evaluating the simulator. Through the utilization of this Metaverse-based aircraft maintenance system, aviation educational institutions are provided with a solution that is both more cost-effective and scalable. In a similar study [10], [15], [133], the authors employ a Convolutional Neural Network (CNN) structure to facilitate the acquisition and classification of auditory characteristics. The objective is to determine the specific commands utilized to operate the virtual digital replica of the Boeing 737 airplane. This is done to achieve the aim of identifying the commands utilized to govern the virtual digital twin.

Additionally, as a consequence of this effort, there has been a reported rise in the accuracy of forecasts and an increase in training capacities. Participating in an immersive experience and exercising effective control over virtual objects within the 3D dual model of the airplane allowed for the acquisition of these skills. A recent study by Kim et al. [74] used Metaverse technology to train marine firm personnel on cybersecurity issues. It generates cybersecurity educational content using virtual ships, marine accident simulations, maritime operations, and other online shipping and maritime learning content [74].

### D. ARMY TRAINING

Because it is not always possible to send military personnel in active battle situations for training, the training of the troops is an essential component in the defense sector. DARPA previously used a range of military simulations with new high-level architectures to give extensive collaborative training and prepare for war strategies. This was accomplished through the Distributed Interactive Simulation (DIS) protocol [134]. This kind of scenario might be replicated with the help of XR technology to provide the warriors with a more realistic training experience. Training them in a virtual environment similar to the environments they would be working in may be beneficial to better prepare the soldiers for dynamic adaptability. In addition, it leads to a large decrease in the costs associated with traveling and moving goods to conduct exercises with the military. In addition, utilizing virtual objects makes it possible to train soldiers with specialized armed equipment without placing them in danger on the battlefield [86].

Nevertheless, even though cutting-edge approaches might be used to produce a comprehensive replacement of military training using XR, incorporating the Internet of Everything and Metaverse technology could further improve it [135]. Even though AR cannot do away with traditional military training, there are currently frameworks that eliminate the need to travel to remote places and assist soldiers in their training without putting them in danger. Technology's diversity compared to actual military training has shifted emphasis away from traditional training techniques and toward military simulations [136]. This transition has been accomplished by delivering immersive training through virtual environments. To achieve this goal, several intriguing alternatives have been suggested. Metaverse-based DEIMOS Military VR Trainers [137] provide shooting, tactical behavior, and observation training situations in various environments. The Korean military academy uses this technology for spatial synchronization and pinpoint accuracy in shooting drills. It gives real-life fighting scenarios, allows trainers to respond to the environment, permits precision target hitting, and provides an interactive training platform in a Metaverse military exercise setting [18].

### E. ANALYSIS AND RECAPITULATION OF ACQUIRED KNOWLEDGE

We provide a concise overview of the delivery of educational services using Metaverse technology for different user situations, highlighting the main features and potential solutions. The contents of Table 8 provide a concise overview of the primary objectives, obstacles, and corresponding countermeasures for managing the difficulties related to Metaverse-based training in several application fields [138]. The chart shows that the main difficulties must be addressed and countermeasures taken to establish an immersive Metaverse learning environment. After reviewing Metaverse platforms for education studies, we have important insights to build effective approaches to overcome these challenges.

1) By utilizing intelligent cloud services and quantum computing, it is possible to achieve the optimal administration of multimodal medical data streamlining in healthcare education [138].
2) We provide a concise overview of the delivery of educational services using Metaverse technology for different user situations, highlighting the main features and potential solutions. To accomplish adequate design, development, and supply chain management, it is possible to deploy Metaverse-driven collaborative robots to boost the skills of industrial workers to handle problematic sections [139].
3) These 3D twin aircraft models can greatly aid trainers in effectively studying the control and functional components of aircraft [74].
4) Through the utilization of Metaverse, eliminating cyber security concerns in the maritime industry guarantees the provision of solid procedures to protect against potential dangers [140].
5) The quality of instructions and the dynamic scenario handling that may be accomplished through the use of the Metaverse could address the issue of adverse condition anticipation in combat scenes for military personnel [141].

6) The Metaverse might be used to drive skill advancements in gaming and the upskilling of creative abilities in the arts. This could be accomplished by careful object recognition and manipulation [142].

## VI. THE ROLE OF TECHNOLOGY IN FACILITATING THE METAVERSE IN EDUCATION

This section will thoroughly examine several technical techniques that can be utilized to build the Metaverse, particularly emphasizing its implementation in the education sector. Figure 6 illustrates a range of technologies that facilitate the implementation of the Metaverse in the field of education.

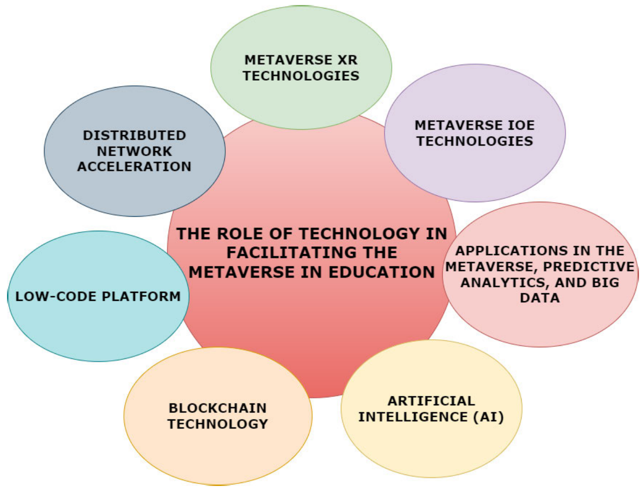


**FIGURE 6.** Technologies that enable the metaverse in education.

### A. METAVERSE XR TECHNOLOGIES

Because of the Metaverse's impact on augmented reality, significant progress has been made in education and skills creation for the workforce. Selecting suitable hardware and software stacks is crucial in developing and deploying diverse Metaverse applications since they are closely linked to fundamental XR technology. The task of XR is to establish the immersive encounter that users have in the Metaverse [121], [143], alongside the vital part that IoE plays in this procedure. The end devices must have XR services to engage with remote users in training and educational applications during virtual meetings within an immersive Metaverse. This feature enables users to engage in mutual interaction. Furthermore, leveraging other technologies like cloud services reduces the exorbitant expenses related to networking and enables users to have consistent training experiences throughout time [74]. XR apps and services primarily drive the Metaverse's current condition despite the relatively steep price of virtual reality headsets. The Metaverse can generate virtual, remote, and immersive encounters by utilizing augmented reality (XR), which holds the potential to enhance significantly e-commerce experiences and decrease expenses related to travel and information exchange [17], [74], [144]. The implementation of XR technology has the potential to facilitate critical thinking, enhance communication, foster collaboration, and stimulate creativity among both teachers and students. This would enable the dissemination of an adaptable and environmentally friendly education. Multidimensional elements can enhance the learning process and provide pedagogical benefits [145]. Table 9 presents a concise overview of the educational, training, and upskilling initiatives undertaken in XR services, specifically focused on their use in the Metaverse.

### B. METAVERSE IOE TECHNOLOGIES

The Metaverse on Internet of Everything technologies will improve remote training by using the virtual world to more intelligently and effectively plan real-world things. The IoE and Metaverse are increasingly essential in this field of study and application [146]. Digital twins are software models that represent physical systems and assets. They are a vital component of the Metaverse, facilitating immersive connections between the physical and digital realms. This is made possible by the Internet of Everything technology improvements and the data streams obtained through intelligent gadgets. The Internet of Everything (IoE) and the Metaverse have already demonstrated high effectiveness in various application sectors. A new area has been created for people to socialize, trade, play games, and even participate in music performances thanks to the combination of the Metaverse and the Internet of Everything (IoE). However, the research community still needs to find solutions to several issues. Furthermore, there is an expectation that the Metaverse will foster a novel paradigm of cooperation among employees, instructors, and students, enabling them to function at much enhanced levels of capability. This will be achieved by integrating the IoE with XR technology by utilizing the Metaverse. Educators can use IoT devices and other data processing equipment to process Metaverse educational content at the edge. The cell towers, the data collecting points, or the Internet of Things devices might all be locations where this could be implemented [147]. Furthermore, to enable the use of applications in the Metaverse, it is necessary to synchronize the network of local Internet of Things devices and educational data collection sources. Table 10 summarizes the educational, training, and upskilling initiatives influenced by the Internet of Everything and can be modified for implementation in Metaverse applications [148].

### C. APPLICATIONS IN THE METAVERSE, PREDICTIVE ANALYTICS, AND BIG DATA

Nowadays, we are all part of the data-generating machine. People with smart gadgets, businesses, and social networks add to the mountain of personal information about people's tastes and habits. There is a current upsurge in interest in online communities that provide a multi-faceted platform for people to connect. Thanks to its advantages, digital content allows people to immerse themselves fully rather than see it. Each of these potential applications generates a large quantity of data. Organizations powered by the Metaverse that engage in sales, marketing, advertising, and other forms of training must use real-time data analytics to forecast future results [149]. The emergence of spatial computing technologies, which mainly rely on processing data from XR devices, has led to an increasing number of challenges in managing the vast amounts of digital data generated [128]. In addition, the collaborative learning environment that spatial computing creates between teachers and students may provide light on the course material. One of the lofty aims of educational frameworks driven by the Metaverse is this very thing. The digital avatars stored on the Zepeto platform generated massive volumes of data, which the authors of [150] analyzed. As a result, they could communicate with a vast audience effectively. The objective of the case study was to merge the physical and digital realms using the Metaverse to analyze news stories. In addition, this might be broadened to incorporate an evaluation of the Metaverse's educational content quality, which could contribute to the settlement of related legal and social issues.

Additionally, the future generation of virtual reality headsets will be able to collect additional user data, such as face recognition and even the ability to identify the users' stress levels. It is also possible that, as the technology develops, it will be able to collect biometric data from individuals and provide users with improved training experiences. It is possible to derive valuable and significant insights from the acquired data using predictive analytics in the Metaverse. In addition, the Metaverse can assist in changing the data by providing a less complicated and more engaging way of displaying the information [130]. It is crucial to employ predictive analytics on XR and IoE data in the Metaverse for various potential educational applications due to the clear benefits it may offer.

### D. ARTIFICIAL INTELLIGENCE (AI)

Machine learning is the foundation for machine intelligence, which uses deductive reasoning to prioritize objectives. Machine learning is the starting point for realizing AI's promise in the Metaverse while learning algorithms polish messaging, advertising, and online interactions. Metaverse technology, AR, and the Internet of Things allow artificial intelligence to influence educational service providers' creative thinking ability. One of the complex educational facilitators might be the Metaverse, which would allow for hands-on instruction based on nonverbal indicators such as the teacher's expression, eye contact, and body language. The truth is that AI helps the Metaverse out by providing design suggestions. Because it is an essential component of the service architecture, it can be incorporated with platforms that require little or no coding [142], [148], [149]. Using artificial intelligence to create Metaverse chips could also assist programmers in producing code [127]. This is because the virtual world is becoming increasingly congested with virtual avatars. Virtual education and training platform developers must innovate to fully realize the impact and promise of machine learning on these platforms if they want to continue supporting and improving their capabilities. According to the published study, several investigations have shown the promise of AI in the Metaverse for training and education services. For instance, Kim et al. [74] highlight the importance of promoting a combination of machine intelligence and human experience to create a beautiful framework that may power the Metaverse and offer learners a fulfilling experience.

### E. BLOCKCHAIN TECHNOLOGY

Blockchain technology is quickly becoming the norm for many companies [150]. The distributed ledger technology enables the management of assets and applications to be carried out independently and decentralized. Protecting users' data and digital information remains a primary worry among educators and students, even though the Metaverse has gained enormous popularity and offers many advantages. Given that blockchain possesses the distinctive qualities of decentralization, immutability, and transparency, it has the potential to provide a promising and effective solution in this field. The programmability of blockchain technology makes it possible to use it in Metaverse applications. This technology can potentially drive educational content by assembling smart contracts from decentralized places [133]. According to the published research, several intriguing approaches exist to incorporate blockchain technology into Metaverse applications. By way of illustration, [150] offers a comprehensive summary of the methods that can be utilized to achieve the seamless integration of blockchain technology in the Metaverse. These methods take into account the aspects of data acquisition, storage, the protection of privacy, and interoperability. Along with blockchain's role in assuring the platform's security, researchers looked at how the Metaverse will affect its enabling technologies, including the IoE, digital twins, AI, and big data. In educational frameworks built on the Metaverse, this constitutes an essential stepping stone towards adopting safe instructional content.

Incorporating financial services into educational content is only one example of how the proliferation of the Internet of Things devices enhances the creation of instructional materials [14], [78], [127], [150]. This is made possible by deploying blockchain technology for the Metaverse, which enhances trust and authority. However, trustless educational materials, components, and contracts may be dismantled due to the potential longer time required for the social scalability of educational services enabled by the Metaverse. The proliferation of virtual commodities and the earlier adoption of blockchain technology could benefit us [135]. On-chain educational data feeds could be established with blockchain technology. Additionally, with the widespread use of blockchain technology and the integration of these two ideas through cloud computing components, avatar customization and the development of new educational feeds

**TABLE 8.** Obstacles and remedies for education, training, and skill development utilizing Metaverse technology.

| Application | Obstacles | Objective | Preventive measures |
|---|---|---|---|
| Medical education | Streamlining and consolidating diverse medical data from multiple sources. | Medical education innovation. | When combined with artificial intelligence, virtual reality, augmented reality, internet of things, web 3.0, intelligent edge, cloud services, robots, and quantum computing, the incorporation of Metaverse has the potential to offer major improvements to the healthcare education industry. |
| Distance learning | Cooperation and engagement. | A captivating and engaging experience for educators and learners. | Choose appropriate XR and IoE devices that have seamless connectivity to meet the requirements of both the instructor and the students. |
| Industrial training | Robot training labor skill augmentation | Control and monitoring complicated manufacturing units. | When it comes to manufacturing, supply chain management, design, development, and virtual warehousing, the combination of hardware and software components of the Metaverse can increase market revenue and provide essential insights that can be used to make well-informed decisions regarding future technologies. |
| Training in aircraft maintenance | Monitoring and controlling maintenance status | Streamlined and intuitive administration of operational components in aircraft. | 3D twin models aid in reading aircraft log books, including equipment condition, status, and remote user requirements. |
| Training in the repair of marine equipment and systems. | Addressing cyber-security challenges | Effective strategies to counter threats. | Integrating Metaverse with blockchain technology has the potential to minimize errors in maintenance tasks and enhance safety by providing alerts and notifications. |
| Training in military tactics and strategies | Recreating and adapting the war scenarios dynamically. | Conditioned for adversity. | Increased efficiency through explicit directives and Metaverse-powered machinery for agile combat control. |
| Artistic skill enhancement | Oversee and control of three-dimensional virtual entities. | Harnessing the power of imagination and creativity. | Enhanced precision and reliability achieved by implementing object detection technology, facilitating immersive learning, and fostering unprecedented creativity. |
| Proficiency in gaming | Integration of artificial intelligence for enhanced immersive experiences. | Collaborative learning | Interacting with virtual people and objects in unified and interoperable spaces enhance the gaming platform, enabling diverse education, training, and skill development applications. |

**TABLE 9.** An overview of the use of augmented reality in education and training that is driven by the metaverse.

| Reference | Various Requests | Solutions for XR | Significant Contribution |
|---|---|---|---|
| Andrews et al. [21] | Health care | 3D visualization and touch-free interface | Discuss catheter tracking, patient anatomy, and scar visualization. |
| Doolani et al. [120], [66] | Educating those working in manufacturing, Manufacturing | Workforce training, Remote guidance Learning | Training Trains workers in maintenance and assembly using XR [123]. 6 case studies were conducted to analyze the operational and disruptive stages [66]. |
| Palmas et al. [40] | Vocational training in the industrial sector | Cutting-edge corporate training | Characterises and develops competencies for XR-enabled training. |
| Zweifach et al. [121], Lopez et al. [78], Goh et al. [48] | Immersive surgical training in medical education. | Holo-graphics, immersive XR, realistic simulation | Consider using XR in medical teaching [124]. Holo-graphic representation of anatomical structures enhances therapeutic care [78]. Helps surgeons visualize patient anatomy in real-time during knee arthroplasty [48]. |
| Gandolfi et al. [38], Pomerantz et al. [67] | Teacher training, Teaching and learning | 360 video research | 360 video research |
| Stanney et al. [80] | Casualty care training | paradigm with many dimensions | Use AI models to create a competency-based teaching platform. |
| Kaplan et al. [54] | Improvements to training | evaluation of various studies | Improves student collaboration. |
| Kim et al. [55] | Skill in nursing | educational smart spectacles | It helps you learn and practise on your own. |
| Heirman et al. [65] | Fire safety education | Virtual and mixed reality experience | Learn how to change how the fire hose device works. |
| Mcguirt et al. [66] | Dietary instruction | Remarkable findings | Community eating habits are analyzed. |
| Ong et al. [64], [67]<br><br>Logeswaran et al. [1] | Ophthalmology<br><br>Teaching about health care | Ophthalmoscopic and surgical simulators<br>Models of teaching | Increase ocular surgery success and decrease complications [67]. Demonstrated notion using ocular imaging [64].<br>Learner-centered methods led to improved learning outcomes. |
| Kosko et al. [79] | Educating educators | Different ways of showing practice | For both theory and practice, a perceptual ability test was given. |
| Le et al. [62] | Training for sports | How ecosystems work | Improvements in the ability to move and think through perception |
| Zwolinski et al. [70] | Projector for management teaching | cell phone | The instruction of HMD AR/VR Business Environment Enhancement Skills encompassed many methodologies. |
| Al-Adhami et al. [104] | Quality of construction | XR based on BIM | quality control inspections were tested on construction grounds. |
| Parsons et al. [133] | Brain science | Simulations with many dimensions | Improving ecological relevance in clinical and social settings is possible. |

**TABLE 9.** ***(Continued.)*** **An overview of the use of augmented reality in education and training that is driven by the metaverse.**

| | | | |
|---|---|---|---|
| Jervsov et al. [71] | Control system | Digital copies | HIL simulation in real-time for control purposes. |
| Zagury et al. [55] | Training in otolaryngology | Framework for evaluation | The education results and the spread of skills in bone surgery were examined. |
| Liang et al. [22] | Checking for a stroke | Simulation of a training doll | During practical training, it was easy to spot signs of a traceable stroke. |
| Alnagrat et al. [3] | Labs on the Internet | Things in a virtual world | Built a virtual training tool to help students improve in school. |
| Yang et al. [144], Guo et al. [79], Xing et al. [147] | Framework for education, study of educational trends | Bibliometrics, XR-Ed structure, interactive links | Improves student instruction efficiency by designing six-dimensional settings [144]. Offers education sector sustainability advice [79]. XR provides a futuristic perspective on education and corporate development tendencies [147]. |
| Southworth et al. [101] | Heart disease | Visualisation in 3D | Helps cardiologists with planning, procedures, and heart rehabilitation. |

might be enhanced in the Metaverse to make them more immersive and trustworthy [15], [55], [93], [99], [148].

### *F. LOW-CODE PLATFORM*

In recent years, the hand-coding of processes has been replaced by using low-code and no-code application platforms (LCAP), which has also accelerated higher-level abstractions in applications based on augmented reality-based software. It allows individuals who are not programmers to carry out various tasks that normally require programming skills [5], [58], [64], [102]. Gartner reports that most successful industries have begun utilizing LCAPs to operate at least a portion of their associated infrastructure. Due to this trend, developers may find it easier to concentrate on the complexities and subtleties involved in creating XR-based educational services in the Metaverse rather than worrying about the difficulties involved in creating and deploying Internet-scale apps. In addition, various creator tools may be utilized to produce Metaverse content equipped with advanced features and to provide improved support for the commercial and educational sectors [35], [138].

There are several scenarios in which consumer gadgets enabled by the Internet of Everything (IoE) could be the cause of the most cost-effective solution for businesses, even though it is difficult for companies to scale down the technology to individual educational institutions. Data insights and the creation of efficient and dependable solutions are given a great deal of attention by low-code platforms [56], [87], [136]. This is because software companies are a constant source of game-changing technological advancements. Another benefit of cloud computing is that it creates more immersive learning environments in the Metaverse, which is excellent for students. More developers will work in stages to build the Metaverse and XR and have access to a more extensive library of plug-in apps and business logic to support them. On the other hand, the current body of research on LCAP does not adequately portray the impact of these XR and IoE platforms on the educational sector, nor does it explain the reasons for their utilization [143]. A higher degree of LCAP support may be accounted for in virtual educational platforms thanks to multiple data endpoints, which also provide safe and scalable solutions [137].

### *G. DISTRIBUTED NETWORK ACCELERATION*

When the programming and the data are dispersed among multiple computing resources, we refer to the computing networks as being distributed to the extent they are distributed. Regarding networking latency, concurrency, and speed, 5G and 6G services may propel distributed networks to perform faster and more efficiently [1], [78]. This acceleration ensures the longevity of the Metaverse and helps bring about more interesting educational applications by letting users share educational content in real-time at the same time. Connecting and speeding up the link between scattered and data-intensive networks is essential [16], [123].

The reason is that Metaverse apps rely heavily on data-intensive networks. For the Metaverse to deliver a valuable learning experience, its frameworks must be optimized end to end, and its computation and communication must be promising. To maximize the advantages of edge computing, Metaverse educational systems should interface with the Internet of Everything. On the other hand, the low performance of IoE devices continues to be a significant obstacle.

A holistic framework known as ScissionLite [46], [108] was designed by the authors to assist in the acceleration of distributed deep neural networks (DNNs) by the insertion of a traffic-aware layer, which ultimately led to an increase in the amount of network traffic. Compared to the traditional slicing approaches utilized in the learning models, this framework significantly improved the interference latency by 10. In addition, the implications of accelerated deep neural networks have the potential to cut down on the interference latency significantly. An examination of the networking and communication factors involved in the deployment of edge solutions was carried out by the authors of [88] and [150] to achieve the realization of an edge-enabled Metaverse. It is possible that the resource limitation difficulties that are now being faced by such platforms could be efficiently handled with distributed edge computing solutions [6], [70]. In addition, the acceleration of computation makes it possible to provide learners deeply involved in Metaverse platforms with a completely immersive experience. Furthermore, it allows low-cost data transmission frameworks to facilitate the exchange of instructional content generated by users in a virtual environment. A decentralized and immutable system for educational services enabled by the edge within a Metaverse framework allows for honest and

**TABLE 10.** An overview of the Internet of Everything (IoE) in education and training within the Metaverse.

| Reference | Implementing Applications | IoE Prompts | Significant Achievements |
|---|---|---|---|
| Bandara et al. [54] | Improvements in student achievement | Worldwide university programs | Meeting student needs by removing unnecessary educational content improves performance. |
| Doolani et al. [120], [66] | Educating those working in manufacturing, Manufacturing | Workforce training, Remote guidance Learning | Training Trains workers in maintenance and assembly using XR [123]. Six case studies were conducted to analyze the operational and disruptive stages [66]. n |
| Gul et al. [124], Chou et al. [135], Abd-Ali et al. [35], Ramlowat et al. [34], Pervez et al. [123], Shaikh et al. [53], Mawgoud et al. [2], Hickman et al. [91], Khan et al. [125] | Education, Educational institutions, Digital campus, M2M, Smart lesson plans, Higher education, Education and learning | Smart campus, Sensor devices, User behavior, Social IoT, Low-cost VR, Industry 4.0 | Showed the value of IoT in education [127]. Educational institutions should prioritize attendance tracking for campus safety [140]. Smart classrooms and labs are envisioned for education development [35], and teaching and learning efficiency are examined [132] [97]. Specialized tactics provide an improved teaching model [126]. Presented a comprehensive teaching framework using network analysis [53]. Protects critical domains in higher education using security solutions [2]. The data triangulation technique offers insights into learning outcomes and emotional factors [91]. Guarantees robust learning skills [128]. |
| Al-Emran et al. [103] | Moral instruction | Accessory devices | I explored the possibilities of the Internet of Things (IoT) in various educational services. |
| Reference | Implementing Applications | IoE Prompts | Significant Achievements |
| Ding et al. [148] | Health and wellness | Online service | Created a VR system for PE that highlights scientific references and encourages promotion. |
| Burd et al. [13], Fragou et al. [107] | Training in computer science | Training in computer science | Lists four IoT-integrated computer science curriculum strategies [98]. Effective learning practices were emphasized using digital technologies, affordances, and other approaches [102] [110]. |
| Cornetta et al. [46] | education in the STEM fields; | The service of fabrication | Offers a web-based master-slave system for managing Fab labs in schools. |
| Al-Malah et al. [35] | Smart educational institutions | Modern educational facilities | Research in the scientific community and innovations in educational services were assessed. |
| Jean et al. [6] | artificial intelligence training | Speech recognition | Assists TAs in the classroom using intelligent aides. |
| Turcu et al. [23], Somantri et al. [141] | Training for the workplace, education in the workplace | Fourth Industrial Revolution, Affordable Internet of Things | Industrial transformation, and corporate practices were examined [23]. Industrial training kits for automation procedures were developed at an affordable cost [147]. |

**TABLE 10.** *(Continued.)* An overview of the Internet of Everything (IoE) in education and training within the Metaverse.

| | | | |
|---|---|---|---|
| Ong et al. [59], [69] | Ophthalmology | Ophthalmoscopic and surgical simulators | Increase ocular surgery success and decrease complications [59]. Demonstrated notion using ocular imaging [64]. |
| Leisenberg et al. [97] | Distant laboratories | Analysing data | The use of cloud platforms and feasible instructional methodologies were examined. |
| Jian et al. [90] | Rehabilitation for athletes | Mobile sensors | The developed system can analyze sportspeople's ECG and EMG data in real-time. |
| Mershad et al. [82] | System for managing learning | Collaborative education | Launched a new LMS that integrates the arts, technology, and science through the Internet of Things. |
| Qi et al. [140] | Higher learning | Online training | College teachers and students were networked using RFID tags. |
| Kravvcik et al. [102] | Instruction and education | Massive amounts of instructional data | Massive amounts of instructional data. |
| Li et al. [113] | System for visual education | Complex campus network | Classroom engagement is improved using user-friendly visual aids, including smart devices. |
| Moreira et al. [42] | Vast campus system | Environments characterized by hyper situations | Students' demands were considered when developing the physical and natural science curriculum. |
| Zhang et al. [51] | Zhang et al. [51] | Integrating AI with edge computing | A greater understanding of innovation and entrepreneurship education was achieved. |
| Xu et al. [99] | Mass education | Statistical framework for modeling | Bayesian network integrates university citizenship into curriculum. |
| Gurgu et al. [37] | Business education | Artificial intelligence and blockchain technology | educate educational institutions on technology changes to improve the global economy. |
| Cui et al. [90] | Table tennis training | AI | The knowledge information system evaluates players' skills and confidence to improve their performance. |
| Li et al. [16] | Music Education | Music Education | Intelligent music lesson. Boosts cultural literacy through the development of a highly efficient music knowledge curriculum. |
| Gkamas et al. [137] | Learning outcomes | Data analysis | Desktop research and surveys underpin macro-level IT workforce upskilling planning. |
| Bright et al. [26] | Provide education to students with disabilities | Assisted wireless devices | Makes technology-mediated education more accessible to students with disabilities. |
| Li et al. [112] | Basketball instruction | Big data | A combination of video gesture detection and data merging allows for creating training regimens that target specific player actions. |

open communication between educators and their pupils [19], [38].

## VII. ADVANTAGES AND DISADVANTAGES, CHALLENGES AND ISSUES, RESEARCH ANALYSIS, AND OF IMPLEMENTING METAVERSE TECHNOLOGY IN EDUCATION

The following section will discuss several advantages and disadvantages, challenges and issues, and research analysis of implementing metaverse technology in education. The utilization of metaverse technology in education offers both benefits and drawbacks. It is crucial to acknowledge that the application and consequences of Metaverse technology can differ depending on unique use cases and the level of integration within educational environments. Below are a few overarching benefits and drawbacks:

### A. ADVANTAGES

Immersive Learning Experience: Metaverse technology provides a deeply engaging and dynamic learning environment. Students can interact with educational material in a three-dimensional environment, enhancing interest and retention in learning.

#### 1) GLOBAL COLLABORATION

Metaverse systems facilitate collaboration among students and educators. Virtual classrooms facilitate global connectivity among learners, fostering cultural interchange and the inclusion of varied perspectives.

#### 2) SIMULATIONS AND PRACTICAL TRAINING

Metaverse technology allows for realistic simulations and practical training. For instance, students pursuing disciplines such as medicine or engineering can simulate and rehearse processes in a virtual setting before implementing them in the physical realm.

#### 3) INDIVIDUALISED LEARNING TRAJECTORIES

Tailored and dynamic learning journeys can be generated within the Metaverse. The technology can adjust to individual learning methods and speed, offering a more customized educational experience.

#### 4) ENHANCING ACCESSIBILITY

Metaverse technology has the potential to enhance accessibility by offering educational opportunities to persons who may encounter geographical or physical obstacles. It enables individuals to engage in educational activities remotely without needing physical presence.

#### 5) INNOVATIVE TEACHING METHODS

Educators can explore avant-garde teaching techniques by utilizing the Metaverse to design dynamic and interactive classes. This can augment student participation and pique their interest in the subject topic.

### B. DISADVANTAGES

#### 1) TECHNOLOGICAL IMPEDIMENTS

Some pupils may lack the resources to engage in the Metaverse. This phenomenon can give rise to a digital disparity, placing individuals without access to sophisticated computers, reliable internet connections, or virtual reality technology at a disadvantage.

#### 2) PRIVACY AND SECURITY CONCERNS

Privacy and security concerns may arise when using Metaverse platforms. Robust security measures are necessary to safeguard sensitive information as users generate and distribute content within these virtual environments.

#### 3) EXCESSIVE DEPENDENCE ON TECHNOLOGY

Excessive dependence on Metaverse technology could diminish focus on conventional educational approaches. It is crucial not to overlook essential abilities such as critical thinking, interpersonal communication, and practical problem-solving.

#### 4) DISTRACTION POTENTIAL

The very engaging nature of the Metaverse could result in heightened diversion levels. Students may be inclined to delve into unrelated topics or engage in activities irrelevant to their educational goals, affecting their concentration on academic objectives.

### C. CHALLENGES AND ISSUES

In the following section, we will discuss several issues and difficulties illustrated in Figure 7. There is, in fact, a great deal of pertinent material to cover. Therefore, we have compiled a list of the five most pressing issues that require immediate resolution: privacy hazards, inclusivity, addiction, and governance challenges.

#### 1) METHODICAL APPLICATION

In meta-education we use different Methodology Applications those are:

- Interactive technology that surrounds the user. Three types of immersive interactive technology are vital to creating the Metaverse. These types of technology are VR, AR, MR. Specifically, these three technologies are referred to as XR. Since they are also instructional resources, we go into depth about them.
- Virtual Reality: VR is a well-established tool in Metaverse education. VR offers a more engaging environment, which has the potential to greatly improve educational outcomes, according to previous studies [10], [49], [67], [89]. More thorough studies on this innovative approach to education are needed, though. VR uses a head-mounted display (HMD) [50], [69] to create an immersive, lifelike 3D virtual environment. The absence of static and dynamic interaction realism is a major problem with HMD. The current state of technology for creating virtual reality images and

display functionalities is, in short, inadequate. The reason we hold this belief is that our brain is very change-sensitive. It only takes a small element to ruin an otherwise engrossing experience. Therefore, increasing the sense of realism in a virtual reality setting is a pressing but currently unresolved issue.

- AR: Most AR devices are more comfortable to wear than VR ones. The lack of a universal standard among AR device manufacturers makes using the same instructional content across devices challenging [91], [123]. One of the significant problems with augmented reality right now is that the content isn't portable. On top of that, research [117], [123] demonstrated that users are less engaged in the learning environment when the actual and virtual worlds are separated. A combination of local and cloud processing power, the exploitation of enormous bandwidth and low-latency connectivity, and the constant optimization of the augmented reality sensing environment are all necessary components for successfully fusing virtual information.
- Mixed Reality (MR): TMR technology allows users to freely interact with virtual and real-world things in real time [68], [99]. VR and AR provide users with more immersion, but MR has several technical needs that must be met. On the one hand, sharp images with plenty of contrast are required for real-world item display on mobile devices. However, for the gadget to provide the impression that the virtual object is either physically present or attached to an item, the system must precisely monitor the whereabouts of the real objects [54], [86].
- Artificial intelligence: Learning outcomes evaluation, language processing for remote learners, and virtual teaching assistants are all ways that artificial intelligence might help improve education in the Metaverse. Three main issues need to be resolved for educational AI systems: the first is how to build virtual teaching assistants that are individualized to the students; the second is how to get rid of language barriers; and the third is how to evaluate the student's learning outcomes fairly and objectively. Important challenges include morally managing AI decision-making in the Metaverse and students misusing AI (by cheating on tests or stealing other students' work) [1], [2].
- Digital Twin: A digital twin is primarily utilized in the Metaverse to digitally transfer physical goods into the virtual world in real-time [3], [4], [5]. Specific Metaverse schooling research requires accuracy. Digital twin precision and real-time functionality are, therefore, crucial. Thus, digital twins should catch and fix errors [6], [7], [8]. Data privacy and security become significant obstacles when working with real-time data to build digital twin models.
- Blockchain: Due to the growing popularity of the Metaverse as an educational tool for students, blockchain's three to seven transactions per second processing speed cannot manage large-scale data processing [9], [18]. The ability of the blockchain network to scale in terms of processing power is a key factor in determining whether or not it can be integrated with Metaverse schooling. Nevertheless, when scalability is enhanced, the likelihood of a blockchain fork rises in tandem with the number of nodes involved in the process. The problem with blockchain is that it will impact its decentralization and security, creating an impossible triangle [10], [11], [12]. Finding a solution that satisfies all three properties is a daunting task. Mining expenses will increase due to the larger blockchain [1], [78]. The Metaverse also emphasizes imperfect humans, especially early learners. The immutability of blockchain makes it impossible for hostile actors to alter data and impossible to trace. Due to space constraints and the possibility of information leakage, it is not advisable to update the status by publishing new information [13], [14], [15], [16].
- Computers and networks: The Metaverse's high processing requirements provide a technological hurdle in networks and computing. The introduction of education

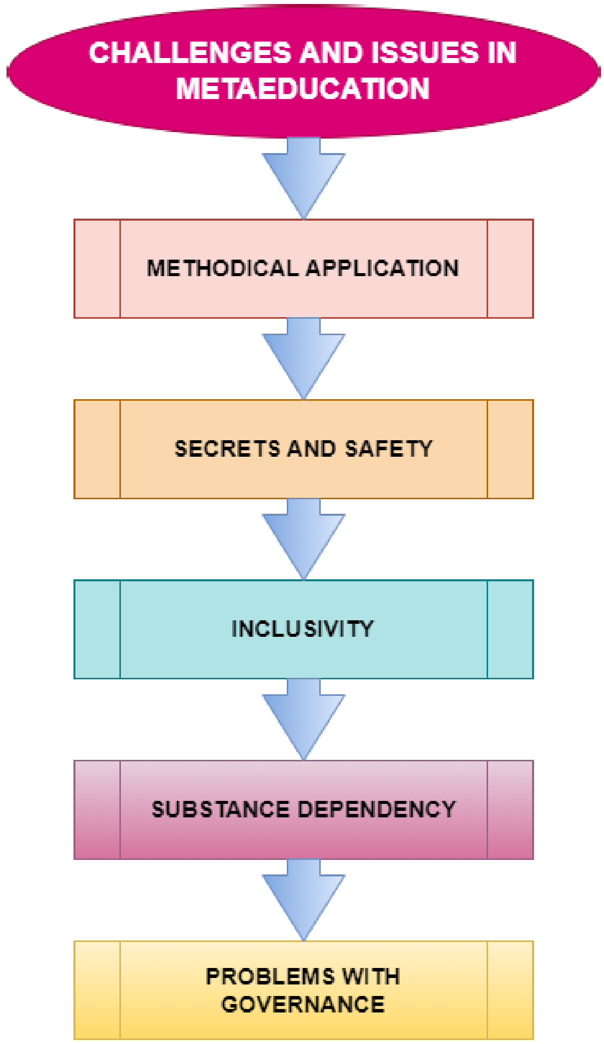


FIGURE 7. Metaeducation issues and challenges.

into the meta-universe would place significant demands on the network throughput and computing power of cloud computing due to the enormous computational quantities involved in simulating and rendering teaching scenes, interacting between the instructor and the student, and human-computer interaction [17], [18], [149].

#### 2) INFORMATION CONFIDENTIAL AND SECURITY

Introducing the Metaverse will undoubtedly cause people to spend more time online than before. To gain a thorough comprehension of the user's thought processes and behavioral patterns, the Metaverse corporations would invariably gather extensive amounts of personally identifiable information from users [19], [148]. The data that is collected will be out of this world. As a result, these businesses must get accreditation for data security and keep programs ready to satisfy any additional standards (such as data regulatory concerns). Our best guess is that the Metaverse schooling system's flaws lie in the various stages of gathering, storing, and managing user data, all of which will need fixing in due course. Information security is an obvious problem, in our opinion [20], [147]. As a result, the CIA principles of Confidentiality, Integrity, and Availability should be incorporated into Metaverse teaching [21], [146]. Regarding these three features in Metaverse schooling, we foresee the following situations:

1) Protecting Personal Information: Metaverse education necessitates collecting identity information or personal emotion tracking to attain greater educational results [31], [145], and there should be numerous layers of protection for sensitive personal data. The gathering of data is entirely voluntary, and that much is clear. It should be acceptable and understandable if people opt to retain their information, even if it means sacrificing a better experience.
2) Strict File Review: The system should thoroughly examine all uploaded files to prevent intrusion (e.g., Trojan horse programs, computer viruses) and ensure that all information on the educational system, particularly digital twins, remains intact. Altering the data in any other way can compromise the digital twin [41], [144]. This is where investigating the possibility of integrating a blockchain with the Metaverse can be fruitful.
3) Schedule: Services provided by the Metaverse's educational system are accessible to users 24/7/365. Defeating denial-of-service (DDoS) and other cyberattacks is possible with certain Metaverse education systems [51], [143].

#### 3) INCLUSIVITY

The initial intent was to promote greater participation in the Metaverse and related educational initiatives. Consequently, designing a welcoming virtual space accommodating a wide range of user needs is critical. Although it is filled with love, it is tough. For instance, low-income communities face insurmountable financial barriers to education, but they are resolute in their pursuit of a potentially transformative opportunity. Providing a high-quality education is often less important than respecting the requirements of exceptional learners, such as those who are disabled or religious [61], [142].

#### 4) SUBSTANCE DEPENDENCY:

You can't have it both ways, as the adage goes. On the one hand, people are more likely to suffer from "cyber-syndrome," a collection of physical, social, and mental illnesses brought on by spending too much time online if the immersive contact is of high enough quality [71], [81]. Contrarily, students may find that their cognitive workload is increased by the abundance of visual and auditory stimulation provided by the XR experience [82], [91]. But, as things stand, immersive game technologies are an inevitable component of Metaverse education. A significant challenge for Metaverse education is creating a game that helps students learn without becoming addicted. Metaverse education should be a tool, not a cure [83], [100]. In addition to avoiding addiction, teaching a subject that does not require Metaverse simulation will achieve superior results when taught in the actual world.

#### 5) PROBLEMS WITH GOVERNANCE

It should prioritize community governance above other parts of the Metaverse because learners' moral levels vary. To avoid ethical issues (such as slang, insults, bullying, and shaming each other), it is essential to establish and uphold community standards of behavior [86], [126]. Another critical issue is the expense of supervision, which is especially pressing in the Metaverse universe due to its size compared to Web 2.0. The lack of social media regulation teaches us that large Internet businesses prioritize profits over rights and ethics [84], [108]. Consequently, companies that offer educational platforms in the Metaverse should act not as complete regulators but as operators. The majority of users affected should decide whether a violation exists. The business's and its customers' needs should be met [85], [117].

### *D. RESEARCH ANALYSIS*

As indicated in Fig. 8, Metaverse education research began in 2007 and ended in 2023. WOS database research rose after 2008, peaking at five in 2009, 2010, and 2013. After 2013, the number of studies dropped; only one was found in 2014. Studies surged in 2015 with seven academic studies. After 2015, research papers decreased till 2019, with no study conducted in 2019. Figure 8 illustrates a research publishing analysis of several research articles in the field of Metaverse education, categorized by the year of publication.

Examining the polynomial regression trend line, investigations on the Metaverse in the WOS database showed a fluctuating tendency from 2007 to 2023, with a recent increase. The Scopus database trend line shows a pattern

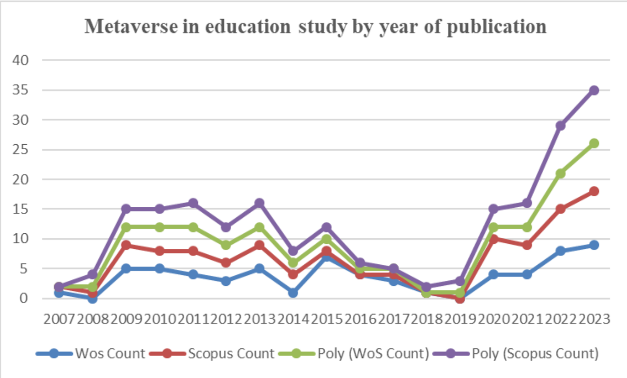


**FIGURE 8. Metaverse in education study by year of publication.**

comparable to the WOS database over time for Metaverse studies. After 2013, the number of studies in Scopus declined from a maximum of four per year in 2009, 2011, and 2013. A rapid growth was observed in 2023 with Nine academic studies. Due to the popularity of virtual environments, Metaverse research in both databases has expanded post-COVID-19. Metaverse research began with Web 2.0 and Second Life (2007–2013). Web 3.0, AR/VR, and faster processing and rendering drive the second wave (2014–2020). The third wave (2021–2024) of Metaverse technology investments caused the 2024 peak.

## VIII. FEATURE RESEARCH DIRECTIONS

As previously indicated, the Metaverse can fundamentally transform the learning process. Opportunities to utilize the Metaverse in the classroom will increase as new technologies emerge. However, the Metaverse in the school has received very little research attention thus far. We anticipate a dramatic increase in the quantity of scholarly works devoted to this area in the years ahead. Therefore, a variety of possible research topics on the Metaverse in education are addressed here to facilitate the expansion of future studies:

1) Creating instructional schemas for the Metaverse. The Metaverse is still being built and requires high-quality, standard-compliant infrastructure. The technology and software of the Metaverse underpin educational processes [143]. School administrators, instructors, and students should be considered when planning the Metaverse. These include, but are not limited to, accessibility, security, humanity, trust, educational capacity, and cognitive traits of students. Furthermore, educational design should prioritize unique and supplementary elements. One possible feature in such an environment is the ability to "airdrop class notes" between student avatars [86].
2) Using the ideals and regulations of the Metaverse in the classroom. Students, particularly adolescent brains, are undergoing a transformative time. Current concerns in educational pursuits might significantly affect their destinies in the future. Consequently, there should be an immediate need to establish and enforce stringent regulations in academic environments in the Metaverse [2].
3) Looking into how parents, school officials, and instructors feel about using the Metaverse in the classroom. Incorporating the Metaverse into the school may provide educators with formidable new challenges and thrilling new opportunities. In addition, the Metaverse can fundamentally transform how students acquire knowledge inside and outside the educational setting [3]. Consequently, investigating the perspectives of educators, school administrators, and parents regarding implementing the Metaverse in the classroom is valuable. This will help with the Metaverse's future administration, design, and educational applications.
4) How the Metaverse can help educators advance in their careers [4]. The importance of teachers in shaping students' learning and implementing educational reform is well acknowledged. The Metaverse is a new kind of instructional technology that has the potential to open up a lot of doors for educators. Consequently, many factors must be considered when planning effective Metaverse-based teacher professional development. New virtual spaces have emerged due to the advent of the Metaverse, with them, new forms of teacher education [5]. Thus, Metaverse-related pedagogical research may need to prioritize teacher preparation and professional growth.
5) Determining the Metaverse's influence on students' learning in terms of their cognition, attitudes, and beliefs. There is a possibility that this will present educational academics with an intriguing new path to investigate. Conducting an exploratory study that examines the academic achievement of kids of different grades and ages who use conventional technology and the Metaverse is something that has to be done [22]. This is because the educational paradigm and execution of the Metaverse may be radically different from that of traditional education. This is the reason why this is the case. It is also worthwhile to investigate the impact of the Metaverse on students' non-cognitive variables and cognitive factors within this innovative environment that prioritizes presence, autonomy, and immersion. Educators can use observation and analysis to comprehensively understand students' behaviors in an intelligent environment that integrates the physical and digital realms [32]. This knowledge will empower them to discern the societal ramifications of the Metaverse and devise more effective pedagogical approaches.
6) Evaluating and comparing the efficacy of various Metaverse platforms for teaching and learning concerning other learning environments [42]. Conducting a comparative study to identify the relatively successful educational environments for teaching and learning is vital when deploying new technologies for educational objectives. Is it more effective for students to learn

in the Metaverse than, say, a traditional classroom setting or online? Can we expect students to maintain consistency in thinking and performance across many Metaverse environments? Which aspect of students' performance will be substantially improved compared to the various environments? These suggested themes are worthy of exploration, in our opinion [52].

7) Constructing novel ideas for a pedagogical and methodological framework compatible with the Metaverse. The unique characteristics of the Metaverse make it a promising location for the future of education, where the traditional model of instruction will evolve into a more dynamic representation and students will progressively take center stage in class Tomb et al. [62]. This is how traditional educational paradigms will be shattered. This is why investigating alternative pedagogical and methodological frameworks that work in the Metaverse is crucial.
8) Talking about the current theories of education founded on the Metaverse. Metaverse education is a novel idea that will spark fresh debates about best practices in pedagogy [72]. The current technology-enhanced education must be rethought and updated. In addition, research into the Metaverse's novel features should inspire fresh ideas for educational theories that can inform its implementation, drawing on frameworks such as distributed cognition, cognitive load theory, flow theory, situated cognition, extended cognition, situated cognition, and the technology acceptance model.
9) Using or creating a framework for using the Metaverse in educational assessment [82]. The difficulty for teachers in traditional and modern classrooms to track students' progress aspecificer data on their learning has led many researchers to focus on students' final grades rather than their actual performance in class. Thanks to advancements in artificial intelligence, computation, storage, etc., the Metaverse allows for precise tracking and analysis of students' progress in real-time [92]. A learning analysis report incorporating both formative and summative data is one example of the many possible outcomes of an evaluation. As a result, it seems the Metaverse can offer another objective evaluation method. From this vantage point, it is necessary to construct a structured evaluation framework to add or modify certain indications in light of the Metaverse's potential use.
10) Finding novel uses and examples in the Metaverse across many fields and industries [101]. The Metaverse offers numerous potential educational applications, such as virtual experiment learning, blended learning, competency-based, and inclusive education. Physics, chemistry, geography, English as a foreign language, nursing and medical education, and communication studies are just a few fields that will undoubtedly undergo significant changes in the Metaverse compared to their traditional classroom settings [109]. Therefore, it is recommended that scholars continue their investigations to discover the various educational domains that can benefit from the Metaverse and present design examples.

## IX. CONCLUSION

Metaverse is a revolutionary technology that could impact education, engineering, and the economy. Modern educational methods must use modern technologies because they improve learning. The founder of Facebook recently announced that Facebook would be called Metaverse or Meta World. This has thrilled many about new technology that could revolutionize the planet. Virtual reality, a new profession, could replace the internet and offer inventive teaching and training approaches. Virtual reality could replace the internet. The information on this page helps scholars and practitioners uncover Metaverse-integrated education research avenues. This study thoroughly explored schooling and the Metaverse. The Metaverse provides visualization that traditional classrooms cannot match. The new education paradigm needs further study in VR, AR, MR, network computing, AI, digital twins, and blockchain. As a fresh educational setting, we have emphasized innovative educational assessment standards, administrative methods, and individual study examination approaches.

The effort also created a framework for Metaverse integration into education. Several research studies have examined Education Metaverse's theoretical foundation and prospective applications. The Education Metaverse's primary components' architecture and relationships are unknown. To address this discrepancy, we propose a five-layer technology framework supported by management and incentive systems based on Metaverse research. The study also highlights three essential components: virtual human, virtual learning resource, and virtual teaching scene. The design and interaction criteria for these components are examined. We construct an Education Metaverse prototype for feasibility and usability. The growth of the Metaverse shows that it and education are intertwined and complementary. During the initial phases of Metaverse development, a more significant number of highly skilled individuals are required. Education can cultivate and impart skills relevant to the Metaverse. Hence, a robust correlation exists between Metaverse and education. What are your predictions for the future utilization of the Metaverse in education, and what adaptations could be necessary? Over time, we may anticipate the transformations in Metaverse education.

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