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SURVEY

Development of a Framework for Metaverse in Education: A Systematic Literature Review Approach

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ABSTRACT A more interactive learning environment is made possible by the metaverse, a made-up world with vastly expanding digital spaces. The metaverse is a development in synchronous communication that enables many users to share different experiences. This study proposes a research framework for adopting metaverse in education. A systematic literature review using the PRISMA methodology identified seventy-three research papers on metaverse and education. Also, this research provided various applications, challenges, dominant themes of research, and future perspectives of a metaverse in education. The proposed framework discusses multiple drivers for adopting a metaverse in education. There are few papers in the metaverse for education, so this research tries to fill the gap. This research also proposed twenty-seven future research questions which can addressed by future researchers. This research will benefit students and teachers across universities/ colleges and schools.

INDEX TERMS Metaverse, education, PRISMA, students, teachers, universities/colleges.

I. INTRODUCTION

The growth of social media platforms and the internet enables easy and affordable access to hardware and software for developing better digital content presented by 3D virtual environments [1], [2]. The metaverse development facilitated regular online human interaction and communication [3]. As a result, the metaverse can be defined as a set with significantly enhanced physical reality and space. Because of this fusion of the real and physical universes, users can create countless digital mirrors of the natural world, both real and unreal, for various purposes [4].

Numerous studies were conducted with the metaverse at their core by various universities and educational institutions [5], [6], [7], [8], [9]. Researchers employed the metaverse in a learning environment, using a problem-based approach in which teachers and students could present the issue and look for potential solutions in the make-believe world using 3D classes [10]. The existence of the metaverse may be used to create a new educational setting; as a result, the use of the metaverse in education can be seen as an enhancement of the existing educational background through the use of technologies related to the metaverse that combine elements of the virtual and physical learning environments [11]. It enables students to enter the educational environment using wearable technology without being constrained by time or location [12], [13].

Akour et al. [14] utilized the technology adoption model, and the study seeks to understand how students in the Gulf region perceive the metaverse as a tool for education. Because it helped the relevant educational authorities comprehend the significance of each factor and allowed them to make plans and efforts following the factors' order of importance, this study was important from a practical standpoint.

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Teng et al. [12] used an extended version of the Unified Theory of Acceptance and Use of Technology (UTAUT) model, taking into account perceived risk, to examine the factors influencing students' adoption of an educational metaverse platform.

Dwivedi et al. [15] investigate the topics in depth by combining an informed narrative and multi-perspective approach from experts from various disciplinary backgrounds on many aspects of the metaverse and its transformational impact. Tlili et al. [16] conducted a metaverse literature review in education. The findings also show how the design of the Metaverse in education has evolved, with generation Z being more specifically targeted by artificial intelligence technologies than generation X or generation Bühler et al. [17] proposed an engineering curriculum with cutting-edge components such as student-centred active and e-learning, visualization/metaverse, and gamification elements.

Petrigna & Musumeci [18] searched the available literature for articles that related the metaverse to treatment and prevention, training and education, and research settings. Zhao et al. [19] performed a thorough investigation to learn more about how virtual reality technology is generally used in nursing education. The research into and use of virtual reality technology in nursing will steadily grow with the development of the metaverse concept. Tsz & Ng [20] examined 19 articles and focused on the metaverse trend, critical technologies found in the metaverse universe, and how researchers have conceptualised the term in the past and present. The findings outline the leading technology platforms employed in the metaverse studies and provide a solid theoretical framework for understanding the potential these platforms may have for online learning in the future.

Kye et al. [21] described the four types of the metaverse, their potential, and their potential drawbacks for educational use. Teachers should cautiously examine how students conceptualise the metaverse; second, they should plan lessons to encourage collaborative and imaginative problem-solving among students; and third, platforms for the educational metaverse should be created to prevent the misuse of student data. From the previous literature review papers, it becomes clear that very few studies have discussed metaverse in the education sector. The educational metaverse promises to achieve the goals of immersive learning by combining technology-based presence with narrative- and challenge-based mental immersion [22]. Khalil et al. [23] showed that teachers and students wanted to use the educational metaverse in teaching and learning. In addition, it was suggested that the university administration develop infrastructure, conduct training, and offer technical support to instructors and students to facilitate using the educational metaverse. Arpaci et al. [24] identified critical factors for predicting Metaverse's educational sustainability. The results showed that the need for liberty and hedonic drive strongly influenced how long Metaverse could be used for education. Table 1 shows the review of the research paper and its research gap. The review paper shows the studies related to healthcare education and nursing education. This study tries to fill the research by proposing the following research questions:

RQ_1: What are the publications trends, top contributing journals, countries of the research, and top cited journals?

RQ_2: What are the recent applications of the metaverse in education?

RQ_3: What are the dominant themes in the metaverse research concerning education?

RQ_4: What are the challenges of a metaverse in education?

RQ_5: What factors influence the adoption of a metaverse in education?

RQ_6: What are the future research trends of a metaverse in education?

Six research questions are formulated to discuss metaverse in education. The first research question will address the various trends in the publications in the metaverse in education. The second research question will address various applications related to metaverse in education like virtual 3D classrooms, virtual campus activities, creating simulating real-life situations, virtual tours, and gamification. The metaverse has several potential educational uses, including language learning, science education, manufacturing training, and medical, nursing, and healthcare training. The metaverse gives students more chances to engage with others, work and learn in a new environment, and explore, learn, and teach there. The third research will discuss various themes of the metaverse related to education. Three disciplines (educational courses, COVID-19, adoption of metaverse) and their subdiscipline (nursing, medical, engineering, mathematics, science, Pre Covid, COVID, Post Covid, among school students, college/university students, and teachers) are discussed. The fourth research question discusses the challenges of adopting metaverses in education, like equipment requirements, privacy and data security, ethics and principles, identity and social interaction. There are numerous advantages to taking college classes in the metaverse, including 3D visual learning, more real interactivity, and easier access for students from distant locations. The fifth research question presents a framework for the adoption of a metaverse in education where we discuss the drivers/adoption factors (perceived trialability, perceived observability, perceived compatibility, perceived complexity, personal innovativeness, social influence, performance expectancy, effort expectancy, facilitating conditions, hedonic motivation, habit, interactivity, vividness); mediating variables (perceived ease of use, perceived usefulness, attitude, and satisfaction); control variables (gender, age, technical knowledge); and dependent variables (usage intention). The sixth and last research question discusses the future of the metaverse in the education sector. Students and teachers can meet in the virtual space using their virtual reality headsets, regardless of their physical location. This type of functionality will improve education and learning. Teachers can create virtual landscapes based on lesson plans to extend a student's learning experience beyond a book reading. Metaverse is one

of the many new trends and technologies that emerge daily. This, however, is not like many other technologies that will fade away in time. Metaverse, however, will endure for a very long time. Also, this research question used one framework of theory-methodology-context (TMC) for proposing the twenty-seven future research questions.

Further, the research paper is divided so that section two discusses the methodology, section three discusses the findings and discussion, and section four provides the conclusion.

II. METHODOLOGY

A literature review is necessary to lay the groundwork for a new conceptual framework or theory and chart a specific subject's evolution over time. The systematic approaches used in the literature review were found to reduce bias and provide reliable outcomes for decision-making [25], [26]. Because the academic community has properly recognised the value of systematic reviews, specialised journals and special issues for systematic literature reviews exist. Systematic reviews are classified into four types: meta-analytic reviews, method-based reviews, domain-based reviews, and theory-based reviews.

The study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol, which included four steps: identification, screening, eligibility, and inclusion.

Wohlin et al. [33] suggested a protocol for carrying out the literature review. It is a three-step process, including planning, conducting, and reporting. The review panel for the study was created to assist the researchers in defining the conceptual boundary, reaching an agreement following independent coding, and settling any differences that may have arisen. It comprised four researchers and two academics with expertise in the education sector to ensure inter-rater reliability and classify them according to various factors while ensuring agreement among them [34], [35]. We chose the Scopus and google scholar databases to cover the currently available literature as both are the largest databases. Scopus, managed by Elsevier publishers, is the ''largest abstract and citation database of peer-reviewed literature in science, technology, medicine, social sciences, and arts and humanities''. Figure 1 shows the PRISMA methodology for this systematic literature review.

A. IDENTIFICATION

Keywords, platform, time, and article topics were investigated at this stage. The definition of the search phrases was the first step in the research. The final list of keywords comprised (TITLE-ABS-KEY (metaverse) OR TITLE-ABS-KEY (metaverses) OR TITLE-ABS-KEY (multiverse) AND TITLE-ABS-KEY (education) OR TITLE-ABS-KEY (university) OR TITLE-ABS-KEY (teaching) OR TITLE-ABS-KEY (students) OR TITLE-ABS-KEY (college) OR TITLE-ABS-KEY (learning). Using the language requirement, only English-language articles were chosen. Scopus and google scholar were selected because it offers 70% more sources than other databases like the Web of Science, making them the best option for literature search. Our search yielded 388 documents from December 2012 to May 2023 time span by searching the keywords in the title, abstract, and keywords of papers published in various journals from the Scopus database. For google scholar, we searched the articles based on the above keywords and got approximately 657 documents. So the total number of articles is 1045.

B. SCREENING

In this step, we checked the articles using an online tool of Mendeley to exclude duplicate entries and the articles published in predatory journals. After clearly reviewing the articles we got from both databases, we found that many articles were duplicate means present in both databases. So further, we finalized 365 articles for further studies.

C. ELIGIBILITY

After being screened, the articles underwent a full-text read. The eligibility criteria were developed in response to the type and relevance of the 365 articles. The qualifying standards were developed based on the article's applicability to the paper's subject. In the process, only publications in a metaverse in education were considered. As a result of this procedure, 292 publications were disregarded because they had no bearing on the study's goals. In conclusion, 73 publications have been chosen for additional research.

D. INCLUSION

The possibility of missing important documents was manually checked. The articles were divided into categories for each dimension, and then their contents underwent a descriptive study following critical standards. When multiple coders evaluate a message's characteristics and come to the same conclusion, this is known as interrater reliability, which measures the consistency of results across various coders. Eight articles were distributed to four eminent academics to ensure inter-rater reliability. They were tasked with classifying the articles based on multiple criteria and ensuring their classifications were agreed upon. To have a thorough understanding of the chosen papers, preliminary research on them was conducted. A thorough examination was carried out to organise the pertinent body of literature. The collection of relevant journal articles used a purposeful and snowballing approach. The snowball sampling strategy did not significantly increase the number of new instances.

III. DISCUSSIONS

This section will discuss the six research questions for metaverse in education. First, we will discuss the publications trends, top contributing journals, countries of the research, and top cited journals. Second, we will discuss some of the applications of a metaverse in education that can benefit students and teachers. Third, we will present a thematic analysis of the articles considered for this study. As we all know,

TABLE 1. Summary of the review papers and research gap.

Authors	The focus of the study	Findings	Research Gap
Kye et al. [21]	This study shows the challenges it can have for the adoption in the education sectors	This study understands the importance of the metaverse and tries to make it known to the students. It also highlighted that an effort should be made to create educational metaverse platforms that guard against student data misuse.	This study only provided the challenges and future perspectives of the metaverse.
Tlili et al. [16]	This study provided a bibliometric analysis of the metaverse in educational environments.	This study found future perspectives and provided a roadmap for the metaverse in education.	This study talked about metaverse adoption in educational settings but did not provide any framework for its adoption.
Tan et al. [27]	This study provided an overview of the metaverse in ophthalmology.	This research reveals the benefits and drawbacks of a metaverse in ophthalmology.	This study provided only an overview of a metaverse in ophthalmology educational settings.
Wu & Ho [28]	This study reviewed the articles related to metaverse in emergency medicine and found its applications.	The results shed light on a metaverse's characteristics, applications, growth, and potential in alternative medicine. With the help of this study, emergency medical services will be better prepared to handle upcoming difficulties.	The study is related to only emergency medicine and provided only its application of it.
Petrigna & Musumeci [18]	The study's objective was to review recent literature and look for articles linking the metaverse to prevention and treatment, education and training, and research settings.	This study found that the virtual world relates to research, education, training, and the prevention and treatment of clinical conditions and health.	This study was related to healthcare and discussed the challenges of a metaverse in healthcare education.
Tsz & Ng [20]	This review provided an overview of the metaverse based on 19 articles only.	The findings outline the leading technology platforms employed in the metaverse studies and provide a solid theoretical framework for understanding the potential these platforms may have for online learning in the future.	This study only provided a future perspective of the metaverse in online learning.
Topraklıkoğlu & Öztürk [29]	This review provided an overview of the metaverse in mathematics education.	The findings suggested the outline of the metaverse and its applications in studying mathematics.	This study only concentrated on the mathematics subject.
Kaddoura et al. [30]	This study used the PRISMA methodology to highlight the importance of the metaverse within the education context.	The findings suggested that the metaverse is the future of learning and teaching.	This study lacks any framework development for the future.
Chen et al. [31]	This study presented a bibliometric analysis of metaverse in education.	This study found the importance of the metaverse and its application in education.	The study was limited to learning environments and attitudes.
Beck et al. [22]	This study identified 47 studies for highlighting the strategies of a metaverse in education.	This study found 45 strategies and 21 practices.	This study was more concentrated on strategies
Onggirawan et al. [32]	This study highlighted the advantages and disadvantages of virtual educational spaces.	This study found that metaverse-based learning is more comprehended than traditional-based learning.	This study only discussed virtual educational spaces.

adopting the latest or emerging technologies will have many challenges, so that we will present the challenges related to the metaverse in education. Then we will formulate a framework based on the factors for adopting a metaverse in education. Lastly, we will discuss future research trends related to the metaverse.

A. RQ1: WHAT ARE THE PUBLICATIONS TRENDS, TOP CONTRIBUTING JOURNALS, COUNTRIES OF THE RESEARCH, AND TOP CITED JOURNALS?

Metaverse is one of the latest research areas, so very few papers are available before 2020. Most of the documents found were in the years 2022 and 2023. Figure 2 shows

the number of publications published from 2012 to 2023. But before 2014, we could not find any publications related to the metaverse. The geographic coverage of this research was determined by the country/region from which the data was collected, as shown in Figure 3. Figure 4 shows the articles published in some of the leading journals. Table 2 displays the top cited articles in the area of a metaverse in education. It also shows the journals' Scopus ranking and Web of Science indexing.

B. RQ2: WHAT ARE THE RECENT APPLICATIONS OF THE METAVERSE IN EDUCATION?

Metaverse can even practise or learn in situations they encounter in the real world [43], [44]. For instance, most individuals may not have the chance to serve in a managerial capacity or gain flight experience. But if the metaverse's creator wants to give users an experience or an opportunity to learn, this might occur there [45]. Some of the applications of the metaverse can be:

✓ Virtual 3D classrooms: Students notice a difference between immersive physical and virtual classrooms as more online schools and colleges have emerged [46]. The development of 3D virtual classrooms in the metaverse will close this gap by enabling students to interact virtually with their classmates and teachers. Students from any location can participate and accomplish much more in this metaverse-powered learning environment than in a conventional classroom.

✓ Virtual campus activities: Through the metaverse, students can partake in extracurricular activities like sports and the arts in a virtual setting. Students can engage in various enjoyable activities, such as music or math clubs and physical campus activities [47]. They can also stroll through their virtual campus from their homes.

✓ Creating simulating real-life conditions: Subject-specific 3D spaces could be created to help students learn while also assisting teachers in better articulating the subject matter [48]. Knowledge in the metaverse is effective because it captivates students by simulating real-world scenarios in which they can conduct scientific experiments, present examples, and even participate in a documentary film, such as one about World War I.

✓ Virtual tours: If you could read about a nation in class and then visit it directly, that would be amazing [49]. Wouldn't it be an incredible experience? Although it is not possible in reality, the metaverse makes it possible by providing virtual travel worldwide [50]. The metaverse aids in expanding students' horizons and worldviews by enabling them to visit any place of their choice in a virtual environment in a matter of minutes.

✓ Gamification: Although concepts can be taught to students in an engaging manner, both statically and passively and actively, the latter method is the most efficient because it does so [51]. Through gamification, which involves incorporating elements of games into non-game objects to increase user engagement, Metaverse accomplishes the same for students [52]. This encourages students to continue learning and submit their assignments on time.

C. RQ3: WHAT ARE THE DOMINANT THEMES IN METAVERSE RESEARCH CONCERNING EDUCATION?

Thematic analysis was used to comprehend the research's significant discipline, critical issue, and primary focus. The thematic analysis is presented in Table 3. When it comes to education, the metaverse can be thought of as a learning environment that has been improved by metaverse-related technologies that combine elements of the real and virtual learning environment. The first discipline is made based on educational courses in which sub-disciplines formed are nursing [19], medical [13], [18], [21], [27], [28], [53], engineering [17], [37], [38], [54], [55], mathematics [56], and science [7], [8], [17], [20], [39], [53], [57], [58].

Using metaverse in healthcare can create an engaging, immersive, and personalised experience for each person. It may open up fresh possibilities for closer interactions between medical professionals and their patients. Metaverse simulations provide feedback to students and assist them in learning by doing interactively. Nursing students' ability to safely administer medications is improved using metaverse simulations of intravenous drug infusion and administration [19]. People can visit the virtual metaverse hospital and consult with medical professionals using their avatars. Here, doctors can consult with patients, examine them, and keep an eye on them from a distance. There will also be chances for professional development and new approaches to conducting research [28]. A virtual laboratory for training in simulated heart attacks, various consultation rooms for medical visits, a virtual cardiac MRI room, and a virtual operating room for cardiac surgery are just a few of the multiple components of the hospital. At a significantly lower cost, students can train in a simulated setting for immersive surgical training through virtual reality in medical training [11]. Technical abilities, such as accuracy and decision-making skills, can be improved in surgical trainees through virtual reality during cadaver training sessions [8], [43].

An engineering study requires a thorough understanding of the fundamentals and some laboratory or experimentation experience [59]. Students can use the metaverse's immersive laboratory and virtual education material. The main problem in engineering education is that traditional education does not provide enough time or materials for individual students to conduct experiments [60], [61]. This, however, can be addressed with the metaverse labs. The absence of interaction and engagement was another problem with online learning [59]. The metaverse has a hugely captivating environment with a 3D aspect to get around this. The engineering curriculum will benefit significantly from all of these features.

The second discipline is related to COVID research, which has been classified into three sub-disciplines, mainly pre-COVID-19 [37], [62], [63], [64], [65], COVID-19 [6], [21], [38], [40], [54], [66], [67] and post-COVID-19 [7], [8], [10],

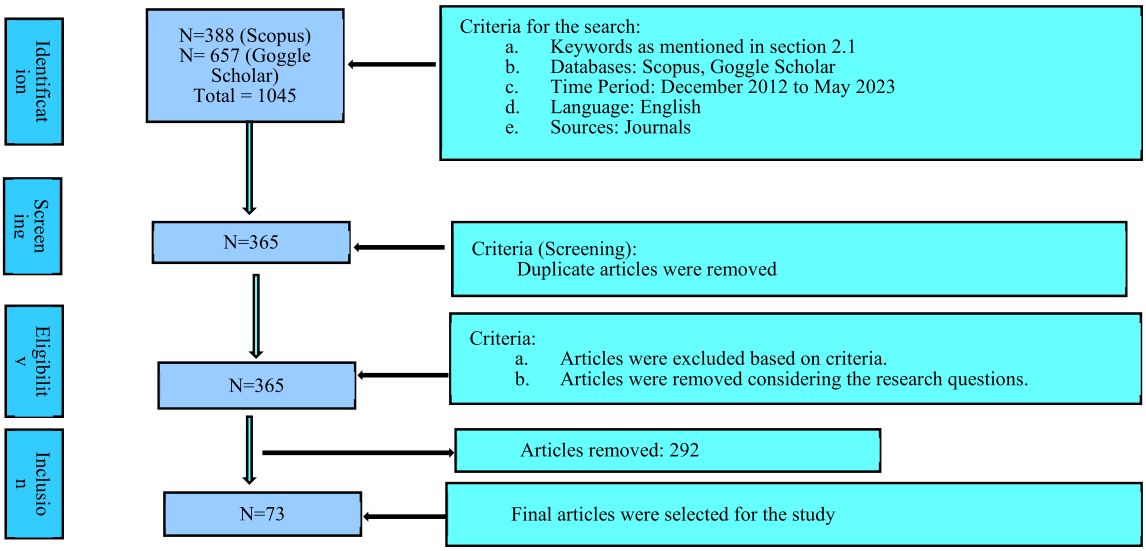

FIGURE 1. PRISMA methodology [36].

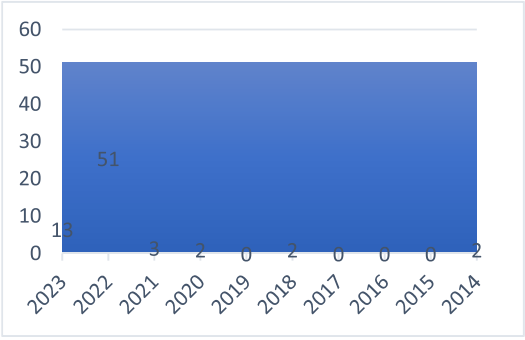

FIGURE 2. Year of publication of the article.

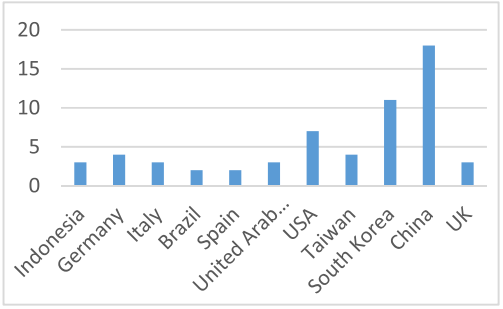

FIGURE 3. Countries of the research.

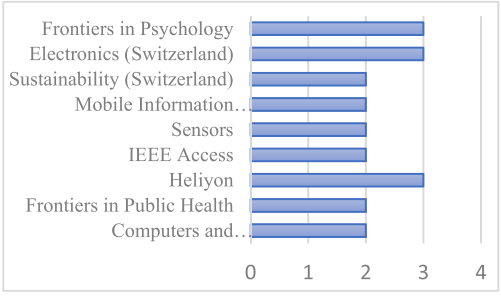

FIGURE 4. Top contributing journals.

[11], [13], [14], [15], [16], [18], [27], [28], [39], [41], [42], [54], [66], [67], [68], [69], [70], [71], [72], [73], [74], [75], [76]. Before and during COVID-19, learning had shifted from traditional classroom settings to blended and virtual ones [54]. The metaverse enables immersive campus life, in which students wearing virtual reality headsets enter a virtual campus or university to learn, explore, and socialise. Learners can, for example, explore different learning pods, visit libraries and breakout rooms, meet coaches and counsellors, and socialise with peers in this digital space. Pandemics in 2020 have forced schools and students to continue learning online [77].

All of us, including students at educational institutions, have been affected somehow by the pandemic [78]. Students who could not attend school moved online, with remote schooling and online classes quickly becoming the norm. Students were devoting hours of their days to Zoom classes, only to spend the rest of their time playing online games with their friends or communicating via the same platforms. These innovations remained even after schools resumed in-person attendance in 2022 [15]. People wonder where online education will go now that technology has advanced [77]. Many believe that the Metaverse will be the leading educational tool, with students able to create a semblance of physical contact in their virtual classrooms, overcoming the major issue with Zoom-era learning - physical isolation [79].

The third discipline is the adoption who are adopting the metaverse for learning and education. This discipline has been divided into sub-disciplines, mainly adoption among school students [8], [42], [71], [73] adoption among university students [6], [7], [13], [38], [40], [54], [55], [67], [72], [76], [80], [81], and adoption teachers/professors [20], [21],

TABLE 2. Top cited research papers.

Authors	Journal	No of citations	Scopus	Web of Science
Kye et al. [21]	Journal of Educational Evaluation for Health Professions	131	Q_2	ESCI
Díaz et al.[37]	International Journal of Emerging Technologies in Learning	77	Q_1	ESCI
Siyaev & Jo [38]	Sensors	62	Q_1	SCIE
Hwang & Chien [39]	Computers and Education: Artificial Intelligence	48	Q_2	
Dwivedi et al. [15]	International Journal of Information Management	47	Q_1	SSCI
Almarzouqi et al. [13]	IEEE Access	42	Q_1	SCIE
Akour et al. [14]	Computers and Education: Artificial Intelligence	39	Q_2	
Siyaev & Jo [40]	IEEE Access	39	Q_1	SCIE
Park & Kim [41]	Sustainability (Switzerland)	36	Q_1	SSCI
Suh & Ahn [42]	Journal of Intelligence	33	Q_2	SSCI

[58], [68]. From an educational standpoint, both business and industry need a workforce that is educated to handle the new challenges in the metaverse environment, which in turn calls for new models of management and organisational leadership [14].

D. RQ4: WHAT ARE THE CHALLENGES OF A METAVERSE IN EDUCATION?

Although the metaverse offers us novel educational perspectives, we must be wary of some metaverse challenges for educational or other purposes [82]. However, there are potential issues. Some of the challenges are:

✓ Equipment requirements: Both students and teachers must have access to an intelligent wearable with a good design that is reasonably priced [3]. According to reports, wearable technology users may experience cybersickness, blurred vision, or dizziness after using them [83], [84]. They may even lose their balance and fall to the ground, which could pose a security risk in real-world scenarios [43].

✓ Privacy and data security: Data is the primary form of governance in the metaverse, allowing for more detailed data collection from users, such as facial images, physical states, transactions, consumption records, etc. Additionally, students with little social experience are more likely to be exposed to criminal events in the metaverse due to a higher level of online anonymity [47].

✓ Ethics and principles: The metaverse are accessible to users worldwide thanks to the high level of freedom. Furthermore, it is urgent to create a well-organized metaverse with rules and ecosystems [27]. In addition, it will be crucial to develop learners' metaverse citizenship through instruction in law and ethics.

✓ Identity and social interaction: To engage in different activities in the metaverse, users' digital identities can directly reflect their egos [85]. The distinction between the real world and the virtual world is becoming less distinct, which may cause users to be confused about their ''real-me identity'' and ''virtual-me identity [72]. As a result, it's important to provide learners from society, school, and families with timely guidance on how to tell reality from the virtual world, approach the metaverse logically and pay attention to real-world interaction [86].

E. RQ5: WHAT FACTORS INFLUENCE THE ADOPTION OF A METAVERSE IN EDUCATION?

Metaverse's interactive capabilities and customised user experience make it so powerful. As a result, researchers use these two factors in teaching and learning environments. Here we proposed a framework for adopting the metaverse in education as an Eduverse. Figure 5 shows the theoretical framework for the Eduverse.

1) DRIVERS/ADOPTION FACTORS (INDEPENDENT VARIABLES)

The drivers for the adoption of a metaverse are shown. These constructs are taken from various theories like the technology adoption model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), etc. Arpaci et al. [70] used the variables like performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, and habit for measuring the social sustainability of metaverse. Table 4 shows the various factors and its adoption.

✓ Perceived Trialability: Intention to use technology and perceived trialability are closely related. Numerous studies have discussed and supported the term ''trialability's positively influencing the system's adoption [14]. The ease of dealing with new ideas is referred to as trialability. It also considers other ideas like the work and risk required to experiment with cutting-edge technology, including the ease of undoing and recovering from operations. Metaverse is an emerging technology in the field of innovation which can change the face of teaching and learning.

✓ Perceived Observability: The level at which the innovativeness of technology is perceived to be remarkable and noticeable by others is called perceived observability [14]. Adopting technology may be impacted by the opinions expressed by classmates and neighbours. The concept of visibility sparks discussions among classmates and other users.

TABLE 3. Dominant research themes for the metaverse in education.

Discipline	Sub discipline	Focus areas	References
Educational Courses	Nursing	Nursing education can be delivered using metaverse, where real-time virtual learning activities can be made.	[19]
	Medical	Medical education can use metaverse to provide students in learning and educational settings with enhanced immersive experiences and a more interactive learning experience.	[13], [18], [21], [27], [28], [53]
	Engineering	Metaverse in engineering education can provide real-time examples.	[17], [37], [38], [54], [55]
	Mathematics	Metaverse in mathematics can provide gamification to understand the subject matter better.	[56]
	Science	Metaverse can create a virtual space where students can learn, communicate and better understand science education concepts.	[7], [8], [17], [20], [39], [53], [57], [58]
COVID-19	Pre Covid	Metaverse is still an emerging technology, and before COVID, there was significantly less scope for metaverse as most of the learning facilities were offline.	[37], [62]–[65]
	COVID	During COVID, online learning had a significant boost as students couldn't attend classes, etc.; these provided a perfect setting for metaverse education.	[6], [21], [38], [40], [54], [66], [67]
	Post-Covid	This online class using metaverse technologies continued even post-pandemic because it had a vast scope.	[7], [8], [10], [11], [13]–[16], [18], [27], [28], [39], [41], [42], [54], [66]–[76]
Adoption of Metaverse	Among School Students	Metaverse can be very useful among school students because they are early adopters of technology, and their learning process can be more accessible.	[8], [42], [71], [73]
	Among College/University Students	In university and college, students can attain their lectures and labs using metaverse technologies worldwide.	[6], [7], [13], [38], [40], [54], [55], [67], [72], [76], [80], [81]
	Among Teachers	Professors/teachers will find it easy to deliver lectures using metaverse technologies.	[20], [21], [58], [68]

Adopting metaverse among students can be influenced by providing them with proper knowledge and learning about the technology.

✓ Perceived Complexity: Complexity is a term used to describe how difficult it is to comprehend new technological advancements [14]. According to earlier research, end users are less likely to use a system when they believe it to be complicated. Complexity harms technology use. Low complexity is necessary for technology acceptance to make it simple and user-friendly for users [1]. Simplicity is the best way to promote the adoption of new technologies. People are less likely to use innovative technology when perceiving it as complicated. Always some complexities will be related to the latest technology adoption. Metaverse or Eduverse is the newest technology; very few personnel will know about it. Initially, it will be complex, but it becomes easier with practice.

✓ Personal innovativeness fosters positive attitudes toward technological innovation [14]. Many claim that an individual's personal innovativeness factors—which can be seen as an example of a risk-taking propensity that manifests as a result of using new technology—have the most profound influence on an individual's cognitive interpretations of information technology. The metaverse adoption process must be viewed favourably by both students and teachers [53]. The intentions and technology preferences of the user are determined by attitude.

✓ Social influence: Studies have found that social impact and norms are related. Social groups influence students' behaviour [12]. People choose to use goods and brands that, in their opinion, complement who they are and convey that image to others. Students' social needs are met when usage follows social norms. The students knowing brands and technology, can quickly adopt Eduverse.

✓ Performance expectancy: Performance expectancy describes how much users believe new technologies will enhance their productivity at work [1]. The metaverse in education offers users a rich and immersive learning experience that can enhance user interaction with virtual elements. Eduverse gives users the ability to manage learning tasks well. Because of the increased learning efficiency, Eduverse users will have a more favourable opinion of the platform.

✓ Effort expectancy: The usability of new technologies is another aspect affecting satisfaction [12]. Additionally, the Eduverse platform was developed by mimicking the real world [87]. Users are more likely to be pleased with the simplicity of using Eduverse because they can learn in a way consistent with their prior experiences, even in the virtual world.

✓ Perceived ease of use refers to how much the user believes the innovation is simple [88]. In light of this, it stands to reason that students will be more motivated to use technology in their learning when they think it requires little effort [1]. The importance of technology in the educational process will be highlighted in this manner. In contrast, if students think using the metaverse is difficult, they might not use it at all, even though technology might help them learn better.

✓ Perceived usefulness refers to the extent to which the user trusts the innovation has significant benefits [1]. Students and teachers need to understand the benefits of the metaverse. Eduverse can change the face of the learning experience. It will be easier for the students to interact with the teachers.

✓ Facilitating conditions: The term ''facilitating conditions'' describes the anticipated level of organisational and technological infrastructure that can support the use of technology [1]. Whether users can get immediate assistance while using the Eduverse platform may impact their feelings about it [12]. In other words, users will have a favourable opinion of the venue if they can rely on its support in the face of potential problems.

✓ Hedonic motivation: Hedonic motivation, also known as perceived pleasure, is a fundamental intrinsic motivation that governs the degree to which entertainment can be obtained through information technologies or the pleasure experienced from doing so [70]. The behavioural intention to use new technology is thought to be significantly and directly influenced by hedonic motivation. Students need to understand that with the usage of the metaverse, their way of learning will become easier and smoother.

✓ Habit: Depending on what they learn, people tend to act automatically, which is what is meant by the word habit [70]. It is emphasised that the past technology uses strongly predict how they will be used in the future [89]. Habit is thought to impact a person's behavioural intention to use a structure like the Metaverse that contains many virtual world elements.

✓ Interactivity: There are two ways to look at it from either a technological feature or a customer's perception [90]. From a technical perspective, it includes range, speed, and mapping. However, it is only available if the customer is willing to interact with the technology. Interactivity is a distinguishing feature because it stimulates psychological and behavioural responses [91].

✓ Vividness is a technology's capacity to create an environment rich in sensory media. Technically, it had two parts: depth or the calibre of the media displayed, breadth, the number of dimensions, or the text, pictures, and videos the medium could offer users [92]. Vividness creates an immersive experience, influences cognitive actions, and influences hedonic and utilitarian motivation [93], [94].

2) MEDIATING VARIABLES

✓ Attitude: Habitual responses to situations are called attitudes [4]. Attitude is commonly used to describe a person's overall disposition toward an object, idea, or institution. Attitudes can be positive, negative, neutral, dormant or widespread [95].

✓ Satisfaction: These attitudes' development is heavily influenced by satisfaction. The expectation-disconfirmation model, which allows users to compare expected and actual cognitive experiences to gauge their satisfaction or dissatisfaction, was used in most early studies on satisfaction [14]. Users are said to be satisfied when certain aspects of an experience exceed their expectations; users are said to be dissatisfied when the experience doesn't meet expectations [12]. Users' satisfaction with information technologies is a crucial determinant of their acceptance.

3) CONTROL VARIABLES

✓ Gender: Gender can decide whether a technology needs to be adopted [46]. Male students might have come other choices in comparison to female students. The attitude of the students may also be concerning gender.

✓ Age: Age plays a vital role in technology adoption. The younger generation is more attracted to technology than the older generations. Students fall under the younger generation, so there can be chances of a positive attitude towards adopting Eduverse.

✓ Technical knowledge: Some technology adoption requires technical expertise for proper handling [46]. Technical knowledge can be like prior experience, learning about the technology, and a positive attitude.

4) DEPENDENT VARIABLES

✓ Usage intention: The intention to use decide whether the technology needs to be adopted. Eduverse is one of the latest technologies that can be adapted to change the teaching and learning experience.

✓ Behavioural Intentions: The more robust the intention to carry out the behaviour, the more likely it will be, according to the motivational factors that influence a particular behaviour. This factor will measure the conduct of the user towards the metaverse.

F. RQ6: WHAT ARE THE FUTURE RESEARCH TRENDS OF A METAVERSE IN EDUCATION?

Virtual reality will significantly impact how humans live in the future. Metaverse will impact every aspect of our lives or industries, especially the education sector. However, the metaverse's impact will improve the future of education and learning [105]. This will not be limited to schools or colleges; businesses or corporations can also use the metaverse to increase the knowledge of their employees. Making frameworks or models for the metaverse that can be used in education. Because the metaverse is still in development, its infrastructure must be fine-tuned and tailored to accepted standards [106]. The designs and frameworks of the metaverse, including hardware and software, serve as the foundation for educational practises. When designing the metaverse for school administrators, teachers, and students, it is thought

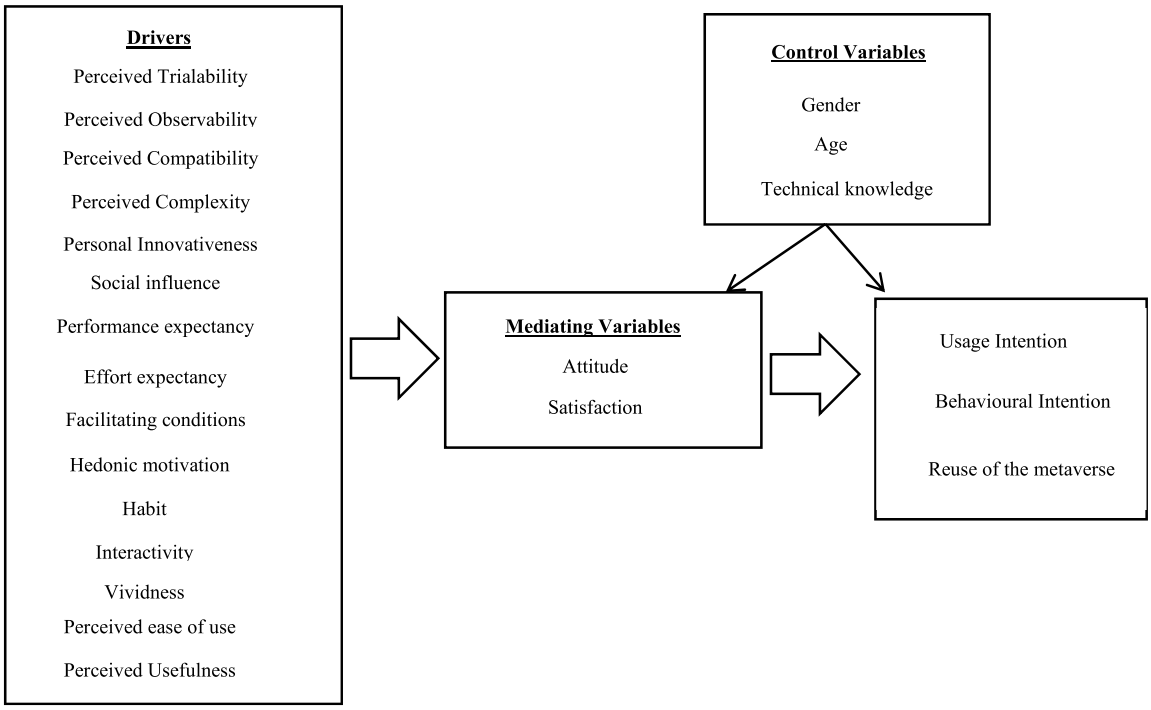

FIGURE 5. The theoretical framework for the adoption of eduverse.

that several factors, including accessibility, safety, humanity, trust, academic capabilities, and learners' cognitive characteristics, should be considered [107], [108].

Assessing students' higher-order thinking skills, such as critical thinking and problem-solving, can be complex [2]. It is challenging to conduct the evaluation based on a test. A promising direction might be to watch and evaluate how students solve problems or complete projects. This suggests that different dimensions can be used to evaluate their performances or competencies. It evaluates the views of parents, teachers, and school administrators on using the metaverse for education. It is possible that using the metaverse will provide teachers and school administrators with both opportunities and challenges.

Furthermore, the metaverse can influence how students' study at home and in class—professional development for teachers concerning the metaverse. There is a widespread belief that teachers are essential to successful education and educational reform. Teachers may have access to various opportunities thanks to the metaverse as a developing educational technology. The metaverse environment is an affordable substitute for professional training because it is entirely virtual and replaces pricey physical equipment or devices.

Examining how the metaverse affects both cognitive and non-cognitive learning in students. It would also be intriguing to investigate how the metaverse influences cognitive and non-cognitive aspects of learners in a setting with such high levels of immersion, presence, and freedom [107]. Evaluating how well students learn and teachers can teach in the metaverse instead of other environments. When implementing new technology in the classroom, it is critical to conduct comparative research to identify the most effective teaching and learning environments [109].

This study tries to fill the research gap by proposing a framework for adopting metaverse in the educational setting. Metaverse is the future of education. Learners can participate in virtual classes from a distance while still getting a feel for the real classroom thanks to the metaverse in the education sector. In addition to making them more immersive, engaging, and communicative, education institutions and technology companies are working to remove physical barriers. Our approaches to educating children and preparing teachers to meet these new challenges must change as technology advances, bringing us new, immersive, imagined worlds. It also opens new communication channels for students, instructors, and parents. Because of virtual world technologies and blended learning methodologies, teachers and students have more flexibility in scheduling lessons, holding meetings, and supplementing practical learning experiences.

The metaverse has the potential to alter how lessons are taught and how children learn if it can follow the best learning principles. Users can communicate with people in virtual offices or classrooms rather than over a laptop screen and microphones. While accessing virtual workshops or educational experiences in panoramic view, users can interact with lifelike virtual characters made by other metaverse players.

This section summarises the study's findings to emphasise emergent trends and suggest relevant areas for future study. This section will feature suggestions for future research areas and summarise the selected literature gaps. Table 5

TABLE 4. Various variables adopted.

Sl. No.	Authors	Technology adopted	Variables used in this study	Discussion
1	Arpaci et al. [70]	Metaverse	Independent variables: Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation, and Habit. Dependent variables: Social sustainability for the metaverse adoption	This study measured the social sustainability for the metaverse adoption. Performance expectancy was having p-value= 0.001 which is less than 0.05 but effort expectancy was having p-value= 0.612 which is greater than 0.05. Also, Social Influence was having p-value= 0.001 which is less than 0.05 but facilitating conditions was having p-value= 0.336 which is greater than 0.05. hedonic motivation was having p-value= 0.023 which is less than 0.05 and Habit was having p-value= 0.001 which is less than 0.05. So, finally we can say that except effort expectancy and facilitating conditions other factors were supported.
2	Teng et al. [12]	Metaverse	Independent variables: Satisfaction, Performance Expectancy, Effort Expectancy, Social Influence, And Facilitating Conditions. Dependent variables: Usage intention	This study used satisfaction as its mediating variable. The independent variables performance expectancy, effort expectancy, social influence, and facilitating conditions was found having positive impact. Also, the variable satisfaction was found to be having positive impact on usage intention of metaverse for the educational platform.
3	Akour et al. [14]	Metaverse	Independent variables: Perceived Trialability, Perceived Observability, Perceived Compatibility, Perceived Complexity, And Personal Innovativeness. Mediating variables: Perceived Ease of Use, and Perceived Usefulness, Users' Satisfaction. Dependent variables: Users' Intention	This study measured the user's intention for the adoption of metaverse in the higher institutions of the gulf countries. The variables perceived trialability, perceived observability, perceived compatibility, perceived complexity was having a positive impact of the mediating variable of user's satisfaction. Personal innovativeness was found to positive impact on both mediating variable of perceived ease of use, and perceived usefulness. the three mediating variable perceived ease of use, and perceived usefulness, users' satisfaction was found positive on the depending variables of user's intention of metaverse.
4	Arpaci & Baharı [24]	Metaverse	Independent variables: Hedonic motivation. Dependent variables: Educational sustainability for the metaverse adoption	Hedonic motivation was found having positive relationship with the educational sustainability.
5	Huang et al. [96]	Virtual Reality	Independent variables: Perceived Ease of Use, and Perceived Usefulness. Dependent variables: Behavioural intentions	It was found that perceived usefulness was having positive relationship with the behavioural intention for the adoption of virtual reality but perceived ease of use was having negative relationship with the behavioural intention.
6	Huang et al. [97]	Virtual Reality	Independent variables: Perceived Ease of Use, and Perceived Usefulness. Dependent variables: Behavioural intentions	This study found both Perceived ease of use, and perceived usefulness having positive relationship for the adoption of virtual reality in the medical education.
7	Shen et al. [77]	Virtual Reality and Augmented Reality	Independent variables: Perceived Ease of Use, Hedonic motivation, Perceived Usefulness. Mediating Variables: Attitude dependent variables: Behavioural intentions	This study measured the adoption of augmented reality and virtual reality in the tourism education. Perceived usefulness and hedonic motivation were found to be having positive relationship with attitude but perceived ease of use was having negative relationship with attitude. Also, attitude was having a positive relationship with the behavioural intention.
8	Lee et al. [98]	Virtual Reality	Independent variables: Social interaction. Mediating Variables: Perceived Ease of Use, Perceived Usefulness, and Attitude. Control Variables: Age, income, and gender. Dependent variables: Intention to use	This study found perceived usefulness was having a positive relationship with attitude but perceived ease of usefulness was having negative relationship with attitude. Also, attitude was having positive relationship with the intention to use virtual reality.
9	Al-Oudat et al. [99]	Virtual Reality	Independent variables: Effort Expectancy, Perceived Compatibility, and Facilitating Conditions. Mediating Variables: Perceived Ease of Use, Perceived Usefulness, and Attitude. Dependent variables: Intention to use	This study found facilitating conditions was having positive relationship with perceived usefulness and also effort expectancy was having positive relationship with perceived ease of use. Perceived ease of use, and perceived usefulness was found having positive relationship with the attitude and also attitude was found having positive relationship with intention to use.

TABLE 4. *(Continued.)* **Various variables adopted.**

10	Abd Majid et al. [100]	Virtual Reality	Independent variables: Perceived Ease of Use, and Perceived Usefulness. Mediating Variables: Attitude. Dependent variables: Intention to use	It was found that perceived ease of use was having perceived usefulness having positive relationship. Perceived ease of use was not having negative relationship with attitude but perceived usefulness was having negative relationship with attitude. Both perceived usefulness and attitude was having negative relationship with intention to use.
11	Shen et al. [101]	Virtual Reality	Independent variables: Performance expectancy, Effort expectancy, social influence, and Facilitating conditions. Dependent variables: Behavioural intention	The variables Performance expectancy, effort expectancy, social influence, and Facilitating conditions was found having positive relationship with the behavioural intention for the adoption of virtual reality in learning.
12	Manis & Choi [102]	Virtual Reality	Independent variables: Perceived Ease of Use, and Perceived Usefulness. Mediating Variables: Attitude. Dependent variables: Use Intention	It was found perceived ease of use, and perceived usefulness having positive relationship with attitude and attitude was having positive relationship with use intention.
13	Barret t et al. [103]	Virtual Reality	Independent variables: Perceived Ease of Use, and Perceived Usefulness. Dependent variables: Intention to use	It was found perceived ease of use, and perceived usefulness having positive relationship with the intention to use.
14	Almar zouqi et al. [13]	Metaverse	Independent variables: Perceived Trialability, Perceived Observability, Perceived Compatibility, Perceived Complexity. Mediating Variables: Perceived Ease of Use, and Perceived Usefulness, Users' Satisfaction. Dependent variables: Users' Intention	It was found perceived trialability, perceived observability, perceived compatibility, perceived complexity having positive relationship with perceived ease of use, perceived usefulness, and users' satisfaction. Also perceived ease of use, perceived usefulness, and users' satisfaction was found having positive relationship with users' intention.
15	Faqih & Jarada t [104]	Augmented reality	Independent variables: Performance expectancy, Effort expectancy, social influence, Facilitating conditions, and Hedonic motivation. Dependent variables: Behavioural Intention.	It was found Performance expectancy, Effort expectancy, social influence, facilitating conditions, and Hedonic motivation having positive relationship with behavioural intention for the adoption of augmented reality.

summarises the gaps in the research. Recommendations for additional research are made using the TMC framework [110], [111], [112], [113], [114]. We proposed twenty-seven future research questions which can be used in future studies in the area of metaverse and education. The TCM framework, where "T" stands for theories, "C" for contexts, and "M" for methodologies, was developed by [115].

1) FUTURE THEORETICAL DIRECTIONS

There have been recent advancements in the metaverse in education in the literature, but there is still much room for development. According to the study, only a few investigations had a theoretical foundation. Fewer research investigations employed the model/framework [24], [116], [117]. So, to fill the gap in the literature, this proposes future research questions which can be addressed. For future theoretical directions, we proposed eleven future research questions. Various theories can be used for the adoption of a metaverse in education. In the literature, there are very studies that have used theories. Under future theoretical directions, we have proposed eleven future research questions. The first and second future research questions will use the unified theory of acceptance and the use of technology to study the adoption of metaverse among students and professors/teachers. The third and fourth future research questions will use the unified theory of acceptance and use of technology and consider age, experience, and gender as controlling variables to study the adoption of metaverse among students and professors/teachers. The fifth and sixth future research questions will use the theory of reasoned action to study the adoption of metaverse among students and professors/teachers. The seventh and eighth future research questions will use the theory of planned behaviour to study the adoption of metaverse among students and professors/teachers. The ninth future research question will be using the theory of planned behaviour for measuring the attitude to study the adoption of metaverse among students, professors/teachers, and students. The tenth and eleventh future research questions will use the technology acceptance model to study the adoption of metaverse among students and professors/teachers.

2) FUTURE METHODOLOGICAL DIRECTIONS

In future methodological direction, we discussed what type of methods can be used. Four future research questions have been proposed. Data collection and future studies related to metaverse in educational settings can be performed

TABLE 5. Future research themes and questions.

Topics	Research gap (Theme)	Future Research Questions (FRQ)
Future theoretical directions		
Behavioural Intention and Attitude	Measuring the behavioural intention for the adoption of a metaverse in education.	FRQ 1: How will the unified theory of acceptance and use of technology affect the adoption of a metaverse in education among students?
		FRQ 2: How will the unified theory of acceptance and use of technology affect the adoption of a metaverse in education among professors and teachers?
		FRQ 3: How (the gender, age, and experience) of the Unified theory of acceptance and use of technology going to affect the adoption of a metaverse in education among professors and teachers?
		FRQ 4: How (the gender, age, experience) of the Unified theory of acceptance and use of technology will affect the adoption of a metaverse in education among the students?
		FRQ 5: How will the theory of reasoned action affect the adoption of a metaverse in education among professors and teachers?
		FRQ 6: How will the theory of reasoned action affect the adoption of a metaverse in education among students?
		FRQ 7: How will the theory of planned behaviour affect the adoption of a metaverse in education among professors and teachers?
		FRQ 8: How will the theory of planned behaviour affect the attitude toward adopting metaverse in education among professors and teachers?
		FRQ 9: How will the theory of planned behaviour affect the adoption of a metaverse in education among professors and teachers?
		FRQ 10: How will the technology acceptance model affect the adoption of a metaverse in education among professors and teachers?
		FRQ 11: How will the technology acceptance model affect the adoption of a metaverse in education among students?
Future methodological directions		
Nature of data collection	Using various data collection methods of quantitative and qualitative approaches.	FRQ 12: How will the data collection by the quantitative methods be helpful in the adoption of a metaverse in education?
		FRQ 13: How will the data collection by the qualitative methods help adopt metaverse in education?
Mixed methods approach.	Using a mixed method approach for a better result	FRQ 14: How can the mixed method approach be used to adopt metaverse in education among professors and teachers?
		FRQ 15: How can the mixed method approach be used to adopt metaverse in education among students?
Future contextual directions		
Handling of disruption like the COVID-19 pandemic with educational perspectives.	During the pandemic, students faced many challenges as they were unprepared for online classes. So, to avoid this type of disruption, a free educational learning platform must be developed using Metaverse.	FRQ 16: How can educational platforms have disruption-free online classes using Metaverse?
Emerging/developing market	There is a need to develop and adopt metaverse-based	FRQ 17: What factors will lead to adopting metaverse in the education sectors of emerging markets?
	learning for emerging markets.	FRQ 18: How will the student's viewpoint on adopting metaverse in the education sectors of emerging markets?

TABLE 5. *(Continued.)* **Future research themes and questions.**

		FRQ 19: How will the professors/teachers view adopting the metaverse in the education sectors of emerging markets?
		FRQ 20: How will educational institutions adopt the metaverse in the education sectors of emerging markets?
		FRQ 21: Will the lack of infrastructure in the educational institutions of developing countries be a challenge?
		FRQ 22: How to increase the awareness for adopting metaverse in education?
		FRQ 23: Will educational institutions be able to bear the cost of metaverse adoption?
Teaching/learning quality	The adoption of metaverse-based learning can improve the students' learning experience.	FRQ 24: Will there be an improvement in the learning quality after the adoption of the metaverse?
		FRQ 25: Will the students clearly understand all the lessons and experiments if metaverse is adopted?
		FRQ 26: Will metaverse-based learning be successful in the rural parts of developing countries?
		FRQ 27: Will the teaching quality of the teachers/professors improve after adopting the metaverse?

using quantitative and qualitative methods. The twelfth and thirteenth future research questions discuss how the data collection using quantitative and quantitative methods be helpful for the adoption of a metaverse in the education sectors. Mixed methods research approach can be used as it comprises both quantitative and quantitative methods. The fourteenth and fifteenth future research questions will be used to study the adoption metaverse in education among students and professors/teachers.

3) FUTURE CONTEXTUAL DIRECTIONS

In the future contextual directions, we discussed the eleven future research questions regarding disruption handling, emerging markets, and teaching/learning quality. During COVID-19, we all know what problems aresed for online classes, as most universities/schools were unprepared for such disruptions. So, it becomes necessary that we are ready to handle these types of disruptions in the future. The sixteenth future research questions propose whether the various educational institutions can handle this type of disruption using metaverse. Emerging/developing market lacks the acceptance of technology at a faster rate in comparison to developed economies. The seventeenth future research questions propose the factors that can lead to adopting metaverse in education. Eighteenth and nineteenth future research questions will verify the student's and professor/teacher's viewpoints for adopting metaverse in emerging economies educational institutions. Twentieth future research questions will find how the emerging economies' educational institutions can adapt. Twenty-first future research questions will find whether the lack of infrastructure of the educational institutions is a barrier to its adoption. Twenty-second future research questions will create awareness for the metaverse adoption. Twenty-third future research questions will find whether the educational institutions have sufficient funding for adopting metaverse. It has become necessary to improve the teaching and learning quality using metaverse. Twenty-fourth of future research questions will address the learning quality and its improvement for adopting the metaverse. Twenty-fifth future research questions will address the understanding levels of the students after adopting the metaverse. Twenty-sixth future research questions will address whether the metaverse will be adopted in the emerging countries' rural parts. The twenty-seventh future research question will address the quality improvement of teaching and learning after adopting the metaverse.

IV. CONCLUSION

The metaverse system is a type of technology that, from economic, engineering, and educational perspectives, will change the world. Cutting-edge technologies, an essential component of educational practises, aid it. All anticipate new technologies that will change the world in light of the Facebook founder's recent announcement that Facebook will now be called Metaverse or Meta World. Virtual reality is a brand-new environment that will displace the internet and open the door for cutting-edge teaching and learning methods. Given the metaverse system's benefits to teaching and learning, this study provided metaverse applications in education, challenges, adoption factors, themes, and future research. This research provided and discussed various themes about metaverse related to COVID, educational types/courses and adoption. This research also provided a framework for the metaverse adoption in the education sector. This research will be helpful in the educational sector as the

metaverse is an emerging technology that can change the education and learning process.

There are a few limitations of the study. This research used only one database of Scopus so that other databases can be used in the future, like Web of Science, EBSCO, etc. This study proposes a research framework that can be empirically tested using survey-based methods. The metaverse can be used in a wide range of circumstances. This study focuses on educational settings because the metaverse system will significantly impact the teaching and learning environments.

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