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RESEARCH ARTICLE

Analyzing the Impact and Prospects of Metaverse in Learning Environments Through Systematic and Case Study Research

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ABSTRACT Recent years have witnessed a remarkable technology shift with immersive technology applications like Metaverse across industries and sectors. As 3D-based virtual reality environments, these applications create digital pairs of the physical world and provide an immersive experience to users with technological competencies supporting daily and social activities by means of their virtual avatars and with real-virtual environments and human-machine interactions. Following the COVID-19 pandemic, educational systems are actively engaged in integrating modern and emerging technologies with traditional teaching methods. The pandemic has significantly altered the landscape of education by introducing a new era of virtual environments and interactions, which has placed new demands on learning settings. Immersive technologies have added new dimensions to the learning process. This current study delves into the feasibility of incorporating immersive technologies, such as the Metaverse, into education, and it assesses the overall academic experience for both educators and learners. The primary aim is to investigate whether immersive technologies are a suitable choice for contemporary and future digital learning environments. To achieve this, the study conducts: 1) a thorough examination of existing knowledge through systematic literature research; 2) analysis of case studies from selected educational institutions; and 3) an exploration of the benefits, challenges, and potential of the Metaverse in various learning environments. The findings endorse the promising opportunities that the Metaverse and other immersive technologies offer for present and future educational innovations, as well as interdisciplinary research possibilities.

INDEX TERMS Digital learning, immersive technology, learning environments, metaverse.

I. INTRODUCTION

Combining traditional teaching methods with digital learning environments is a popular practice across learning systems. Digital learning methods provide Internet-based learning environments to improve learner independence and promote student-centered learning [1]. During the COVID19 pandemic outbreak, the education sector witnessed many students studying remote and in isolation, which gradually increased the relevance of digital applications to make learning less difficult. The pandemic prompted the global academic community to default to online meeting platforms like Zoom and Google Meet for facilitating online classes [2]. In other words, the COVID19 pandemic triggered an emergency context for learning and thus made way for more digital integration in learning at all levels worldwide. The global

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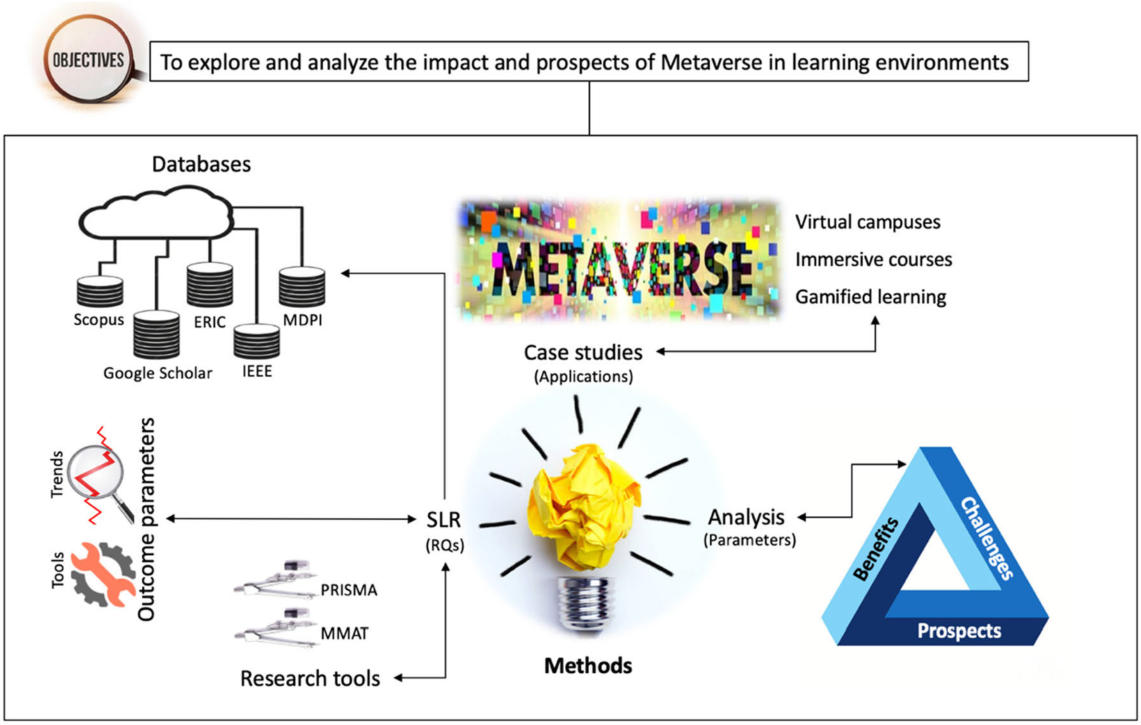

FIGURE 1. Research framework.

pandemic has introduced us to a mixed life with virtual activities. Post COVID19, the use of digital resources for almost everything from working and studying online to ordering food straight to the doorstep has normalized life in numerous ways. In the context of education, technology-driven pedagogy is an established academic practice, planning and executing new and emerging technology-based learning systems and smart classrooms engaging students in more interactive learning processes [3]. This was reshaped post COVID19. As the pandemic outbreak has affected students and educators across the world, digital learning formats have become increasingly popular with more demands for virtual and online courses [4]. In other words, the pandemic caused learning systems to be actively involved in incorporating new and emerging technologies with traditional teaching methods [5]. While the pandemic has remarkably influenced pedagogical dynamics by introducing a new normal of virtual environments and interactions and placing new demands on learning environments, immersive technologies have brought in new dimensions to learning processes. Thus, virtual engagement is relatively more important in learning environments now as such interactions can cause interesting learning experiences for students and improve teacher effectiveness for educators [6]. Education technologies and digital resources, like digital learning tools and techniques, are widely considered relevant for enhancing learner creativity and teacher effectiveness [7]. Post COVID19, digital learning mechanisms are acknowledged as equally or even more pertinent as/than traditional teaching systems mainly due to convenience of time and space, easy accessibility, and interactivity leading to active learner engagement and skill and capacity building. With increasing demands of virtual learning environments, the education industry is expected to witness more virtual worlds for better experiential learning [6]. In today's academic landscape, where technology continually shapes learning experiences, immersive technologies offer a bridge between theoretical knowledge and practical application. Their relevance lies in transforming traditional educational approaches, enhancing engagement, fostering skill development, and preparing students for the ever-evolving digital world. This has further necessitated the role of emerging and immersive technologies, like Metaverse, Digital Twin technologies, etc., aimed at enhancing the overall academic experience for both educators and learners.

The current study explores and analyses the implementation of immersive technologies in general and Metaverse in particular in current and future learning practices. It conducts a systematic literature research on the existing body of knowledge addressing Metaverse and other immersive technologies in education. It also analyzes state-of-the-art case studies of Metaverse-based learning processes and practices from selected educational institutions and discusses the benefits, challenges, and prospects of immersive technologies in learning systems.

II. MATERIALS AND METHODS

The current study aims at exploring and analyzing the impact and prospects of Metaverse across learning environments by investigating three aspects of inquiries: a systematic review

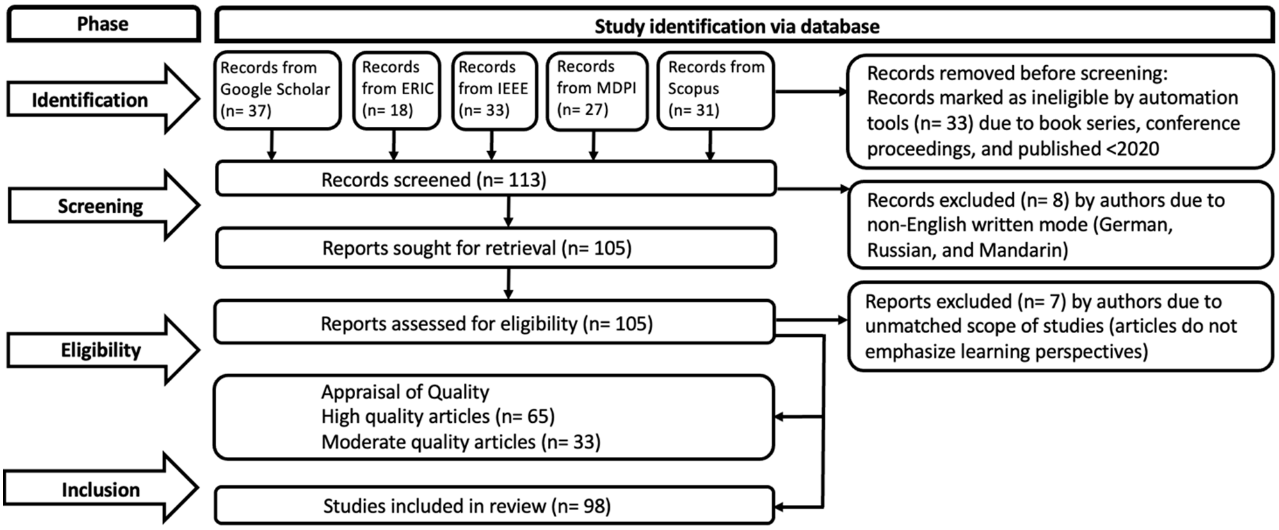

FIGURE 2. Selection process.

of relevant research, discussion of case studies, and an extensive analysis. A comprehensive description of the research framework is shown in Figure 1 below.

To identify and analyze the impact and prospects of Metaverse in particular and immersive technologies in general across learning systems, the study first conducted a systematic literature review (SLR) on its existing body of knowledge to answer the following research questions (RQs):

- RQ1: How does Metaverse impact the current learning practices?
- RQ2: What are the prospects of Metaverse in the future learning processes?

The study got access to related literature from the online databases of Google Scholar, ERIC, Scopus, IEEE, and MDPI. These databases were selected as they are widely accessible, comprehensive, and user-friendly that index scholarly literature across various disciplines, offering a vast collection of articles, papers, theses, and more pertaining to education and technology-related research and practice. The search strings and keywords used in the databases were: Metaverse, Educational technology, Digital learning, Immersive technology, Virtual reality, E-learning, and Future education. The data included academic articles published between 2020 and 2023. This publication range was selected due to several factors, including pandemic-driven shift to remote learning. The pandemic emphasized existing disparities in access to technology and the Internet among students, bringing attention to the digital divide and prompting efforts to bridge this gap. Moreover, during this period, technological advancements offered enhanced capabilities for delivering immersive and interactive learning experiences. In other words, these years witnessed a paradigm shift in education, emphasizing the pivotal role of technology in ensuring access, fostering innovation, and equipping students with the skills necessary for success in a rapidly evolving digital world. The study used PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for including and excluding relevant literature, adapted the selection process of [8], screened related articles (n=113) based on the inclusion criteria, and finalized articles accordingly (n=98), as shown in Figure 2 below.

It used PRISMA because these guidelines are effective in assessing the study quality, synthesizing research findings through meta-analysis, and underlining transparency of the review process. Additionally, the study used MMAT (Mixed Methods Appraisal Tool) to evaluate the relevance of the finalized articles. MMAT is effective in evaluating the relevance and appropriateness of research findings. The screening process included mainly journal articles in English language that match the scope of the current study – emphasize learning perspectives.

The study also conducted case studies of various academic institutions to discuss and analyze the applications and impact of Metaverse and other immersive technologies in educational practices. These case studies provide concrete, real-world examples of how academic institutions are integrating immersive technologies into their educational practices. Analyzing case studies also allows educators and institutions to learn from successful implementations. In essence, case studies serve as valuable resources for educators, institutions, and stakeholders, offering practical insights, guiding decision-making, and fostering a deeper understanding of how immersive technologies can transform educational practices. The case studies for this research mainly focused on three primary applications of Metaverse in the current learning mechanisms, as shown in Figure 3 below.

The cases of virtual campuses, immersive courses, and gamified learning were selected for the current research based on a) types of immersive technologies used, b) success stories, c) challenges faced, and d) specific pedagogical approaches. These case studies serve as tangible examples of immersive experiences within educational settings.

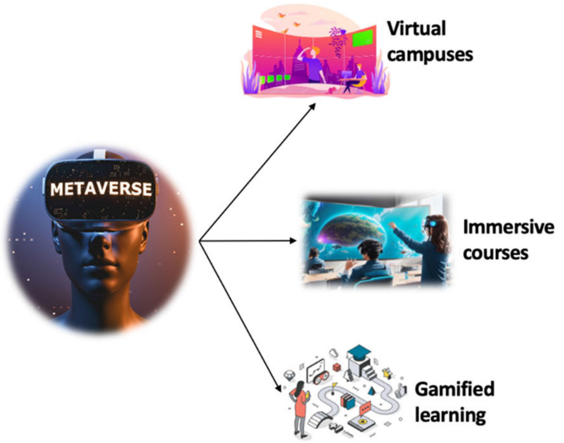

FIGURE 3. Metaverse applications.

Virtual campuses showcase how immersive environments can replicate real-world campus experiences, fostering engagement and collaboration among students and educators [9], [10]. Immersive courses and gamified learning environments demonstrate how immersive technologies can transform traditional learning materials into interactive and engaging content, catering to diverse learning styles and enhancing learning outcomes [11], [12]. These often lead to higher levels of engagement, as they offer interactive elements, simulations, and personalized learning experiences that captivate students' attention. Moreover, virtual campuses and immersive courses often involve complex technical setups and logistical considerations. Therefore, case studies on these applications are relevant to shed light on the technical infrastructure required, implementation challenges faced, and solutions employed to ensure seamless operation. In other words, case studies on virtual campuses, immersive courses, and gamified learning serve as valuable sources of insights into the practical applications, impact, challenges, and potential benefits of integrating immersive technologies into learning environments. They offer a comprehensive view of how these technologies shape educational experiences and inform decisions regarding their integration for enhanced learning outcomes. The study also conducted an analysis on the benefits, challenges, and prospects of using metaverse and other immersive technologies in various learning environments. Figure 4 below showcases the research alignment of these three aspects in this study.

Discussions and analyses of the findings from the systematic research and case studies are included in the following section.

III. RESULTS AND DICSUSSION

A. SYSTEMATIC LITERATURE REVIEW

The implementation of immersive technologies, including the concept of Metaverse, in education is a recent and transformative development that holds significant promise for reshaping the ways of teaching and learning processes. The impact of COVID19 resulted in increased use of digital applications in education across the world. The pandemic has moved physical classrooms to online classes on Zoom or other video conferencing software platforms. However, these are usually 2D learning environments which lack immersion and learner engagement. Metaverse-based classrooms, on the other hand, enable 3D immersive environments with more engaging teaching and learning activities [7]. In terms of implementing immersive technologies in learning systems, Metaverse is the latest addition to the academic sector.

1) METAVERSE AND OTHER IMMERSIVE TECHNOLOGIES

Internet has always been the key technology directing individuals to substitute their reality with their agents. Metaverse is the most current form of Internet developed over the last three decades after the existence of the Blockchain. It is generally defined as a futuristic space – the 'third space' or post-reality universe [13] – that connects Virtual Reality (VR)/Augmented Reality (AR) and Blockchain, changing human experience through technology to transcend physical reality [14]. It is a 3D-based virtual reality in which real individuals conduct their daily activities through their virtual avatars – basically an immersive experience that supports developing social communication [15]. Originally coined by novelist Neal Stephenson in his 1992 science-fiction novel Snow Crash, Metaverse is conceived as a virtual world with unique environments and serves a particular purpose. It provides an immense multidimensional virtual environment in which users can interact with one another through digital avatars regardless of location and time.

The concept of Metaverse consists of a few key components involving creation of virtual reality and coexistence of physical-virtual: users and their digital avatars, technology capabilities, behaviors, and outcomes [16]. It creates digital pairs of the physical world and requires technological competencies to operate in the virtual environment and connect it with the physical world. It contains immersive technologies with real-virtual environments and human-machine interactions commonly known as Extended Reality (XR), which further includes all forms of reality such as VR, AR, and Mixed Reality (MR) and technologies such as Digital Twin [17], [18], [19], Artificial Intelligence (AI), 5G, and the Internet of Things (IoT). Applications of Digital Twin involve human interaction in a virtual space functioning as mirror images and not as alter egos [20], [21]. Metaverse allows users to significantly interlap between virtual and real life in various spheres. It enables users to continue indefinitely and favors those who take control, make decisions, and predict possible events [22]. With more sectors – including healthcare, automotive, entertainment, and business [23] – talking about different facets of Metaverse lately, academicians are its latest addition. In other words, Metaverse and other immersive technologies provide an immersive learning environment in which users can interact with one another through a virtual learning platform within the virtual world with their real attributes and behaviors.

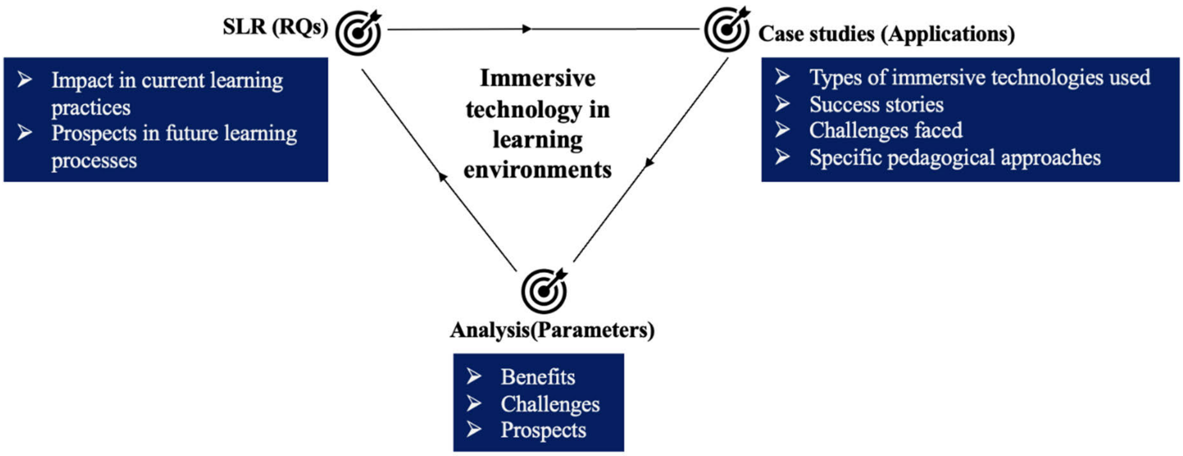

FIGURE 4. Research aspects alignment.

2) IMMERSIVE APPLICATIONS IN LEARNING ENVIRONMENTS

With technology covering every sphere of the society, it is important for everyone to become lifelong adaptive learners [24]. Moreover, unsettling factors like globalization, inequality, political turmoil, environmental degradation, and public health concerns are serious global challenges that require a skilled younger generation. Therefore, there is an urgent need for education to prepare learners for thriving in the rapid changes in every segment including society, technology, and economy. As traditional practices of learning contain classrooms, grading systems, and curriculum structures, it is difficult for technologies to make learning completely digital [24]. However, immersive learning practices can provide non-mediated artificial experiences with educational benefits [25]. For instance, Metaverse with its immersive virtual space can turn virtual classrooms more realistic by using 3D simulations with enhanced gamification and learning activities [26]. A realistic campus Metaverse or virtual museum can provide learners with a more interactive experiential learning environment irrespective of time, space, and location. Studies have analyzed the relevance and use of immersive learning through VR-based field trip activities [27], active learning approach for improving learner competence [28], immersive visualizations for sorting algorithm complexity [29], and immersive VR for second language learning [30]. Metaverse and other immersive technologies can help shape learning systems and create more learning opportunities regardless of subjects and pedagogical methods. Metaverse is an umbrella term that addresses every digital aspect of the future, thereby making it relevant in education as well for its interactive features and portability [20], [21]. However, most of the developments of Metaverse is limited to gaming and entertainment while it is a recent concept in academics and has limited sources and usage in this field [31]. Parents and even educators are skeptical about using Metaverse applications in education [5]. But literature addressing the use of Metaverse for educational purposes is emerging [32], [33]. This can further encourage educationists to explore Metaverse and other advanced immersive technologies, which can contribute immensely to adding new dimensions to education technologies. Therefore, it is important that educationists direct their research and activities to explore new possibilities in immersive technologies with an aim to developing more interactive learning environments and enriching a holistic academic experience. It also entails the importance of determining appropriate strategies for utilizing Metaverse in the field of education along with its impact in the learning process. Exploring the use of Metaverse in learning environments, researchers used 3D classes and various avatars to find possible solutions for learners [34] and Metaverse tools to increase immersion and get self-directed learning experiences [35] while improving learning efficiency [36]. It further demands systematic inquiries into the influential role Metaverse can potentially play in developing students' learning perspectives while persuading their academic satisfaction and personal innovativeness [37].

Metaverse system is the latest addition to the AI technologies and collaborative learning systems used for enhancing educational technologies and learning innovations. With so many emerging educational technologies and an increased focus on the use of virtual reality, there is a significant requirement of tools like Metaverse and Digital Twin to trace the development of students' learning skills and performance. Integration of Metaverse and problem-based learning approach has been successfully executed in different academic fields including engineering, technology, mathematics, natural sciences, cultural studies, social sciences, and materials science [38], [39], where students are required to apply their knowledge to solve problems in the virtual situation. Metaverse can help them prepare to identify, evaluate, and communicate the problems with their peers and/or teachers through chat-based discussions, which can further direct them to a clear understanding and increased interest in finding possible solutions.

In terms of digital learning in higher education, Metaverse technology can initiate an efficient learning environment integrating Blockchain-driven simulation, enhancing reality,

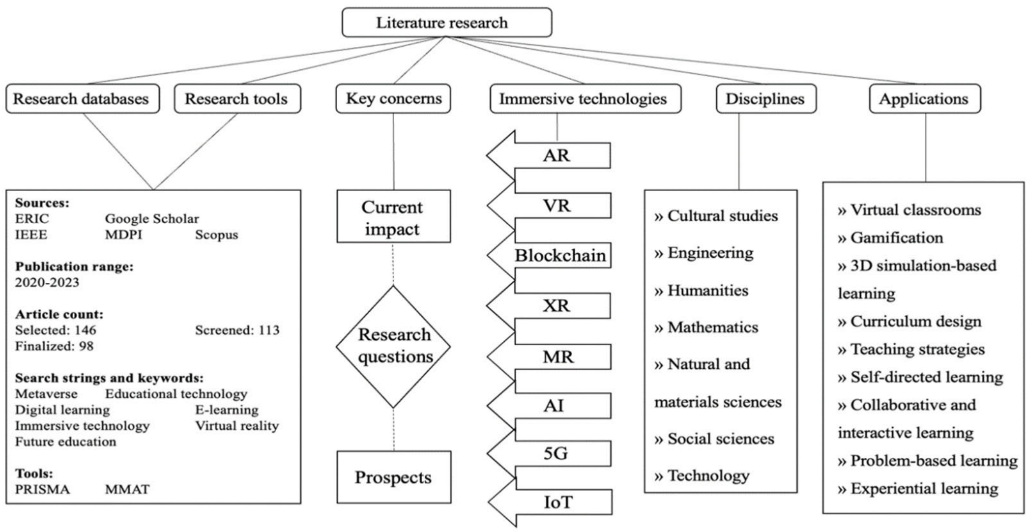

FIGURE 5. Taxonomy of SLR output.

and thus nurturing high-level talent required across industries [40]. As it features adaptive pedagogical strategies, digital learning strategies can help learners improve their language and communication skills, critical and creative thinking abilities, and problem solving through different modes of accessibility of information sources. Metaverse technology can make learners' online experience even more interactive, engaging, and interesting without affecting their performance while enriching their experiential learning. Studies [41] and [42] have identified the following types of Metaverse implemented in learning systems: AR, Lifelogging, Virtual Worlds (VW), and Mirror Worlds (MW). Language and translation studies have mostly used VW; QR code scanning and escape game activities used AR; Lifelogging was used for critical and creative exploration on educational social media; and MW was used for tackling spatial and physical restrictions in game-based immersive learning. While developing Metaverse applications for digital learning environments, it is important to develop its framework considering concepts like users and their avatars, applications, and interaction modes like VW, MW, Blockchain, Non-fungible token (NFT), and so on [43]. This further requires a wide array of specific technological knowledge for developers, educators, and learners to use Metaverse to its optimal value. Although Metaverse applications have been used in various fields of study, it is not yet completely explored for more fruitful academic outcomes and is still in the developing stage.

In a nutshell, findings of the SLR research by the current study revealed that Metaverse and other immersive technologies and applications have already been introduced and incorporated in various dimensions of educational practices at different levels. With the normalization of emerging technology integration in academics post COVID19, immersive learning tools and applications are instrumental in curricula and other dimensions of learning mechanisms. A taxonomy of the major outputs of SLR is shown in Figure 5 below, summarizing the findings of this part of the research.

TABLE 1. Synthesized findings for RQ1.

Impact	
Tools	Trends
Online classes	Increased use of digital applications in physical/virtual classrooms
	3D learning environments for immersive learner engagement and experience
Immersive learning practices	3D simulations with gamification and learning activities across disciplines
Problem-based learning approach	Use of Metaverse and other immersive tools to monitor learner skills and performance development
Metaverse applications	Use in critical and creative exploration on educational social media, game-based immersive learning for tackling spatial and physical restrictions
Teaching processes	Use of immersive applications for developing learning and assessment strategies

Synthesized findings for RQ1 and RQ2 are listed in Table 1 and Table 2 below. The tables summarize tools and trends observed in the light of the impact of Metaverse in the current and its prospects in the future learning environments.

Apart from these aspects, there are also several sustainability issues and concerns associated with the widespread adoption of immersive technologies including VR, AR, and MR. Environmental impact is a key concern, for example, to consider while implementing these technologies. Immersive technologies often require powerful hardware, such as high-end GPUs and CPUs, which consume significant amounts of electricity and even consume additional energy to maintain the hardware's optimal operating temperature [44], [45]. This can contribute to increased energy consumption and carbon emissions if not managed efficiently. This is further associated with another issue – the electronic waste. As immersive technology hardware evolves rapidly, older devices can quickly become obsolete, leading to electronic waste disposal issues. Many electronic devices contain

TABLE 2. Synthesized findings for RQ2.

Prospects	
Tools	Trends
Immersive technologies (VR, AR, XR, MR, etc.)	Increased use of real-virtual environments and human-machine interactions
	Requirement of developing immersive learning framework and curriculum design
	Requirement of developing immersive courseware to further create an army of specialists
Integrated learning environments	Requisite for fulfilling skilled workforce requirement across industries
	Interdisciplinary collaboration between technology and learning to optimize immersive applications and methodologies
Immersive technology-based research	Use of immersive applications for studying learner behaviorism and strategy development in virtual communication
	Design and development of immersive environments for collaborative and problem-based learning across disciplines

hazardous materials, including heavy metals and toxic chemicals, which can contaminate soil and water if not properly managed during disposal or recycling, thereby influencing adverse environmental impacts [46]. Proper recycling and disposal mechanisms need to be in place to mitigate this problem.

Sustainability concerns of immersive technologies are also related to resource use. The production of immersive technology devices and manufacturing of VR headsets, AR glasses, and such equipment rely on the extraction of rare minerals and metals, which can have adverse environmental and social impacts in regions where mining occurs [47], [48]. High-quality immersive technology hardware can be expensive, which can create disparities in access among students and institutions leading to unequal educational opportunities. Moreover, network accessibility issues in underserved areas may contribute to digital divide. Rapid technological advancements in immersive technology hardware and software can lead to frequent upgrades and replacements, making it challenging for educational institutions to keep up with the latest developments [49], [50]. Further, the immersive nature of technologies like Metaverse blurs the lines between virtual and real worlds, potentially leading to increased screen time, isolation, and detachment from real-world interactions [51]. Addressing the balance between immersive learning experiences and the need for real-world interactions is crucial for holistic education and mental well-being.

Analysis of these sustainability challenges is instrumental in seeking solutions, demanding a diverse strategy that includes innovating in technology, designing responsibly, using energy-efficient hardware, implementing programs to recycle electronic devices, ensuring fair access, and continuously evaluating how immersive technologies affect the environment in learning settings. In short, finding harmony between the advantages of immersive learning and eco-friendly practices is essential for using these technologies effectively while safeguarding our environment and society in the long run.

B. CASE STUDIES

The current study focuses on relevance of implementing immersive technologies, through the impact and prospects of Metaverse, in learning environments in the post-COVID19 era. This entails a thorough examination of the functionality and operability of immersive technologies implemented in academics. The current study focused on three Metaverse applications – virtual campuses, immersive courses, and gamified learning – currently being implemented and practiced in various educational institutions.

1) VIRTUAL CAMPUSES

Metaverse-based virtual campuses represent a cutting-edge development in the education sector. They leverage the concept of Metaverse to create digital, immersive, and highly interactive learning environments. The concept of virtual campus refers to a digital or online environment that replicates the physical campus of an educational institution in a virtual or simulated form. It is designed to facilitate teaching, learning, collaboration, and other campus-related activities in a digital space. Virtual campuses are often used in higher education but can also be found in K-12 education and corporate training. Virtual campuses are particularly valuable for distance education and online learning, allowing students to access educational resources and engage with instructors and peers without the need to be physically present on a campus. They have become even more relevant with the advent of immersive technologies, such as VR and AR, which can create highly interactive and immersive learning experiences within these digital environments. One of the leading names in the use and applications of immersive technologies is Meta by Mark Zuckerberg. Meta, which began as Facebook in 2004 and renamed in 2021, has since expanded its scope and ambitions significantly. With the aim to move beyond 2D screens toward immersive experiences, Meta has announced plans to invest in immersive learning through its Oculus brand. Meta's $150 million immersive learning project aims to launch 'metaversities' – Metaverse-based university campuses including their grounds and building exteriors and interiors – with VR and AR technologies to enhance educational experiences. Selected universities will have online students meeting and taking classes in Metaverse. These universities will also be delivered 3D headsets for students to use in the courses. Although such immersive experiences empower student learning and pedagogy, the inexorability of user privacy issues related to corporate surveillance and user protection mechanisms against it will be a critical point of reference [52]. It also leads to the ongoing debate of surveillance capitalism that rapidly encroaches on users' personal and mental space collecting more data on individual behavior and social interaction than previous databases for developing machine learning and other predictive algorithms [53].

With more tech giants and organizations jumping into the innovation riot of immersive education mechanisms development and applications, metaversities are fast becoming the new normal of the current and future education systems. Metaversities or virtual campuses represent the concept of immersive, digital, and interconnected learning spaces that leverage VR, AR, and other emerging technologies to provide a unique educational experience. These are digital learning spaces that exist within Metaverse. These campuses aim to provide immersive learning experiences where students can attend classes, interact with instructors and peers, and engage with educational content in a highly immersive and interactive manner. Many universities and institutions of higher education have started exploring metaversities as a way to expand access to education and provide innovative learning experiences. These mechanisms are not only making educational resources affordable but also influencing learner performance by improving experiential and interactive learning environments, increasing accessibility for remote learners, and attracting more digital natives [54]. 3D virtual campuses with multiuser virtual environment can significantly affect synchronous distance teaching while providing a flexible and accessible mode of education to both educators and learners [55]. With emerging technologies like 5G and Artificial Intelligence of Things (AIoT) in practice, universities and institutions of higher education can leverage advanced technologies create a more emotionally aware and user-friendly campus virtual assistant, ultimately enhancing the smart campus experience [56]. In the light of this discussion, it can be rationally argued that virtual campuses represent a bold vision for the future of education, where the boundaries between physical and digital learning spaces blur. This further directs future research to an urgent requirement of more in-depth insights on the possibilities and prospects of futuristic education and its trends. While the concept of a virtual campus is an exciting prospect, it will require ongoing development, investment, and thoughtful consideration of the educational, social, and ethical aspects of immersive learning in the metaverse.

2) IMMERSIVE COURSES

The practice of allowing learners to interact with real-world scenarios digitally or virtually in an engaging and interactive learning environment is a recent phenomenon in education. Such learning techniques not only stimulate real-world interactions but also facilitate learner emotions and behaviorism. Immersive courses are integrated educational programs or learning experiences that aim at engaging and immerse learners in the subject matter or topic being taught. These courses are characterized by their depth, intensity, and often experiential nature. Many universities offer immersive courses, which enable learners to improve in experiential learning, hands-on experiences, and flexible learning environments. Northwestern University in the US, for example, offers Integrated Marketing Communications (IMC) – a master's program – that includes 5-day immersive courses on subjects including design thinking, digital leadership, and global perspectives. While assisting learners with career-building skills in marketing, these courses are tailored to provide learners with a global outlook of marketing through the lens of new cultures of different consumers and marketplaces [57]. Texas Immersive Institute (affiliated with The University of Texas at Austin) offers immersive courses on experimental storytelling, hacking, and business strategies facilitating collaborative and cooperative learning and transdisciplinary perspectives [58]. The primary aim of such immersive courses is to practice and promote intensive learning while focusing on specific subject or skill over a relatively short period of time ranging from a few days to several weeks or even months. Through experiential learning, students actively participate in hands-on activities, simulations, or real-world experiences related to the subject matter. This can include field trips, internships, lab work, or projects.

While developing immersive classrooms and VR-based learning settings for students, it is significant to focus on the teacher's role and functions in immersive pedagogical practices. Universities are investing on immersive classroom setups for teachers to improve their classroom management competencies and technological knowledge and behaviorism to handle conflict situations in immersive settings [59]. Initiatives are also focused on teacher trainings and teacher preparation programs to identify challenges in immersive teaching, develop pedagogical content in immersive environments, and improve their cultural competence to operate multilingual and multicultural classrooms in virtual settings and exchange teaching innovations with their peers [60], [61], [62]. In other words, initiatives and actions on teaching reform are on the rise to improve teaching methods and techniques, teachers' comprehensive quality of the immersive content, and teachers' ability to achieve learner engagement and interaction [63]. Such pedagogical initiatives also contribute to a growing body of research in the area of immersive learning and other interdisciplinary spectrums.

a: GAMIFIED LEARNING IN IMMERSIVE ENVIRONMENTS

Gamified learning practices in immersive settings involve integrating game design elements into educational experiences within VR, AR, or the metaverse. This innovative approach aims to enhance learning engagement, motivation, and effectiveness. Across various academic systems, this technique is gaining traction. Research has shown that gamified teaching methods can enhance students' conceptual and procedural understanding of science [64], boost motivation and perception of science [65], and seamlessly blend informal learning activities with formal curricula to achieve specific learning outcomes [66].

b: CASE STUDY: 3D MODELLING OF A VIRTUAL PIG FARM IN THAILAND

The current study delves deeper into the potential of gamified and immersive learning by examining a case study involving a public university in Thailand. The university developed a 3D model of a virtual pig farm using software tools Blender and Unity. The process began with a comprehensive survey, capturing real-time pig farm images and designing a layout for the virtual farm (shown in Figure 6).

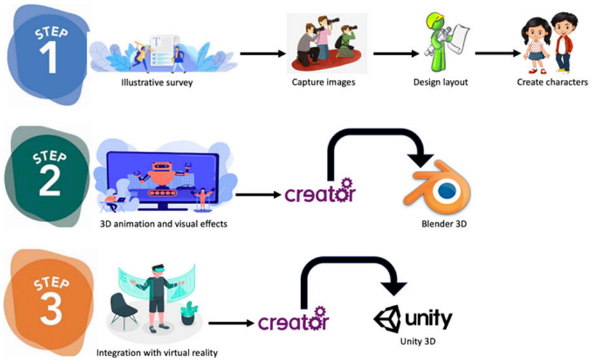

FIGURE 6. Workflow of 3D modelling.

Subsequently, 3D animation and visual effects were added using Blender, transforming the static model into an interactive one. The final step involved integrating the 3D model with virtual reality and gamification features [4], creating an engaging and interactive virtual pig farm environment (shown in Figure 7).

FIGURE 7. 3D model of the virtual pig farm.

c: INTERACTIVE FEATURES AND AVATAR CREATION

Within this virtual pig farm, users can create avatars for attendants and vets, customizing various features such as gender, physical attributes, and emotions (shown in Figure 8).

These avatars serve as tools for teaching behavioral skills, allowing users to monitor, manage, and attend to the pigs. Users can freely navigate the farm, explore different rooms, and interact with the virtual environment (shown in Figure 9). While the simulation is currently at an elementary level and has limitations, it represents a significant step toward creating immersive, real-world learning experiences.

d: FUTURE IMPLICATIONS AND LIMITATIONS

While this 3D farm serves as a promising prototype, its full potential is yet to be realized. Its implementation in formal learning environments remains a topic of future exploration. Despite its limitations, this study sheds light on the benefits, challenges, and prospects of immersive technologies in education, especially in the post-COVID19 era. The immersive features of these tools not only engage learners but also optimize the acquisition of diverse skills. Further development, incorporating more interactive and immersive elements tailored to specific learners' needs, holds promise for the future of education.

FIGURE 8. Avatar creation features.

FIGURE 9. Inside layouts.

C. ANALYSIS

Integration of digital technologies into academic curricula across disciplines of science and technology is a common phenomenon. But it is relatively recent in the case of humanities and social sciences, particularly in terms of incorporating immersive technologies in pedagogical practices. As education is going fairly digital across learning systems, it is relevant that immersive tools and applications are optimized for learning systems with full potential. This further requires a thorough analysis of the benefits, challenges, and prospects immersive technologies can offer to academia at all levels, including students, teachers, and researchers.

1) BENEFITS

The application of immersive technologies like Metaverse and Digital Twin is effective mainly due to its interactive features and personalized user experience. Users can reinvent themselves with their customizable avatars with desired attributes available [67]. The discussion of case studies (Section III-B) is an evident example of it. Compared to traditional methods of learning, immersive technology-driven education can overcome several limitations such as of space, interactivity, and accessibility [68]. It not only speeds up learning progress but also keeps accurate track of it. Studies [69] and [70] investigated the use of XR in learning processes and reported that it can improve students' learning experience with increased comprehension, retention, and engagement while enabling educators to explore learning methods through immersive technologies. Studies [71] and [72] have identified specific skills required for the future workforce including critical thinking, complex problem solving, creativity, service orientation, decision making, negotiation, cross-collaboration and teamwork, social learning, emotional intelligence, and cognitive flexibility. Using virtual world in pedagogical environments can provide learners with clear understanding of these aspects and appropriate solutions while minimizing learning difficulty and cost. Post COVID19 pandemic, learning systems along with others have embraced certain modes of new normal including remote working and/or non-face-to-face teaching environment. This further supports the relevance of VR-based learning environments. Immersive learning environments can create improved learning outcomes with better real-virtual experience and flexibility of access to both real-world and virtual information. XR can enable both students and educators to interact and collaborate better. While students can anticipate more active learning engagement, teachers can develop more interactive pedagogical strategies through emerging technologies. Metaverse and other immersive applications can thus increase learner creativity and enhance motivation while enabling customization to suit a wide range of learning environments and eventually improving learners' digital learning performance [73]. Games are the most common XR application that can facilitate learning in real-time, virtual, and more authentic contexts than classrooms. Using Metaverse for game-based learning, studies [74] and [75] have reported that it allows learners to gain higher levels of control in various learning scenarios, improve critical thinking to resolve problems efficiently, and eventually enhance learning motivation and communication skills. With the prospects of developing vivid scenarios, Metaverse and other immersive technologies provide an enormous space for social communication with the freedom of sharing, creating, collaborating, and thriving.

2) CHALLENGES

Immersive technology, Metaverse in this context, is still a growing application in academics compared to its usability and engagement in other sectors, and even less in the fields of humanities and social sciences. Post COVID19, there is a direct shift from traditional pedagogical practices to the use of digital applications in learning systems across disciplines, which still requires huge efforts from educators and learners to understand and implement these technologies in learning environments. There are various concerns to consider while attempting to understand why educators are not yet fully convinced of it. Metaverse is the latest addition in education. People who are not updated on the current technological development do not tend to understand the use and application of Metaverse in learning environments [76]. Not all students have access to the required hardware or stable Internet connections for an immersive Metaverse experience. Moreover, integrating immersive technologies into the curriculum effectively requires training educators and aligning the technology with specific learning objectives. This further affects the usability of Metaverse in various learning environments, particularly for people from education who also seem to be less confident of using the same. The use of AR and VR for educational purposes can be hampered by factors like inaccessibility to these technologies through smartphones, lack of content to use these technologies in academics, and the digital divide (across teacher-student and peer groups) within learning systems [77], [78]. Moreover, these technologies are associated with physical health issues (dizziness, nausea, etc.), loss of attention, and mental health issues [79], [80]. Being a new technology, Metaverse, Digital Twin, or any immersive technology is still not completely linked with academics and academicians. It also entails their lack of technological knowledge in Metaverse, which further leads to lack of teacher competencies and pedagogical structure in some applications [81]. Developing quality immersive content for educational purposes demands expertise and resources, posing a challenge for many institutions. Ensuring the safety and privacy of students within the Metaverse raises concerns regarding data security, online behavior, and monitoring. Since a digital learning environment enables students to learn with creativity, it is important for both teachers and students to learn and update themselves about the infrastructure, operability, and interactive applications of Metaverse without which Metaverse implementation in learning systems cannot succeed [43]. Moreover, students can feel inflexibility and cognitively overloaded with some applications if instructions are not clear, and even experience technical issues. High cost of VR tools to conduct a high level of immersion is another factor that hampers its implementation in educational practice [82]. Information overload, unauthorized augmentation and fact manipulation, data privacy, fake avatars, and identity theft are some of the concerns users face while using Metaverse and Digital Twin [83]. As most of the XR applications across learning systems are influenced by game developers, pedagogical structure is not necessarily evident in these applications [6]. This makes it more relevant that immersive applications are integrated into learning practices so that teachers and students benefit from its new and emerging technological breakthroughs. Since technology is constantly evolving, available knowledge is not sufficient to learn and therefore, new research is an apparent requirement.

With reality merging into virtuality and blurring the boundaries quickly, it is important to keep a constant watch on cyber-attacks. For instance, ransomware is a malware designed for encrypting files on a computer, which is a common threat in Metaverse [84]. It targets and attacks users in charge of virtual goods of great economic value. Therefore, Metaverse application users are required to be aware of cyber-legal aspects that can apply cyber-intelligence methods and thus ensure cybersecurity. Another serious concern is the availability of diverse tools and applications in the Metaverse environment. As new applications are developed to cater to various teacher and student requirements, most of these are incompatible tools thereby challenging content and data transfer [85]. It is often feared that technologies like Metaverse may enable us to develop new habits that can adversely affect the culture and relationships in the real world. For instance, the everyday world we live in is connected as well as controlled by the virtual opinions and decisions made by others and not by our common sense. This poses a serious threat to personal and social aspects concerning individuality. It is important to note that Metaverse is designed to enhance the human experience and not to replace it. Thus, the existence of virtual worlds should be realized in a more realistic fashion keeping in mind that it must not compete with physical reality. Therefore, significant measures should be taken by academic organizations and authorities to overcome these challenges. Authorities can take initiatives in establishing programs that provide access to necessary hardware and Internet connectivity for students who lack resources. They can partner with organizations or leverage funding to provide subsidies or loaner devices. It is important to partner with technology companies or consortiums to share resources and infrastructure costs [86]. Moreover, cloud-based solutions can be utilized or collaboration with existing platforms can be initiated to minimize the need for building extensive proprietary infrastructure [87], [88], [89]. Policymakers and authorities should develop and enforce strict guidelines for student safety and privacy within the Metaverse. Implementing robust data security measures, moderation protocols, and educational campaigns about responsible online behavior would address safety concerns appropriately. In other words, addressing these challenges requires a multi-faceted approach that combines technological solutions, pedagogical support, collaboration, and a commitment to equity and student well-being within the immersive learning environment.

3) PROSPECTS

With Metaverse prioritizing user experience and digital, there is more increased blurring of the lines between digital and physical learning in academics. With AR, it can further bridge the gap and introduce new and improved ways of learning while enhancing the overall academic experience for all associated with it [90]. Whereas VR can blend real and virtual worlds more accurately and create a truly immersive pedagogical environment with wider perspective and 3D graphics as realistic as possible. In the case of MR, it can replicate the properties of physical reality and then create a world completely immersed in the virtual world. Industries and businesses use Metaverse in a continuous real-virtual connection, which further requires an educated workplace to deal with new and upcoming challenges in such immersive environments. Moreover, developing all kinds of content for this environment will require a large number of specialists who can 'learn to unlearn' in time and identify and choose the most efficient learning methods [91]. Therefore, higher education institutions can play a serious role in developing and providing immersive platforms for learners, educators, and staff for flexible and seamless communication along with educational leadership training for suitable decision making. While universities can offer immersive courses for students to improve their cognitive skills, knowledge competency in different subjects, and experiential learning, there is a need for an integrated approach to introducing immersive learning at the university through specialized technical setup, curricula design, and robust research aiming for quality education [92]. As the increased popularity of Metaverse is caused by its enormous future business opportunities, the education sector holds the greatest potentials of its applications [93]. Interdisciplinary collaboration, particularly between technology and learning, can result in not only enhancing knowledge about new technologies but also enabling effective MR-based experiences to optimize immersive applications and methodologies [94], [95].

There are promising research opportunities of immersive technologies in academics with specific scope addressing different aspects of digital learning implemented in the learning systems across the world post COVID19. First, virtual worlds created and developed in the Metaverse environments create digital identity or versions of it through avatars in different learning scenarios. Users treat their digital avatars as alter egos or their entities in digital existence, which can demonstrate not only their facial appearance but also their facial expressions and gestures [96]. This opens possibilities of investigating digital identity formation patterns, avatar selection criteria, and more relevantly, behavior studies and strategies of learners in such virtual communication contexts along with details about the immersive learning experience as a whole. There has been limited or no studies on the use of Metaverse in teaching students with disabilities and special needs [97]. This could be a relevant scope for future research contributing to the accessibility and inclusivity of these immersive applications in pedagogical environments with different scenarios. One of the most potential educational possibilities offered by Metaverse is the acquisition of cultural knowledge [98], which makes significant room for future research on the formation patterns of cultural norms and values, the alternative reality of people who are part of both virtual and physical worlds. This also calls for research possibilities on behavioral realism and ethical norms of the digital avatars who are real people. In the light of this discussion researchers can find these potential research questions relevant for future investigations:

- How do users select their digital avatars in Metaverse environments, and what factors influence their choices?
- What are the behavioral patterns and communication strategies exhibited by learners in virtual communication contexts through their avatars?

- What are the specific challenges and opportunities for using the Metaverse in teaching students with disabilities and special needs?
- What strategies or tools can enhance the learning experiences of students with disabilities in immersive learning environments?
- To what extent does immersion in virtual cultures influence the behavior and social interactions of individuals in both virtual and physical worlds?
- How can immersive environments be optimized for collaborative and problem-based learning across various academic disciplines?
- What design elements or features contribute most effectively to enhancing collaboration and problem-solving within immersive learning environments?
- Do immersive learning environments foster deeper interdisciplinary understanding and collaboration among learners compared to traditional methods?

Research can also be conducted in the design and development of immersive environments for collaborative and problem-based learning across disciplines. This will apparently help researchers explore new approaches in teaching processes, including learning and assessment strategies, while optimizing emerging communication technologies to identify potentials of Metaverse and other immersive technologies in learning environments.

In terms of educators and technology developers, pedagogical training is crucial to understand the pedagogical implications and effective integration of immersive technologies into teaching practices. Integrating immersive technology with curriculum objectives is also significant to ensure that its integration enhances learning outcomes and supports specific educational goals. As immersive learning is more engaging in nature, educators can be instrumental in allowing students to create content, collaborate in virtual environments, and explore immersive learning experiences tailored to their interests. They should also develop strategies for assessing learning outcomes within immersive environments and provide timely feedback to students to enhance their learning experiences. Teachers should ensure that immersive learning experiences cater to diverse learners, including those with disabilities, by implementing accessibility features and considering different learning styles while encouraging collaborative projects across disciplines to foster interdisciplinary understanding and problem-solving skills. As for technology developers, designing intuitive interfaces and immersive environments that are easy to navigate and conducive to learning is important. They should implement accessibility features to ensure inclusivity for all users and provide user-friendly tools for educators to create and customize immersive content easily while prioritizing data security measures to project user privacy. By implementing these recommendations, educators can optimize the use of immersive technologies to create engaging, inclusive, and effective learning experiences, while technology developers can ensure the development of user-friendly, secure, and innovative immersive tools that meet the needs of educators and learners. In the context of administrators and educational leaders, there should be provisions of resource allocation, research and collaborative initiatives, and policy and guidelines to support the integration of immersive technologies. Government and policymakers should create policies that facilitate the integration of immersive technologies in educational settings, addressing issues related to funding, infrastructure, and standards. They should initiate to promote equitable access to immersive technologies and ensure that underserved communities have access to these educational resources. By engaging all stakeholders and fostering collaboration, communication, and support, the effective integration of immersive technologies in learning environments can be maximized, ensuring a positive impact on education and learning outcomes.

IV. CONCLUSION

With Metaverse transforming real space to virtual space and enabling learning across location, time, and space, it is undoubtedly the future of academic practices. The current study explored the impact and prospects of implementing immersive technologies like Metaverse in learning environments by reviewing SLR of related literature, case studies on virtual campuses, immersive courses, and gamified learning, and analyzing available literature with highlights on the benefits, challenges, and prospects for future learning. However, the study is limited in terms of its selection of related literature for the systematic research as it focused only on the available literature post COVID19. Its selection criteria included journal articles published between 2020 and 2023. To further specify the selected literature, the study addressed two research questions concerning the impact and prospects of current and future learning processes. In terms of the case studies and analysis, its selection was limited by focusing on three main applications – virtual campuses, immersive courses, and gamified learning – and three concerns – benefits, challenges, and prospects. Future research can address these limitations to offer a more comprehensive and nuanced understanding of the impact, challenges, and potential of immersive technologies in educational settings, encompassing a broader range of literature and diverse case studies. Immersive technology-driven learning practices will not only modify the conventional teacher-student connection but also break the boundary between teachers and students. Post COVID19, virtual space in academics became more relevant and a reality to be embraced for enhancing learning experience. The pandemic has remarkably marked a turning point in the implementation of emerging and immersive technologies in academics, highlighting the relevance of learning these technologies to optimize academic experience in the best possible ways. Academic institutions across the world are now integrating VR and AR with traditional classrooms to supplement textbooks and lectures for more engaging and immersive experiences. Findings of the current study highlighted that these applications demonstrate the versatility and potential impact of immersive technologies in diverse learning environments. Their use continues to evolve as technology advances, offering new opportunities for enhancing education and training across various fields and settings. The increased use of Metaverse and other immersive applications in learning environments can introduce new knowledges to enhance teaching-learning processes and educational experiences for both learners and educators. Immersive training approach by learning mechanisms not only enhances practical knowledge and minimalizes risks but also develops workforce skills and prepares professionals in fields like healthcare and aviation. Immersive technologies further have the potential to reduce the environmental footprint in several ways while influencing users' social interactions and behaviors. Industries like entertainment, gaming, healthcare, and manufacturing leverage these technologies for innovation, product development, creating new economic opportunities and enhancing customer experiences. The integration of immersive technologies also raises ethical dilemmas and cultural considerations with issues surrounding data privacy, digital rights, and virtual identities, which can be addressed in future research. Understanding the wider impacts of immersive technologies necessitates a holistic approach. It involves considering environmental sustainability, societal implications, ethical considerations, accessibility, and the overall influence on various aspects of human life. In the coming future, the hazy lines between real and virtual will fade and disappear to make room for more innovations in teaching and learning environments. More awareness and optimization of Metaverse, Digital Twin, and other immersive technologies in academics are required. While the challenges of adopting/adapting immersive technologies need to be seriously taken into consideration, concerns should be focused on its benefits and prospects of its applicability. This further calls for active encouragement of more interdisciplinary collaboration between fields of technology and research in learning systems to ensure effective implementation of immersive technologies in digital learning environments. With emerging technologies in education and other sectors, the usability and impact of Metaverse, Digital Twin, and such immersive technologies requires further investigation and systematic inquiries.

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