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Metaverse system adoption in education: a systematic literature review

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Abstract

The evaluation of information systems (IS) models, which are employed to research the adoption or acceptance of metaverse systems, is thought to be a subject of major significance. Studying the adoption or acceptability of the metaverse system is not a recent study area, and many academics have taken on the task. We should be acquainted with the leading IS models used in this study trend to assess these models and give academics a comprehensive understanding of this study trend. The primary goal of this research, in contrast to previous reviews, is to systematically evaluate the metaverse research in education from the viewpoint of IS theories/models to offer a thorough pointer that might help the scholars to carry out additional research in metaverse acceptance. A total of 41 research that was published between 2011 and 2022 were examined in the present systematic review. The main study results showed that the Technology Acceptance Model (TAM) is recognized as the most widely used model in forecasting people's intentions to uphold the metaverse system. Furthermore, it was discovered that SmartPLS (PLS-SEM) is a typical tool for validating metaverse models. In addition, the key research purpose covered in the bulk of the reviewed research is to study how students adopt or accept the metaverse system and the technology that supports it. Additionally, most of the research that was gathered was done in China, Taiwan, and the USA, accordingly. Additionally, in most of the evaluated research, it was discovered that university students were the primary respondents concerning data acquisition. These findings are anticipated to significantly improve both our comprehension of metaverse system study and the utilization of IS models.

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Introduction

The aim of computer scientists and researchers was to rapidly develop the aspects of virtual environment. Due to the advancement of the Internet and the widespread distribution of social media, cheap and easy access is provided to hardware and software with the aim of offering enhanced digital content that is signified by three-dimensional (3D) virtual environments (Collins, 2008; MacCallum & Parsons, 2019). Stephenson (1992) coined the term *metaverse*, whereby an immersive 3D virtual environment was explained through a science fiction novel. The development of metaverse helps in carrying out every day communication and interaction among humans. Hence, metaverse may be referred to as a world that virtually enhances physical space and physical reality. It is an integration of real as well as physical universe through which the users are able to imagine various and myriad digital mirrors of the actual world and mirrors that are NOT present in the actual world for different purposes (Arcila, 2014; Collins, 2008; Díaz et al., 2020; Márquez, 2011).

A large number of studies have been conducted in various universities and educational institutions, with the focus of these studies being on the metaverse. The metaverse was used by the researchers in an educational setting, concentrating on the adoption of a problem-based technique in which students and teachers can present the problem and identify potential solutions in the imaginary world with the help of three-dimensional classes and the avatar (Barry et al., 2009; Farjami et al., 2011; Kanematsu et al., 2012, 2013). It was determined by Jeon & Jung (2021) that a metaverse platform is a vital tool using which learners can enhance their motivation and immersion. It allows them to generate real feelings regarding the use of innovative learning approaches and acquire self-directed learning experiences. In addition, the significance of using the metaverse system in different fields of study globally was demonstrated by Farjami et al. (2011), Han (2020), and Kanematsu et al. (2013). The focus of these studies was on formulating real-life experiences where the metaverse system is employed to obtain solutions to the problem. This shows that a conceptual model needs to be developed that can explain the significant role of the metaverse system from the point of view of students. The conceptual model is capable of examining whether the metaverse system is effective, focusing on the perception of students from a distinct point of view.

The metaverse is an extension of real-time interaction that allows many people to enjoy a variety of experiences. The metaverse is an imagined world with increasingly realistic digital spaces, enabling a more dynamic learning environment in educational settings. From the standpoint of education, both the industrial sector and corporation demand an educated workforce to address the new obstacles of the metaverse environment, which necessitates new management and operational leadership paradigms. Furthermore, these environments describe and study human conduct in an educational setting to evaluate how it varies from conduct in the real world. This review intends to review and synthesize metaverse systems studies that systematically incorporated educational environments. A collection of 41 research

articles released between 2011 and 2022 were assessed using preset standards. The key research fields in metaverse systems, the main and the most frequent factor categories utilized in metaverse systems in the education sector, the most important research methods, the main disciplines, and the main educational levels. The eleven research questions listed below are presented in this retrospective research:

1. What are the primary research goals of the articles collected?
2. What are the primary research methods used in the articles gathered?
3. What are the primary countries represented in the articles accumulated?
4. What are the primary disciplines of the articles gathered?
5. What are the highest educational levels of the target group in the articles that have been accumulated?
6. What are the primary software/tool used in the articles gathered?
7. What are the primary research model used in the articles accumulated?
8. What are the key factor categories in the articles gathered?
9. What are the most frequently researched factors in the collated articles?
10. Which key databases are these collated articles included in?
11. What are the trends across time in metaverse/virtual reality studies?

In addition, the methodological and conceptual characteristics of metaverse systems in education are covered in this review. In this paper, multiple methodologies were used to assess journals, symposia, covered publications, and workshop pieces to study metaverse systems in education. This paper also assists the recipient in becoming acquainted with the core concepts associated with metaverse systems, as well as how education specialists have employed metaverse systems in the education and the current problem spectrum.

Literature review

The basic purpose of education is to provide students with the knowledge and training that are considered important in society to equip them for life, job, and citizenship (Wittich et al., 2017). The act of enabling learning, acquiring knowledge, abilities, or constructive values is typically referred to as education. Enhancing graduates' credentials, abilities, and skills throughout the educational process is the responsibility of the educator (Dewey, 2007). Classes typically include two components theoretical and practical, including activities, labs, or internships. In theoretical courses, knowledge is transferred among a sizable group through lectures that may also include debates. The demands of students and the job prospects throughout time compelled modifications in the educational system (Blumenfeld et al., 1991). The practical aspect had been given precedence. Due to the technical difficulty, the need for conceptual thought, and the reality that these notions are not physical, many students have difficulty comprehending ideas, particularly in science courses (Zheng et al., 2015). Basic flaws limit continued research and improvement of more complex issues. Students are not allowed to self-configure lab equipment, encounter

emergencies, or undergo the impacts of configuration errors that could cause equipment breakage. Practical exercises, which are dependent primarily on sophisticated research equipment, must be performed under oversight. Additionally, there is no way to practice and make up lost time outside of the lab timetable. Contemporary technologies, including online courses (Magdalene & Sridharan, 2018), blended learning (Al-Maroof et al., 2021; Halverson et al., 2017), various computer-based platforms (Van der Kleij et al., 2015; Zhang et al., 2018), and many more, are the present alternatives. This tool enables students to revisit the same material multiple times, make mistakes, and improve from them. The edtech industry can enhance learning outcomes for the bulk of students, according to numerous instances of hardware and software that have proved effective in educational procedures (Collins & Halverson, 2018). Sophisticated new technological resources are being introduced by an increasing number of educational institutions worldwide to assist them in better fulfilling the needs of their heterogeneous student demographics. Digital learning materials, particularly those from open academic services, are overtaking classical books (Atkins et al., 2007). Traditional copybooks have been supplanted with notebooks, tablets, or smartphones with specialized apps (Ally, 2009), and personalized learning (FitzGerald et al., 2018) and distance learning (Kaye & Rumble, 2018) are utilized to adapt the educational experience to each student's educational abilities, shortcomings, interests, and aspirations. It is commonly recognized that the usage of Information and communication technologies has been shown to increase students' perceptions of education (Hõrak, 2019; Lieshout et al., 2018). It is an area of study that is expanding quickly, constantly searching for new technical alternatives. The interactive computer-generated world known as metaverse, which was previously only used for gaming, is now being used for professional development in fields including education, health, and psychiatry forces. Numerous review studies were done to emphasize the importance of the metaverse in helping the teaching and learning procedure in response to the growing curiosity in metaverse research among academics. One of the evaluation research projects was carried out to uncover an intriguing scholarly outlook that emphasizes the necessity for additional research into the motivations behind researchers' involvement in metaverse spaces and the motivations behind some of them in integrating technology for engaging computer-generated surroundings. To assist researchers in creating metaverse surroundings, the academics offered a repository of metaverse techniques and applications. In a survey paper, Lee et al. (2021a) made the first attempt to establish a comprehensive framework that analyzes the most recent metaverse development in the context of innovative technologies and metaverse ecosystems, and highlight the potential for the digital "big bang." The drivers for the shift from the existing Internet to the metaverse are technologies. The technical framework of the metaverse was presented in a review study by Ning et al., (2021) that discussed the development trends of the metaverse from the five viewpoints of network infrastructure, management technology, basic prevalent technology, virtual reality object connection, and virtual reality convergence. This study also covers the social and hyper spatiotemporal aspects of the metaverse and explores its initial application domains as well as some potential issues and difficulties. Seven crucial subjects that are pertinent to the metaverse were identified by Lee et al., (2021b) in their comprehensive survey on

computational arts, which presents new artworks in hybrid virtual-physical realities. The subjects address the components that make up the metaverse, such as virtual characters, sceneries, and auditory and textual features. The increased frontiers of metaverse cyberspace have also been mirrored in several amazing original inventions, including immersive arts, robotic arts, and other user-centric strategies that support modern artistic yields. The study also acts as a starting point for creative works in the field of surreal cyberspace for artists and metaverse technologists. The application of virtual reality in construction engineering education and training (CEET) was explored in a systematic review by Wang et al. (2018). They target all academic works written between 1997 and 2017 that discuss VR and objectively compile and assess all the VR applications in CEET.

To outline the benefits of the metaverse as an innovative education space that supports Universal Design for Learning, Mistretta (2022) undertook a review paper. The uses and value of virtual reality, or the metaverse, in education and training, have been the subject of numerous research (Dahan et al., 2022; Kamińska et al., 2019; Mistretta, 2022; Smutny et al., 2019). This publication also examines channels that provide a variety of access points for participation, advocacy, action, and discourse. Furthermore, Smutny et al. (2019) conducted a survey paper to investigate how virtual reality is now employed to assist with learning and teaching. The research's findings outline the allocation of curriculum material in virtual reality programs as well as the top user-rated educational VR programs. The other review study was carried out in metaverse-based e-learning systems (Dahan et al., 2022). The academics looked at some earlier studies to determine the unique technologies that the metaverse framework should offer, and they then talked about how the metaverse framework might be used in an e-learning environment framework. Prospective metaverse-based apps will be simple to create as a result, as the suggested architecture would enable a seamless operation of virtual learning environments on the metaverse. E-learning will also be a more enjoyable and involved experience. Additionally, Kamińska et al. (2019) conducted a second survey paper to systematically analyze virtual reality and its uses in education. They discussed future VR possibilities and compiled the most intriguing, current VR educational uses concerning a variety of educational areas, including general, engineering, and health-related education. This survey also contributes by outlining several strategies for analyzing and validating simulations as well as methodologies for simulation creation.

It is clear from this those prior evaluations have primarily concentrated on the academics' participation in virtual reality or metaverse classes (Smutny et al., 2019), the classroom atmosphere during the Covid-19 pandemic (Mistretta, 2022), the system of the metaverse if implemented as an e-learning environment framework (Dahan et al., 2022), and the impact of virtual reality on students' attitudes and accomplishments (Kamińska et al., 2019). The goals of the existing reviews were constrained, even though they gave us a greater grasp of virtual reality or metaverse study. The primary goal of this research, in contrast to previous reviews, is to systematically evaluate the metaverse research in education from the viewpoint of IS theories/models to offer a thorough pointer that might help the scholars carry out additional research in Metaverse acceptance.

Metaverse: scope and characteristics

The purpose of developing the term metaverse was to achieve fictional objectives, where users function as avatars or pseudonyms to replicate interaction with other users in several day-to-day scenarios. Metaverse refers to a three-dimensional, immersive, virtual world in which social and economic interaction occurs between the users, irrespective of their location. Computational-based interaction takes place between the users (Arcila, 2014; Díaz et al., 2020; Márquez, 2011; Vázquez-Cano & Sevillano-García, 2017). There are significant characteristics of the metaverse that distinguishes it from other tools within an educational setting, such as "Interactivity, Corporeity and Persistence". Users are able to interact with each other in a virtual learning platform as part of a virtual world. Through the interactivity feature, the world becomes more dynamic and an innovative educational scenario of autonomous and collaborative learning is established that offers access to all the existing resources. The metaverse system can work without leaving the actual world, while maintaining a consistent connection with the virtual world without any time restrictions. In the same way, the corporeity feature adds the avatar with no limit in the virtual world, which gives rise to a highly realistic environment with respect to their definition as their shape is the same or better than 3D games. The persistence feature is also very important as it helps save conversation, objects and data even after users have left the virtual world (Ando et al., 2013; Castronova, 2001; Díaz et al., 2020; Tarouco et al., 2013).

From an education point of view, industries and businesses look for an educated workplace that is able to fulfill the new problems that emerge in the metaverse environment and that need novel management and organizational leadership models. Furthermore, these environments better explain and evaluate the human behaviors in an educational situation to determine the ways in which human behavior in these settings is identical or distinct to behavior in the real world. Higher education institutions are also able to benefit from the different methods by offering a platform for faculty, students and staff to interact in an entirely flexible environment, where there are no limitations on classrooms, contrary to the traditional classrooms. Students can easily communicate with professors in a digital environment simply by pressing a button. This means that the metaverse is capable of employing a real university and institution by transforming it to a virtual world in which there can be interaction between students, teachers and learning models in hybrid and collaborative classrooms (Ando et al., 2013; Tarouco et al., 2013).

The importance of metaverse in education

University lectures used to be given in person to a small group of students by a genuine lecturer—a solitary resource. The manner universities and academic work are promoted could be altered by metaverses. Students will benefit from a more "cyber-physical" learning experience thanks to the Metaverse, where the virtual and physical worlds converge. Owing to metaverses, students can easily switch between

online stores and lecture rooms with a single avatar. Certain types of conventional university teaching may contribute to the development of the metaverse. A lot of individuals would prefer cyber-physical institutions to conventional brick-and-mortar institutions. In the metaverse, they might gain knowledge through virtual experiences provided by numerous international universities.

Because of the metaverse system's rapid surge, researchers are looking at its significance in the field of education. Prospective academics and programmers might work together to create instructors that can help educators in their metaverse reality (Han & Noh, 2021; Preston, 2021). With an emphasis on its pedagogical significance, Han & Noh (2021) performed research to look at the perspectives and requirements of higher education teachers about metaverse-based education. The primary objective of the research is to ascertain instructors' perspectives toward adopting the metaverse system in higher education. They formed the opinion that the Metaverse can be used in addition to conventional communication techniques.

One other research evaluated the metaverse system's effects as an innovative technology in adjacent universities. Instructors also believed that there were procedures in place and support available as needed for the classroom environment, including for the use of curriculum material and instructional techniques. A novel approach to the conundrum that instructors and students face in online learning environments is the metaverse system. The difficulties instructors have in conveying specialized classes and the percentage of student satisfaction with online learning are two noteworthy concerns that can be fixed (Jeon, 2021).

Method

"Identification of inclusion and exclusion criteria, data sources and search strategies, quality assessment, and data coding and analysis" (Kitchenham & Charters, 2007) were the four processes used to perform the review. The specifics of these stages are presented in the sub-sections that precede. The guidelines used to conduct the present review research's systematic review can be accessed within Kitchenham & Charters (2007). Regarding improved organization, the systematic literature review (SLR) approaches suggested in Moher et al. (2009a) were also used in this research. The developed SLR method comprises the initial process of defining a review standard, while the review processes include planning, conducting, and evaluating the review. The review was carried out using the methods below. The search was selected, the quality of the work was evaluated, the major research was picked, the data were synthesized, the review was documented, the data was retrieved, and ultimately, validation was carried out.

Furthermore, the research question formulation is an important part of the SLR process because it establishes the research's frames of reference at the outset. Figure 1 depicts the six stages of the review methodology that were employed in this study. Figure 1 next highlights the procedure of merging a search strategy that emphasizes developing the preliminary research. Even if this process is completed, a method for determining the search terms/criteria must be developed, and the initial research must be correlated to the SLR.

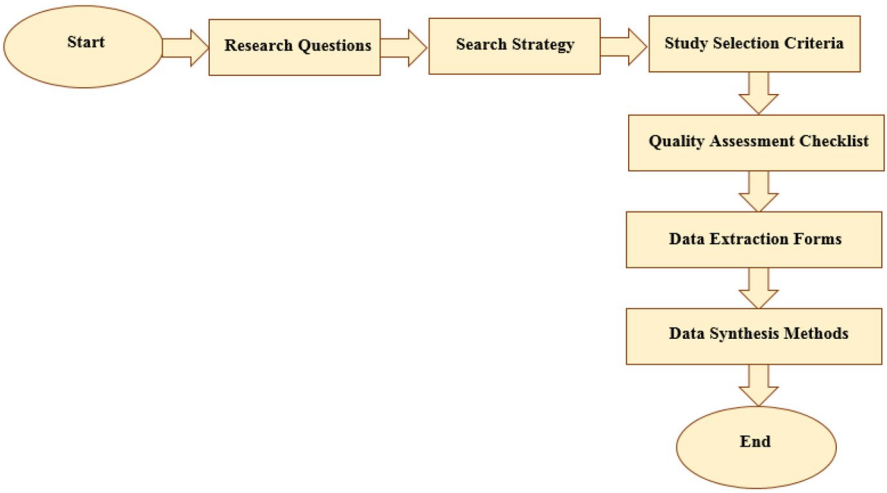

Fig. 1 Protocol Review Stages (Moher et al., 2009a)

Inclusion/exclusion criteria

The articles that meet the inclusion and exclusion criteria listed in Table 1 will be analyzed for the review research.

Data sources and search strategies

The search for articles to be considered in this systematic review will begin in May of 2022. The "ACM Digital Library, Emerald, Google Scholar, IEEE, ScienceDirect, Springer, Taylor and Francis Online, and Wiley Online Library" databases were employed to conduct a comprehensive search of published research to compile the research articles for inclusion in this systematic review. The search terms utilized to find pertinent publications were predicated on the keywords in Table 2. Because keywords provide the foundation for accessibility to pertinent publications, proper keyword selection is critical for the selection of articles for inclusion in the systematic review (Costa & Monteiro, 2016). The search findings acquired using the already mentioned keywords provided

Table 1 Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Must involve metaverse systems in education	Articles on metaverse systems but not in education field
Must involve research framework	Articles without research framework
Must be written in English language	Articles published in languages other than English
Must be published between 2011 and 2022	

Table 2 Keyword search

Keyword search
"Metaverse" or "Augmented Reality" or "Virtual Reality" or "Virtual Worlds" or "Second Life" or "Immersion virtual reality" & or "Mixed Reality" or "Avatars" or "Digital Twins" & ["Education" or "Learning" or "E-learning"] & ["Students" or "pupil" or "learner"] & ["technology adoption" or "technology acceptance"]

Table 3 Final search results across the databases

No	Database	Count
1	ACM Digital Library	6
2	Emerald	12
3	Google Scholar	98
4	IEEE	10
5	SAGE Pub	5
6	Springer	15
7	ScienceDirect	18
8	Taylor and Francis Online	10
9	Wiley Online Library	3
Total		177

accessibility to 177 articles (see Table 3), comprising 87 redundant articles that were extracted. As a result, we received 90 articles. The researchers assessed each article under the inclusion and exclusion criteria, with 41 research articles meeting the inclusion criteria and so being incorporated in the evaluation procedure. Throughout the searching and filtration phases of the articles for the present review paper, the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) were used (Moher et al., 2009b). Figure 2 shows the PRISMA flowchart.

Quality assessment

Following filtration ($N=41$), seven criteria from the quality assessment checklist were used to assess the quality of the research articles that were eligible for further analysis. Quality assessment is just as significant as inclusion and exclusion criteria (Al-Emran et al., 2018). The quality assessment checklist is presented in Fig. 3. The checklist was a tweaked version of (Kitchenham & Charters, 2007) suggestions, and it was not intended to criticize any of the researchers' projects. The questions were scored using a three-point scale which is standard for scoring questions, with 1 point being allocated to 'Yes,' 0 points being allocated to 'No,' and 0.5 points being allocated to 'Partially.' Any research could receive anywhere from 0 to 7 points. The research's higher overall score indicates that it is better able to respond to the

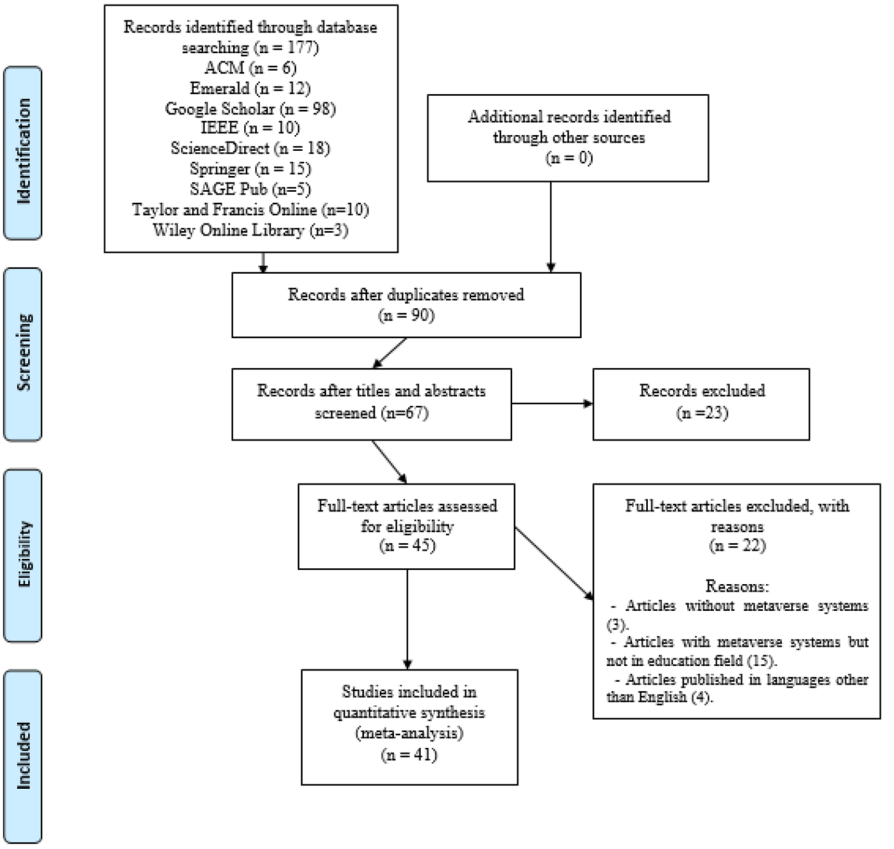

Fig. 2 PRISMA flow diagram

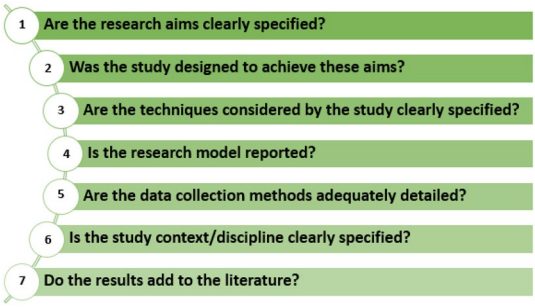

Fig. 3 Quality assessment checklist (Kitchenham and Charters, 2007)

research questions. The results of every research's quality assessment are presented in Table 4, which shows that all 41 studies met the quality assessment criteria, indicating their acceptability and competence for further analysis.

Table 4 Quality assessment results

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Total	Percentage (%)
P1	1	1	1	1	1	1	1	7	100
P2	1	1	1	1	1	1	1	7	100
P3	1	1	0.5	1	1	1	1	6.5	93
P4	1	1	1	1	1	1	1	7	100
P5	0.5	0.5	1	1	0.5	1	0.5	5	71
P6	1	0.5	0.5	1	0.5	1	1	5.5	79
P7	0.5	0.5	0.5	0.5	1	1	0.5	4.5	64
P8	1	0.5	0.5	0.5	0.5	0.5	1	4.5	64
P9	0.5	0.5	0.5	1	0.5	0.5	0.5	4	57
P10	1	1	0.5	0.5	0.5	0.5	0.5	4.5	64
P11	1	1	1	0.5	1	1	0.5	6	86
P12	1	1	0.5	0.5	1	0.5	1	5.5	79
P13	1	1	1	1	1	1	1	7	100
P14	0.5	0.5	0.5	0.5	0.5	1	0.5	4	57
P15	1	1	0.5	0.5	0.5	1	1	5.5	79
P16	1	1	1	0.5	1	0.5	1	6	86
P17	0.5	0.5	1	0.5	0.5	0.5	0.5	4	57
P18	1	1	1	1	1	1	1	7	100
P19	1	1	1	1	1	1	1	7	100
P20	1	1	1	1	1	1	1	7	100
P21	1	0.5	1	0.5	1	0.5	0.5	5	71
P22	1	0.5	1	1	1	0.5	0.5	5.5	79
P23	0.5	0.5	0.5	1	1	0.5	0.5	4.5	64
P24	1	1	1	0.5	0.5	1	1	6	86
P25	1	1	0.5	0.5	0.5	1	0.5	5	71
P26	1	0.5	0.5	0.5	0.5	0.5	0.5	4	57
P27	1	1	1	1	1	1	1	7	100
P28	1	1	1	1	0.5	1	0.5	6	86
P29	0.5	1	1	1	0.5	0.5	0.5	5	71
P30	1	1	1	1	1	1	1	7	100
P31	1	1	1	1	0.5	1	1	6.5	93
P32	1	1	1	1	1	1	1	7	100
P33	1	1	1	1	1	1	1	7	100
P34	1	0.5	0.5	0.5	0.5	0.5	1	4.5	64
P35	1	1	1	1	1	1	1	7	100
P36	1	1	1	0.5	1	1	1	6.5	93
P37	1	1	1	0.5	0.5	1	1	6	86
P38	1	0.5	1	0.5	1	1	1	6	86
P39	0.5	0.5	0.5	0.5	0.5	0.5	0.5	3.5	50
P40	1	1	1	1	1	1	1	7	100
P41	1	1	0.5	0.5	1	0.5	1	5.5	79

Data coding and analysis

The following characteristics of research methodology reliability were coded: (a) year of publication (b) primary research area in metaverse systems (c) research methodology (example, interview, survey, experiment, etc.), (d) education level (such as higher education, high school, and elementary school.), (e) region, (f) and database (e.g., Springer, ScienceDirect, IEEE, etc.).

Results and discussion

To obtain responses to 11 research questions, the present systematic review looked at 41 research publications about metaverse in education that were conducted from 2011 to 2022.

RQ1: What are the primary research goals of the articles collected?

(1) Analyzing the factors of adoption of virtual reality ($N=32$), (2) Analyzing the factors of adoption of metaverse systems ($N=5$), (3) Analyzing the adoption and usage of augmented reality ($N=3$), and (4) Analyzing the factors that affect the use of virtual classrooms to improve academic performance ($N=1$) (see Fig. 4). Those mentioned are the major themes that have been used to group the study objective of the publications that have been analyzed. To sum up, the most common study issue addressed is figuring out factors that influence students' adoption of virtual reality. It is important to remember that the keyword "adoption" alludes to research that gages how well students are adopting virtual reality now before it becomes widely used later, while "acceptance" pertains to research that assesses students' acceptance of virtual reality following their use.

RQ2: What are the primary research methods used in the articles gathered?

We can see that almost 97% of virtual reality academics focused primarily on questionnaire surveys to gather data. The researches ($N=1$) that employed hybrid approaches come after this (e.g., interview, experiment, survey, etc.). This outcome

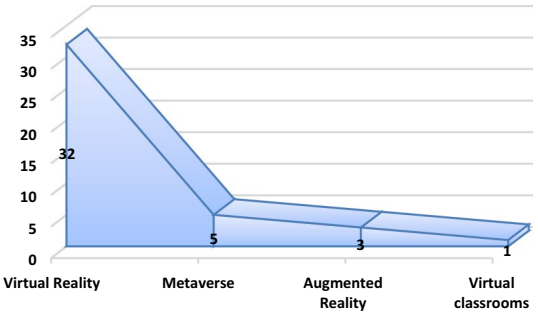

Fig. 4 Research purposes distribution

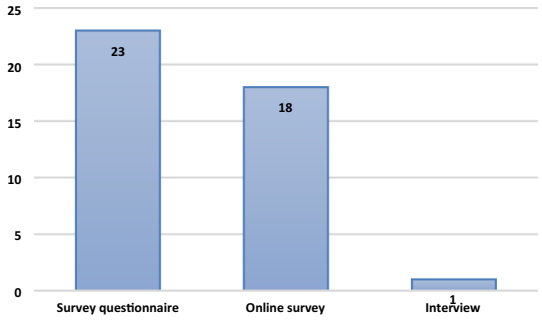

Fig. 5 The primary research methods

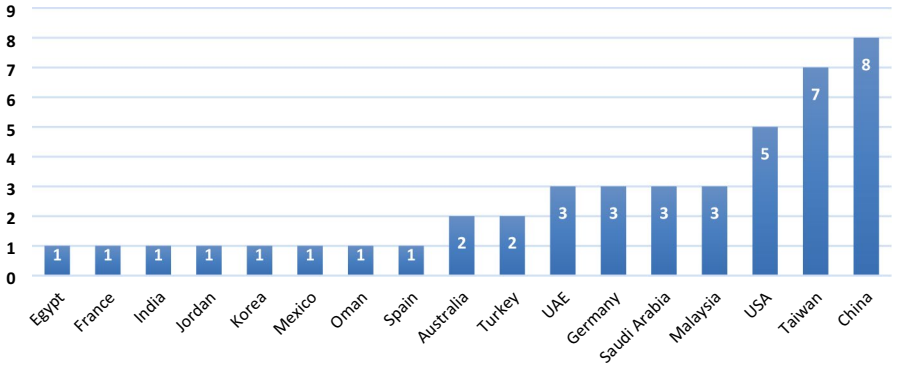

Fig. 6 The primary countries represented in the articles

can be attributed to the survey instrument's status as the most widely used approach for a range of technology acceptance analyses and as a useful model testing resource in the field of information systems. The prevalence of the evaluated papers according to the research methodologies employed is displayed in Fig. 5.

RQ3: What are the primary countries represented in the articles accumulated?

Most of the gathered research ($N=8$) was carried out in China. The research that came after that was carried out in the USA ($N=5$) and Taiwan ($N=7$), accordingly. This finding may be explained by the fact that Chinese academics are very interested in researching virtual reality, and their focus is drawn to it. As a result, there is still room for research on this topic in nations that the available studies did not cover. According to the countries in which this research was conducted, the categorization of the analyzed research is shown in Fig. 6.

Note that the frequency mentioned here is not in a one-to-one, for example, study number P2 (Akour et al., 2022) was conducted in three countries (UAE, KSA, and Oman). Study P7 was also conducted in the United States and China (George et al., 2020).

RQ4: What are the primary disciplines of the articles gathered?

Scientific papers from a variety of fields were categorized as (General). The arrangement of the examined papers in terms of their disciplines is shown in Fig. 7. We can see that about half of the research ($N=20$) did not identify the field of research. Additionally, the preponderance of the reviewed research (17%) focused on medical education ($N=7$). Aviation training ($N=3$) and tourism education ($N=2$) are the next two subjects, accordingly.

RQ5: What are the highest educational levels of the target group in the articles that have been accumulated?

We can see that research done in higher education settings accounted for almost 83% of the studied papers ($N=34$), trailed by research done in high school settings ($N=2$). The arrangement of the evaluated research according to educational level is shown in Fig. 8. Considering graduate and undergraduate students are the most frequent adopters of virtual reality for academic reasons, this conclusion may be explained by the fact that virtual reality is more successful in the domain of instructing and studying within higher educational institutions.

RQ6: What are the primary software/tool used in the articles gathered?

The prevalence of the evaluated research concerning the statistical software employed for data analysis is shown in Fig. 9. Statistical software is typically used to assess academic papers that include both quantitative and qualitative data. SmartPLS (PLS-SEM) is the most often employed data analysis software ($N=15$) in the

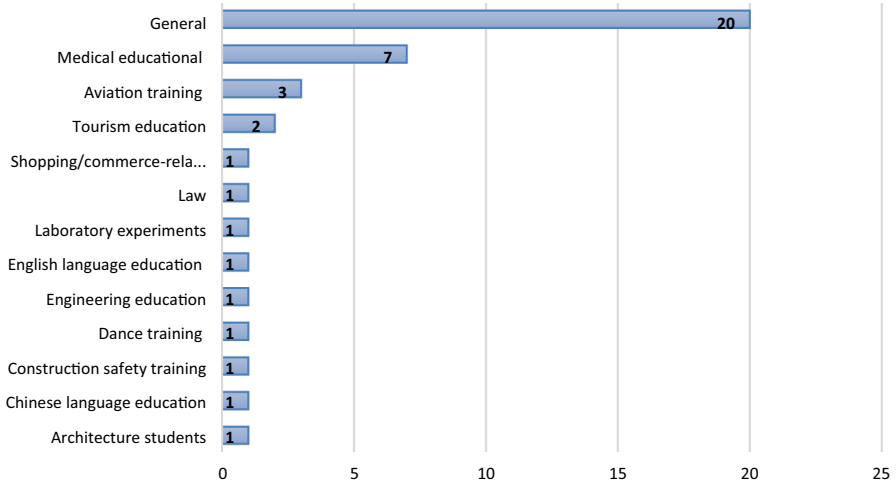

Fig. 7 The primary disciplines

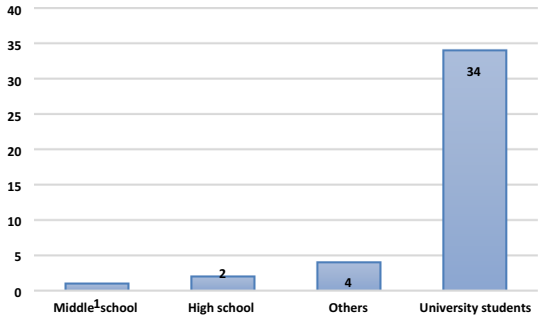

Fig. 8 The primary educational levels

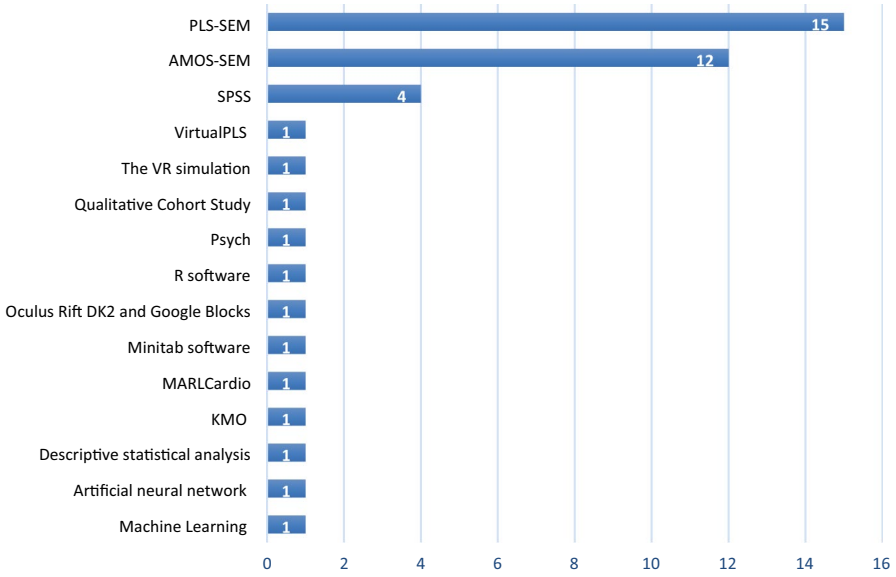

Fig. 9 Popularity of various software in researches

research under consideration. The research that precedes employs AMOS-SEM ($N=12$) and SPSS ($N=4$), accordingly. The fact that SmartPLS (PLS-SEM) is considered the most popular and trustworthy statistical software for data analysis is noteworthy. This may help to clarify why SPSS was used the most frequently in the reviewed research.

RQ7: What are the primary research model used in the articles accumulated?

We can see that the Technology Acceptance Model (TAM) was used in about 67% of the evaluated publications ($N=29$), second by research that used the Unified Theory of Acceptance and Use of Technology (UTAUT) ($N=12$). Considering graduate and undergraduate students are the most common adopters of virtual reality for academic reasons, this conclusion could be explained by the fact that

the TAM model is more beneficial in enhancing acceptance and adoption of new technology within higher educational schools. The arrangement of the evaluated research concerning the research model is shown in Fig. 10.

RQ8: What are the key factor categories in the articles gathered?

The arrangement of most environmental variables among the databases is shown in Table 5. In total, 41 research recognized and evaluated 96 external factors.

RQ9: What are the most frequently researched factors in the collated articles?

The factor frequencies determined from the reviewed studies are displayed in Fig. 11. We have tallied the frequency of each factor employed in the gathered research to determine which factors were most regularly utilized to prolong the TAM or UTAUT in the virtual reality environment. Most research that extended the TAM or UTAUT employing the factor is measured by the "frequency" characteristic. Once the relevant studies were found, all the constructs offered in the research were combined to establish the external factors frequently employed. External factors whose ties to TAM or UTAUT were validated and corroborated in three or more analyses were brought into consideration and evaluated to be certain in the strength of the correlation between the external factors and TAM or UTAUT. As a result, we can see that "Social Influence/Subjective Norm, Performance Expectancy, Effort Expectancy, Facilitating Conditions, Perceived Enjoyment, Self-efficacy, Immersion, Perceived Compatibility, User Satisfaction, Imagination, Interaction, Perceived Anxiety, and Personal innovativeness" are the most common observed factors that successfully influenced the adoption and acceptance of the virtual reality setting.

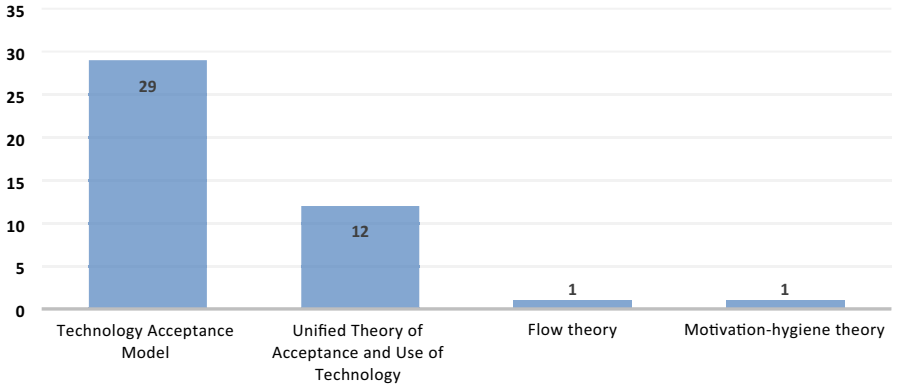

Fig. 10 The primary research model

Table 5 The key factors

Factor	Count
Social influence/subjective norm	14
Performance expectancy	13
Effort expectancy	12
Facilitating conditions	12
Perceived enjoyment	11
Self-efficacy	10
Immersion	5
Perceived compatibility	4
User satisfaction	4
Imagination	3
Interaction	3
Personal innovativeness	4
Perceived anxiety	3
Active experimentation	2
Concrete experience	2
Experienced realism	2
Hedonic motivation	2
Involvement	2
Learning motivation	2
Perceived complexity	2
Perceived observability	2
Perceived playfulness	2
Perceived price value	2
Perceived triability	2
Purchase intention	2
Realism	2
Reflective observation	2
Regulatory uncertainty	2
Sense of presence	2
Spatial presence	2
Ability to act	1
Ability to examine	1
Abstract conception	1
Abstract conceptualization	1
Appreciation	1
Autonomy	1
Cognitive engagement	1
Competence	1
Competencies	1
Concentration	1
COVID-19 pandemic context	1
Curiosity	1
Deep learning	1

Table 5 (continued)

Factor	Count
Espoused individualist/collectivist	1
Espoused masculinity/femininity	1
Espoused power distance	1
Espoused uncertainty avoidance	1
Experimental fidelity	1
Fantasization	1
Feedback	1
Flow	1
Future perception	1
Goal orientation	1
Hedonic quality-stimulation	1
Hygiene	1
Information overload	1
Information quality	1
Interface quality	1
Learner interaction	1
Learning outcome	1
Mastery-approach	1
Mastery-avoidance	1
Media richness	1
Mobility	1
Motivators	1
Nausea	1
Oculomotor	1
Organizational factor	1
Perceived behavioral control	1
Perceived health risk	1
Perceived interaction	1
Perceived Learning	1
Performance approach	1
Performance avoidance	1
Plausibility illusion	1
Pragmatic quality	1
Presence	1
Price willing to pay	1
Purchase attitude	1
Recommendation	1
Relatedness	1
Security, technology availability	1
Self-assessment of performance	1
Service quality	1
Social interactions	1
Social presence	1

Table 5 (continued)

Factor	Count
Strength of the social ties	1
Stress/worry/pressure	1
Surface learning	1
System attributes	1
System quality	1
Trainer	1
Trust	1
Usability	1
Wellbeing	1
Word-of-mouth Intention	1

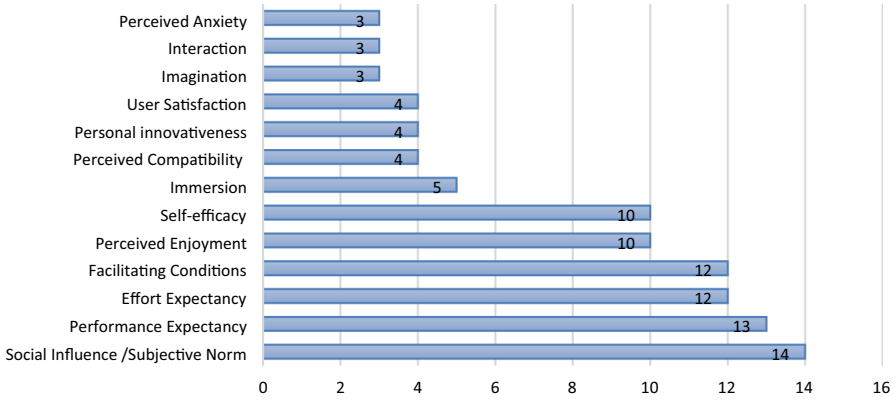

Fig. 11 The most frequently researched factors

RQ10: Which key databases are these collated articles included in?

We can see that the number of research in the first top rank database, "Google Scholar" ($N=22$), is followed by "Springer" ($N=8$), "ScienceDirect" ($N=7$), "Taylor & Francis" ($N=2$), "ACM," and "IEEE" ($N=1$), in that order. The databases where the evaluated study publications were nominated are depicted in Fig. 12.

RQ11: What are the trends across time in metaverse/virtual reality studies?

Figure 13, which shows the publication year, shows growth in virtual reality research over time. The accumulation of research on virtual reality by year of publication is shown in Fig. 13. As we can see, the research spans the years 2011–2022. The largest number of papers has expanded quickly from one in 2011 to six in the previous four years. There are now seven research projects in 2019, up from one research in

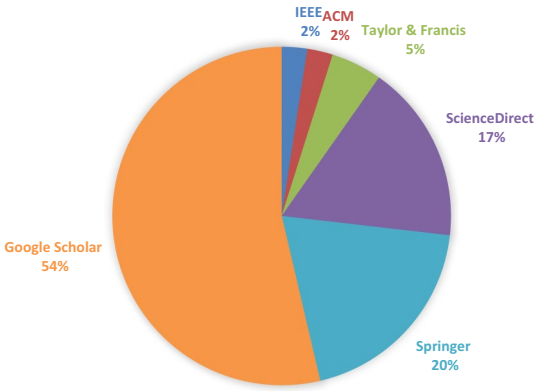

Fig. 12 Distribution of studies in terms of databases

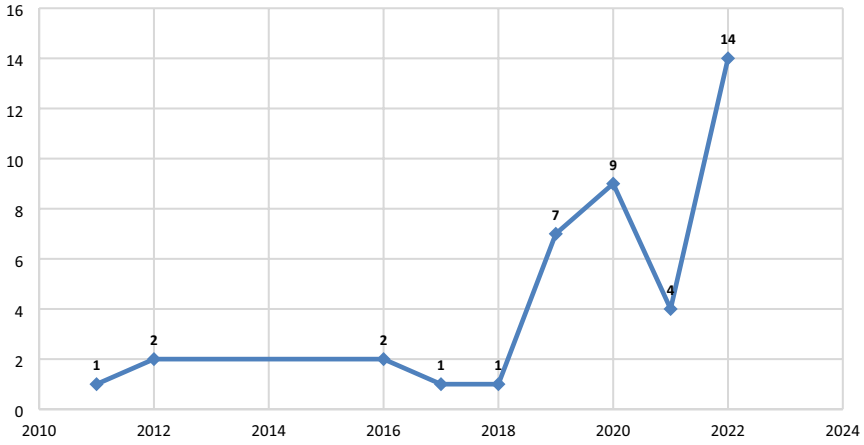

Fig. 13 The trends across time in metaverse/virtual reality studies

2018. A sum of 34 studies was conducted, and nearly 83% of these 41 papers were released between 2019 and 2022. With 14 papers, the year 2022 saw the most study releases. The following year with the most papers was 2020, with a net of 9 papers released in the virtual reality domain.

Similarities and differences between this review study and previous reviews

The current and previous studies shed insight on the use of various research methods, namely quantitative, qualitative, and mixed methods, in the context of the similarity. In between the current review research and the other reviews, there are several commonalities and distinctions. The strong influence of metaverse within higher

education facilities on students' educational accomplishments and results was also validated by this review study and the previous reviews. Contrasting this review study with other reviews revealed a variety of noteworthy distinctions. In contrast to prior studies, this review study did not restrict the data it collected to a particular period. For example, Wang et al. (2018) limit its scope to publications between 1997 and 2017. Second, the discipline in which metaverse was adopted was not constrained by the current review. In the other reports, where discipline was a key problem, though, this was not the position for this study. For instance, the review study by Wang et al. (2018) was primarily concerned with the properties of virtual reality in the education and training of construction engineering. Third, this review research did not restrict the data it collected to any one country. Fourth, while the current review covers papers from a variety of disciplines, prior evaluations focused on a particular context. For example, a systematic review (Dahan et al., 2022) exclusively investigated the framework for e-learning environments. Last, the model or theory adopted in the analyzed studies is responsible for the large discrepancy between the current analysis and the other evaluations. The existing reviews make it clear that none of them provide any information on theories or models of technology acceptance. As a result, there is a dearth of research on the metaverse. Rather, the emphasis of this review research has been on exploring the metaverse research from the standpoint of the IS theories and models employed, which then leads to one of the key characteristics that set this research apart from the others.

Study implications

Theoretically, the findings showed that research on metaverse adoption is increasing, indicating that there is still a need for more studies to be done to better understand the factors influencing its adoption. The findings revealed that most of the research on the metaverse was carried out in China, Taiwan, and the USA, suggesting that much more study must be done in other countries to better comprehend the factors influencing its adoption. Most respondents in the metaverse research that were reviewed were university students, which is another possibility for a prospective study to take into account students from various educational fields. The majority of performed research has centered on factors influencing students' or teachers' adoption of the metaverse. To ascertain what keeps the metaverse relevant for educational reasons, future studies may investigate why it is still employed. The findings establish the methodology's usefulness for measuring the adoption of various metaverse research using the TAM and UTAUT models. The findings also indicated that the Expectation-Confirmation Model (ECM) has not been widely used to assess the ongoing application of the metaverse. This finding opens the possibility of performing additional studies utilizing post-adoption/post-acceptance models, like ECM. Additionally, the findings showed that questionnaire surveys were the primary method of data collecting in the majority of earlier metaverse research. To better comprehend the underlying links between the affecting factors, additional study is advised to employ mixed methodologies, including interviews or focus groups in conjunction with surveys. According to the findings from a pedagogical perspective,

metaverse was the technology that impacted metaverse classrooms the most. Prospective decision making on the relevance and applicability of technologies over others, particularly when it pertains to accepting synchronous or asynchronous method assistance, can be assisted by the classification of educational technologies underneath the metaverse landscape. Additionally, this can help professionals and teachers choose the technology that best complements their lesson plans and develop appropriate preparations. Numerous theoretical, methodological, and pedagogical implications are provided by this systematic review.

Conclusions and future work

This review study intends to thoroughly look into the various features of metaverse investigations, focusing on the works that use IS theories and models. These viewpoints comprise the publishing year, the country, the sample, the model or theory, the technology, the study strategy, and the goal of the study. Regardless of the premise that earlier metaverse review research provided a beneficial comprehension of the metaverse study, it is still disregarded to be thoroughly explored from various angles. 41 research studies in aggregate have been evaluated carefully. There were a maximum of seven noteworthy findings from the ongoing research. It is first important to highlight that involvement in metaverse research on IS models and theories began in 2019 ($N=7$), and continued by 2020 ($N=9$), with a notable surge in 2022, when 14 scientific papers were produced. Second, many of the studies that were collected were done in China, Taiwan, and the USA, accordingly. Third, in most of the assessed research, it was discovered that university students made up most of the data collection. Fourth, TAM is recognized as the most widely used model in forecasting people's intentions to uphold the metaverse system. Fifth, it was discovered that questionnaire surveys were the most widely used research method for data collection. Sixth, it was discovered that SmartPLS (PLS-SEM) is an effective tool for validating metaverse models. Seventh, the main research goal discussed in much of the reviewed research is determining whether students adapt or accept virtual reality and the technologies that support it. Three factors restrict this systematic review. First, papers were gathered from only four scientific databases, including "ACM Digital Library, Emerald, Google Scholar, IEEE, ScienceDirect, Springer, Taylor and Francis Online, and Wiley Online Library". In consequence, this might not give a complete picture of the metaverse studies that have been submitted in other databases. Academics might carry out checks for metaverse studies in additional databases, such as Web of Science, Scopus, and Business Source Premier, as a prospective studies. Second, the application of IS theories and models in comprehending the adoption of the metaverse was the exclusive subject of this research. Subsequent studies could concentrate on evaluating more theories from the social science and education fields. Third, the research used in the evaluation only looked at conference proceedings and journal articles. Upcoming analyses might look at publications namely books and book chapters in addition to the high-quality publications that this research reflects.

Appendix

Analysis of metaverse system research papers

Article ID	Ref	Year	Country	Objective	Database	Method & Sample
P1	Almarzouqi et al., (2022)	2022	UAE	"Evaluate students' perception of the application of MS in the United Arab Emirates (UAE) for medical-educational purposes"	IEEE	Online survey1858
P2	Akour et al., (2022)	2022	UAE, KSA, and Oman	"Investigate the students' perceptions towards metaverse system for educational purposes in the Gulf area"	ScienceDirect	Online survey 862
P3	Manis and Choi (2019)	2019	USA	"This study explores factors influencing consumer acceptance of VR hardware by extending and individuating the original TAM for virtual reality hardware (i.e., VR-HAM)"	ScienceDirect	Online survey 283

Article ID	Ref	Year	Country	Objective	Database	Method & Sample
P4	Barrett et al., (2021)	2021	China	"This article reports on a study that investigated user acceptance of a high-immersion virtual reality learning environment to learn English paragraph writing structure"	ScienceDirect	A post-session questionnaire 134
P5	Hussin et al., (2011)	2011	Malaysia	"Investigate and provide a preliminary analysis of a framework that predicts level of technology acceptance in a post-secondary institution in Perak, Malaysia"	Springer	Survey 41
P6	Ustun et al., (2020)	2020	Turkey	"To examine student acceptance and use of virtual reality technologies in medical education"	Google Scholar	Survey 421
P7	George et al., (2020)	2020	USA, China	"Conduct a methodological replication of one of the most widely cited MIS Quarterly papers on TAM and national culture"	Google Scholar	Survey 242
P8	Plotzky et al., (2020)	2020	Germany	"To examine the VR simulation's acceptance and knowledge Improvement"	Google Scholar	Survey 47

Article ID	Ref	Year	Country	Objective	Database	Method & Sample
P9	Fussell and Truong (2020)	2020	USA	"To identify, validate, and confirm impact factors relevant to VR use in aviation training as well as flight training in general"	Google Scholar	Online survey 42
P10	Lange et al., (2020)	2020	Germany	"To observe the degree of acceptance of VR applications by nursing students in Germany"	Google Scholar	A quantitative questionnaire. The qualitative interview followed 12
P11	Özgen et al., (2021)	2019	Turkey	"To use VR in basic design education and focuses on the usability of VR, especially for problem-solving activities"	Springer	Questionnaire 20
P12	Chang et al., (2020)	2020	China	"Explaining the acceptance of a novel VR-assisted mental rotation (MR) training system"	Google Scholar	Online survey 55
P13	Iqbal and Sidhu (2022)	2022	India	"Solving the long-term learning retention and poor learning efficiency for mastering a dance skill"	Springer	Online survey 86
P14	Nizar et al., (2019)	2019	Malaysia	"To analyze the influencing factors towards the use behavior of AR by using the MARL-Cardio app as an experiment instrument"	Google Scholar	Survey questionnaire 75

Article ID	Ref	Year	Country	Objective	Database	Method & Sample
P15	Huang et al., (2016a, 2016b)	2016	USA	"To develop a research framework that integrates the technology acceptance model (TAM) and self-determination theory to understand how tourists use a 3D virtual world"	Google Scholar	Web questionnaires 186
P16	Lee and Kim (2022)	2022	Korea	"Aimed to empirically verify user acceptance of metaverse platforms by referring the unified theory of acceptance and use of technology (UTAUT)"	Google Scholar	Survey questionnaire 120
P17		2021	Saudi Arabia	"The aim of this study was to examine the factors that may influence the use of virtual classrooms"	Google Scholar	Online survey 235
P18	Shen et al., (2022)	2022	China	"Determine the acceptance of Augmented Reality and Virtual Reality applications in the tertiary tourism education within the context of current pandemic"	ScienceDirect	Online survey 604

Article ID	Ref	Year	Country	Objective	Database	Method & Sample
P19	Lee et al., (2019)	2019	South Korea	"This study empirically analyzes how the introduction of social network characteristics as a diffusion strategy for virtual reality devices affects consumers' intention to use"	ScienceDirect	Survey questionnaire 350
P20	Fussell and Truong (2022)	2022	USA	"The goal of this research was to determine the factors that influence students' intention to use VR in a dynamic learning environment"	Springer	Online Survey 487
P21	AL-Oudat and Altamimi (2022)	2022	Jordan	"Investigated the factors affecting the adoption of VR in higher educational institutes"	Google Scholar	Online Survey 503
P22	Huang and Liaw (2018)	2018	Taiwan	"To evaluate learner perceptions of novel learning technologies, the present study examines learners' behavioral intention to use such a virtual reality learning environment"	Google Scholar	Survey questionnaire 308
P23	Sagnier et al., (2020)	2020	France	"To test an extended Technology Acceptance Model designed for studying user acceptance of VR"	Google Scholar	Survey questionnaire 89

Article ID	Ref	Year	Country	Objective	Database	Method & Sample
P24	Plotzky et al., (2021)	2021	Germany	"To examine the VR simulation's acceptance and increase of knowledge among participants"	Google Scholar	Quasi-experimental pre-post-test design 51
P25	Chen et al., (2012)	2012	Taiwan	"This study explores the effectiveness of disaster prevention programs using virtual reality and partial least squares techniques"	Springer	Online Survey 87
P26	Abd Majid and Mohd Shamsudin (2019)	2019	Malaysia	"Identify the factors that could affect the respondents' acceptance of Virtual Reality (VR) in classrooms"	Google Scholar	Online Survey 98
P27	Shen et al., (2019)	2019	Taiwan	"To investigate the direct determinants affecting students' reasons for HMD use in learning"	Springer	Survey questionnaire 376
P28	Bernhard (2019)	2019	Taiwan	"Investigate the factors that leadpeople to try VR in VOM context"	Google Scholar	Online survey 97
P29	Shih et al., (2012)	2012	Taiwan	"Investigates the willingness of teachers who use VR system to educate students and understand the relevant factors of improving the use of VR system"	Google Scholar	Survey questionnaire 85

Article ID	Ref	Year	Country	Objective	Database	Method & Sample
P30	Huang et al., (2016a, 2016b)	2016	Taiwan	"This research describes the use of high performance real-time interactive software (VR4MAX) to build a prototype 3D VR learning system"	Taylor & Francis	Survey questionnaire 167
P31	Shen et al., (2017)	2017	Taiwan	"Investigate the factors affecting students' behavioral intention to use a virtual reality headset (VRH) in learning"	ACM	Survey questionnaire 376
P32	Barrett et al., (2020)	2020	China	"Investigated learner attitudes towards Hubs by Mozilla, a multi-user VR learning environment, for the purpose of learning Chinese as an additional language"	Taylor & Francis	Survey questionnaire 33 CSL learners
P33	Zhang et al., (2022)	2022	China	"Investigate the factors behind low acceptance of VR technology"	ScienceDirect	Survey questionnaire 1158
P34	Kemp et al., (2022)	2021	Australia	"Determine an appropriate specification of educational compatibility within a technology acceptance model suited to engaging educational technologies"	Google Scholar	Online survey 517

Article ID	Ref	Year	Country	Objective	Database	Method & Sample
P35	Xie et al., (2022)	2022	China	"This study explored the relationships among computer self-efficacy, perceived immersion, and intention to use VR training systems"	Springer	Online survey 334; 124 junior middle school students and 210 senior high school students
P36	Rocha Estrada et al. (n.d.)	2022	Mexico	"This article analyzes teachers' and Students' acceptance of a web-based virtual reality (WebVR) tool called Virtual Campus proposed to overcome the limitations of teaching strategies using video conferencing platforms"	Google Scholar	Survey questionnaire 426; 262 students and 164 teachers
P37	Luo and Du (2022)	2022	China	"This study aims to clarify the relationship among students' self-efficacy, goal orientation, technology acceptance"	Springer	Survey questionnaire 94 junior and senior students
P38	Cabero-Almenara et al., (2022)	2022	Spain	"This study aims to facilitate knowledge acquisition and to develop university students' competences through the use of MR"	Google Scholar	Survey questionnaire 20

Article ID	Ref	Year	Country	Objective	Database	Method & Sample
P39	Mostafa (2022)	2022	Egypt	This research paper aims to identify the factors affecting Egyptian users of new technologies such as Metaverse"	Google Scholar	Online survey 661
P40	Pedram et al., (2020)	2020	Australia	"This study proposed and tested a framework for learning in immersive VR based on previous research that has identified the most relevant variables for describing the process of learning in VR"	ScienceDirect	Survey questionnaire 284 rescue brigades men
P41	Alawadhi et al. (2022)	2022	UAE	"The current research investigated the students' perceptions of the use of metaverse systems in medical training within the medical community of the United Arab Emirates (UAE)"	Google Scholar	Online survey 435

Article ID	Technique(s)	Model	Discipline/ context	Type	External variables	Core variables
P1	Machine Learning (ML) algorithms and Structural Equation Modeling (PLS-SEM)	Technology Acceptance Model (TAM)	Higher education (University students)—Medical educational	Metaverse (MV)	"Personal innovativeness," "Perceived Compatibility," "User Satisfaction," "Perceived Triability," and "Perceived Observability"	"Perceived Usefulness," "Perceived Ease of Use ," and "Users' Intention to use"

Article ID	Technique(s)	Model	Discipline/ context	Type	External variables	Core variables
P2	Artificial neural network (ANN) and (PLS-SEM)	TAM	Higher education (University students)—General	MV	"Perceived Trialability," "Perceived Observability," "Perceived Compatibility," "Perceived Complexity," "Personal Innovativeness," and "Users' Satisfaction"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"
P3	Structural equation modeling (SEM)—R software	TAM	Members of LinkedIn – General	Virtual Reality (VR)	"Perceived enjoyment," "Purchase attitude," "Purchase intention," "Curiosity," "Age," and "Price willing to pay"	"Perceived Usefulness," "Perceived Ease of Use," "Use attitude," "Users' Intention to use," and "Actual use"
P4	PLS-SEM	TAM	Higher education (University students—Undergraduate)—English language education	VR	"Immersion," "Imagination," and "Interaction"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"
P5	A standard step-wise regression analysis	Unified Theory of Acceptance and Use of Technology (UTAUT)	Higher education (University students) – General	VR	"Performance Expectancy," "Effort Expectancy," "Social Influence," and "Gender"	"Behavioral Intention"
P6	KMO (Kaiser–Meyer–Olkin Measure of Sampling Adequacy)	UTAUT	Higher education (University students)—Medical educational	VR	"Performance Expectancy," "Effort Expectancy," "Facilitating Conditions," and "Social Influence"	"Behavioral Intention"

Article ID	Technique(s)	Model	Discipline/ context	Type	External variables	Core variables
P7	Confirmatory factor analysis (CFA) using AMOS (version 25)	TAM	Higher education (University students) – General	VR	"Espoused Power Distance," "Espoused Uncertainty Avoidance," "Espoused Masculinity/ Femininity, "Espoused Individualist/ Collectivist," "Subjective Norm"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"
P8	The VR simulation runs on the HTC Vive Head Mounted Display (HMD) with Vive controllers	UTAUT	Higher education (University students—Medical educational	VR	"Performance Expectancy," "Effort Expectancy," "Facilitating Conditions," "Social Influence," "Anxiety," "Self-efficacy," "Sense of Presence," "Spatial Presence," "Involvement," and "Experienced Realism"	"Behavioral Intention"
P9	Confirmatory factor analysis (CFA) using AMOS (version 25)	TAM	Higher education—Aviation training	VR	"Perceived Enjoyment," "Performance Expectancy," "Perceived Health Risk," ""Regulatory Uncertainty," and "Self-efficacy"	"Perceived Usefulness"

Article ID	Technique(s)	Model	Discipline/ context	Type	External variables	Core variables
P10	A qualitative cohort study	UTAUT	Higher education (University nursing students—Medical educational	VR	"Performance Expectancy," "Effort Expectancy," "Facilitating Conditions," "Social Influence," "Hedonic Motivation," "Moderation Factors," and "	"Behavioral Intention" and "Further application possibilities"
P11	Oculus Rift DK2 and Google Blocks	TAM	Higher education—(Architecture students)	VR	"Perceived Enjoyment"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"
P12	PLS-SEM	TAM	Higher education (post-graduation)—General	VR	"Perceived Enjoyment," and "Satisfaction"	"Attitude," "Perceived Ease of Use," and "Users' Intention to use"
P13	SPSS	TAM	Higher education—(Dance training system)	AR	"Perceived Enjoyment," "Complexity," and "Self-efficacy"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention touse"
P14	MARLCardio	UTAUT	Higher education—General	Augmented Reality (AR)	"Performance Expectancy," "Effort Expectancy," "Facilitating Conditions," and "Social Influence"	"Behavioral Intention"
P15	AMOS-SEM	TAM	High school or college degree—Tourism education	VR	"Competence," "Autonomy," "Relatedness," and "Enjoyment"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"

Article ID	Technique(s)	Model	Discipline/ context	Type	External variables	Core variables
P16	PLS-SEM	UTAUT	Student—Laboratory experiments	MV	"Performance Expectancy," "Effort Expectancy," "Facilitating Conditions," "Social Influence," "Satisfaction," "Purchase intention," "Word-of-mouth Intention," "Media Richness," "Information Overload" and "Fantasization"	"Behavioral Intention"
P17	AMOS-SEM	UTAUT	Higher education (teaching staff)—General	Virtual classrooms	"Performance Expectancy," "Effort Expectancy," "Facilitating Conditions," "Social Influence," and "Mobility"	"Behavioral Intention" and "Actual Use"
P18	PLS-SEM	TAM	Higher education (tourism education)—Tourism education	Augmented and Virtual Reality (AVR)	"Hedonic motivation," and "Perceived price value"	"Perceived Usefulness," "Perceived Ease of Use," "Usage Attitude," and "Users' Intention to use"
P19	AMOS-SEM	TAM	General	VR	"Perceived Enjoyment," "Social Interactions," and "Strength of the social ties"	"Perceived Usefulness," "Perceived Ease of Use," "Usage Attitude" and "Users' Intention to use"
P20	AMOS-SEM	TAM	Higher education—Aviation training	VR	"Perceived Enjoyment," "Perceived Behavioral Control," "Performance Expectancy," "Regulatory Uncertainty," and "Self-efficacy"	"Perceived Usefulness," "Perceived Ease of Use," "Attitude toward use" and "Users' Intention to use"

Article ID	Technique(s)	Model	Discipline/ context	Type	External variables	Core variables
P21	PLS-SEM	TAM	Higher education—Aviation training	VR	"Perceived Facilitating Condition," "Perceived Compatibility," "Perceived Effort Expectancy," and "Usability"	"Perceived Usefulness," "Perceived Ease of Use," "Attitude toward use" and "Users' Intention to use"
P22	PLS-SEM	TAM	University students- higher education—Shopping/ commerce-related	VR	"Learning motivation," "Perceived self-efficacy," and "Perceived interaction"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"
P23	PLS-SEM	TAM	Undergraduate students in psychology and graduate students in engineering	VR	"Pragmatic Quality," "Hedonic Quality-Stimulation," "Nausea," "Oculomotor," "Ability to act," "Ability to examine," "Interface quality," "Self-Assessment of Performance," "Realism," and "Personal Innovativeness"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"
P24	PLS-PM library in R©	UTAUT	Higher education (University students—Medical educational	VR	"Performance Expectancy," "Effort Expectancy," "Anxiety," "Self-efficacy," "Sense of Presence," "Spatial Presence," "Involvement," and "Experienced Realism"	"Behavioral Intention"

Article ID	Technique(s)	Model	Discipline/ context	Type	External variables	Core variables
P25	VirtualPLS 1.04 software (PLS-SEM)	TAM	University students- higher education—General	VR	"v-learning self-efficacy," "Subjective norm," "Organizational factor," "System quality," "Information quality," "Service quality," and "Playfulness"	"Perceived Usefulness," "Perceived Ease of Use," "Attitude toward use" and "Users' Intention to use"
P26	SPSS	TAM	University students—higher education—General	VR	N/A	"Perceived Usefulness," "Perceived Ease of Use," "Attitude toward use" and "Users' Intention to use"
P27	AMOS-SEM	UTAUT	University students—higher education—General	VR	"Performance Expectancy," "Effort Expectancy," "Facilitating Conditions," "Social Influence," and "Concrete experience," "Reflective observation," "Abstract conceptualisation," and "Active experimentation"	"Behavioral Intention"
P28	SPSS	UTAUT	University students—higher education—Law	VR	"Performance Expectancy" and, "Effort Expectancy"	"Behavioral Intention"
P29	PLS-SEM	TAM, flow theory and motivation-hygiene theory	Teachers and users—General	VR	"Hygiene," "Motivators, "Concentration," and "Perceived Enjoyment"	"Perceived Usefulness," "Perceived Ease of Use," "Attitude toward use" and "Users' Intention to use"

Article ID	Technique(s)	Model	Discipline/ context	Type	External variables	Core variables
P30	PLS-SEM	TAM	Higher education (University students—Medical educational	VR	"Immersion, "Imagination," and "Interaction"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"
P31	AMOS-SEM	UTAUT	Higher education (University students)—General	VR	"Concrete experience," "Reflective observation," "Abstract conception," "Active experimentation," "Performance expectancy," "Effort expectancy," "Social influence," and "Facilitating conditions"	"Behavioral intention to use"
P32	AMOS-SEM	UTAUT	Higher education (University students)—Chinese language education	VR	"Immersion, "Imagination," "Interaction," and "Learning Motivation"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"
P33	AMOS-SEM	TAM	Higher education—(Construction safety training)	VR	"Self-efficacy," "Perceived playfulness," and "Perceived price value"	"Perceived Usefulness," "Perceived Ease of Use," "Usage Attitude," and "Users' Intention to use"
P34	Psych	TAM	Higher education (University student)—General	VR	"Educational Compatibility," "Cognitive Engagement," "Social Influence," "System Attributes," "Perceived Anxiety" and "Facilitating Conditions"	"Perceived Usefulness," "Perceived Ease of Use," "Usage Attitude," and "Users' Intention to use"

Article ID	Technique(s)	Model	Discipline/ context	Type	External variables	Core variables
P35	AMOS-SEM	TAM	Middle and high school—General	VR	"Computer Self-efficacy ," "Experimental Fidelity," "Learner Interaction," "Subjective Norm," "Facilitating Conditions," "Perceived Immersion,"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"
P36	Minitab software	TAM	Higher education (University student)—General	VR	"Future perception," "COVID-19 pandemic context," "Competencies," "Appreciation," and "Recommendation"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"
P37	Descriptive statistical analysis	TAM	Higher education (University student)—General	VR	"Self-efficacy," "Goal orientation," "Performance-approach," "Performance-avoidance," "Mastery-approach," "Mastery-avoidance," "Deep learning," "Surface learning," and "Learning outcome"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"
P38	Descriptive statistical analysis	TAM	Higher education (University student)—General	VR	"Perceived Enjoyment"	"Perceived Usefulness," "Perceived Ease of Use," "Usage Attitude," and "Users' Intention to use"
P39	PLS-SEM	TAM	Facebook users—General	MV	"Social Influence," "Security, Technology availability," and "Trust"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"

Article ID	Technique(s)	Model	Discipline/ context	Type	External variables	Core variables
P40	AMOS-SEM	TAM	Training sessions– General	VR	"Wellbeing," "Realism," "Immersion," "Presence," "Social Presence," "Flow," "Stress/Worry/ Pressure," "Plausibility Illusion," "Trainer," "Feedback," and "Perceived Learning"	"Perceived Usefulness," "Perceived Ease of Use," "Usage Attitude," and "Users' Intention to use"
P41	PLS-SEM	TAM	Higher education (University students—Medical educational	MV	"Perceived Enjoyment" and "Personal Innovativeness"	"Perceived Usefulness," "Perceived Ease of Use," and "Users' Intention to use"

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Data availability Data available on request from the authors.

Declarations

Ethical statements I hereby declare that this manuscript is the result of my independent creation under the reviewers' comments. Except for the quoted contents, this manuscript does not contain any research achievements that have been published or written by other individuals or groups. I am the only author of this manuscript. The legal responsibility of this statement shell be borne by me.

Conflict of interest All authors declare no conflict of interest.

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