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Review article

Factors affecting metaverse adoption in education: A systematic review, adoption framework, and future research agenda

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ABSTRACT

The Metaverse, underpinned by its technical infrastructure, heavily relies on user engagement and behavior for successful integration into educational settings. Understanding its driving factors is essential for such a platform to transition from theory to practice, especially in educational settings. However, these factors remain elusive due to inconsistencies in infrastructure and environments. Therefore, this systematic review aims to fill this void by presenting an integrative view on Metaverse adoption in education. This is achieved via three primary dimensions: establishing a taxonomy of the factors influencing Metaverse adoption in education, proposing a framework for Metaverse adoption, and suggesting future research trajectories in this domain. The review systematically classifies the influential factors into four distinct categories: psychological and motivational factors, quality factors, social factors, and inhibiting factors. The proposed framework provides a structured approach for future studies investigating the Metaverse adoption in educational settings. The proposed framework also emphasizes that educational institutions should not only consider the technical prerequisites but also the social, psychological, and motivational aspects of the Metaverse. The study also pinpoints several critical research agendas to enhance our understanding of Metaverse adoption in education. The insights from this review are invaluable for educational institutions, policymakers, developers, and researchers, significantly enriching the emerging field of Metaverse adoption.

1. Introduction

The information and communication technology (ICT) industry experiences a paradigm shift every decade, and it has been suggested that the Metaverse is the new paradigm for the current decade [1]. In 2021, Mark Zuckerberg introduced the concept of a transformative period for the digital landscape, wherein human physical presence would be integrated into an innovative virtual construct termed the Metaverse [2]. The Metaverse is a developing technology that has drawn the interest of many educational

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researchers and practitioners [3,4]. Avatars, blockchain technology, and virtual reality (VR) headsets contributed to this new iteration of the Internet, which also features a new way of fusing the real and virtual realms [5–7]. [8]. Metaverse is a term that refers to the next generation of the Internet, where users can have an immersive online experience in a network of virtual environments [9,10]. The progression of technology supporting the Metaverse's development is accelerating quickly. This advancement incorporates the utilization of VR headsets, augmented reality (AR), extended reality (XR), and haptic gloves [11]. In this digital world, users have avatars that they can use to interact with other users and objects in the same environment.

Recently, the concept of the Metaverse has garnered significant attention from higher education institutions (HEIs). Emerging technologies in HEIs have become increasingly important in recent years [12,13]. The Metaverse offers a dynamic learning environment and a new form of real-time interaction for people [14]. The Metaverse provides an immersive learning environment that boosts motivation by enabling students to participate in virtual classes and communicate with instructors and peers via avatars [15,16]. The Metaverse offers a more comprehensive and realistic learning experience than traditional virtual or augmented reality-based education. For instance, in learning English as a foreign language, the Metaverse aims to create a life-like environment that allows learners to use English for different activities (work, learning, social events), distinct from virtual reality-based education concentrating solely on language courses [17]. As a result, the Metaverse enables learners to operate in more authentic contexts than virtual reality education. Additionally, the Metaverse provides a formal training program. Instruction comes from a non-player character master. This character can simulate an authentic training process. For example, it can mimic a three-month period in a professional training institute. In contrast, augmented reality-based training is limited. It is typically a short-term activity. This training often lasts only 1 h to complete a specified practice [18].

The development of the Metaverse has opened up new possibilities for education [19]. Despite the early stage of this technology, many studies have highlighted its potential benefits and challenges [20]. Even with considerable research, a clear understanding of the elements that drive Metaverse adoption remains elusive [21]. This deficiency impedes researchers and experts in formulating efficient methods to boost the acceptance of the Metaverse. It highlights the pressing need for more in-depth research and a detailed examination of this field [22]. Although previous studies have delved into different facets of Metaverse adoption, a comprehensive review using recognized adoption theories and models to grasp this domain has yet to be conducted [23]. This indicates a lack of comprehensive understanding and possibly a fragmented approach in prior research. In addition, earlier studies might have examined some factors influencing Metaverse adoption in education, but a comprehensive taxonomy that systematically categorizes these factors into distinct groups appears to be missing. Most attention might have been focused on the technical prerequisites, neglecting these non-technical but essential aspects. The literature also lacks a structured framework for adopting the Metaverse in education. This gap makes it difficult to systematically explore and analyze the factors influencing this adoption, thereby hindering the development of efficient strategies to encourage more widespread use of the Metaverse in educational settings. Therefore, this systematic review aims to comprehensively analyze the current literature on Metaverse adoption in education. To achieve this aim, the following research objectives were put forward.

RO1. To analyze the key factors influencing the adoption of Metaverse in education.

RO2. To propose a Metaverse adoption framework for educational purposes.

RO3. To provide critical research agendas on Metaverse adoption research.

A systematic review of multiple studies was conducted to accomplish these objectives, focusing on the latest developments in Metaverse adoption in the education sector. The review highlights the most recent trends and findings related to implementing Metaverse for educational purposes. This systematic review provides the most recurrent adoption theories for Metaverse and the factors that significantly affect its adoption in education. Additionally, this review proposes a Metaverse adoption framework for educational purposes. The proposed framework incorporates the synthesized factors, providing a comprehensive guide for institutions to assess their readiness for Metaverse adoption. This systematic review not only provides insights into the current state of Metaverse adoption in education but also identifies several promising avenues for future research. These research agendas aim to fill the gaps in the current body of knowledge and further advance our understanding of Metaverse adoption in education. Given the rapid development of Metaverse technology and the growing interest in its educational applications, this study is timely and significant. It is hoped that its findings will inform and inspire future research and practice in Metaverse adoption in education.

2. Background

2.1. Technology adoption theories and models

Theories and models of technology adoption are essential to understanding how individuals and organizations adopt new technologies. They offer insights into the determinants and processes involved in technology adoption decisions. Several theories and models have been instrumental in scrutinizing technology adoption at the individual and organizational levels. These models have been developed through a continuous process of validation and extension. Notably, the Theory of Reasoned Action (TRA) introduced by Ajzen and Fishbein [24] is a psychological model that has further evolved into the Theory of Planned Behavior (TPB) [25] and, subsequently, the Decomposed Theory of Planned Behavior (DTPB). The Technology Acceptance Model (TAM) [26], derived from the TRA, was introduced in information systems. It has been then expanded into TAM2 [27] and eventually to the Unified Theory of Acceptance and Use of Technology (UTAUT) [28]. The UTAUT model is a synthesis of other models, incorporating the aforementioned theories along with Rogers' Diffusion of Innovations (DOI), Bandura's Social Cognitive Theory (SCT) [29], and Deci & Ryan's

Motivational Model [30]. In covering the technology acceptance models, a domain-specific approach has been taken, with a chronological organization within each domain to map the evolution and interconnections between models. Despite each model's unique investigative approach to the acceptance process, common threads and themes emerge across these models.

Recent studies have applied these technology adoption models in the context of Metaverse adoption in education. For instance, Sunardi et al. [31] delved into the acceptance of augmented reality in video conference-based learning during the COVID-19 pandemic in higher education, utilizing the UTAUT2 framework. Similarly, Yang et al. [32] investigated the intent of college students to utilize the Metaverse for basketball learning, grounding their study in the UTAUT2 model. Gim et al. [33] examined the interconnectedness between the quality of VR-based education, self-determination, and learner satisfaction, incorporating the SDT, IS success model, and TAM into their analysis. Teng et al. [19] undertook an empirical study to scrutinize the factors influencing learners' adoption of an educational Metaverse platform, extending the UTAUT model in their research. Alawadhi et al. [34] explored the determinants affecting the acceptance of the Metaverse in medical training among medical students, utilizing both TAM and IDT. Kim et al. [35] probed the impact of students' perceptions on their intention to engage with the Metaverse learning environment in higher education, employing the TAM framework. Almarzouqi et al. [36] predicted users' intentions to utilize the Metaverse in medical education, incorporating TAM and IDT into their analysis. Akour et al. [37] developed a conceptual framework for evaluating Metaverse adoption in higher institutions across the Gulf area, underpinned by TAM and IDT, and conducted an empirical study to validate it. Additionally, Makransky and Mayer [38] scrutinized the advantages of immersive virtual reality for virtual field trips, applying the cognitive-affective model (CAM) in their research. These studies demonstrate the application of established technology adoption models to the emerging field of Metaverse adoption in education, enriching our understanding of the factors influencing adoption in this context.

2.2. Metaverse and education

Employing the Metaverse in education is not recent and has been the focus of scholarly debate for several years. Kemp and Livingstone (2006) scrutinized the potential of integrating virtual worlds like "Second Life" with learning management systems to enhance the educational process [39]. Collins (2008) postulated that the Metaverse could evolve into the subsequent platform for social interaction and suggested that higher education institutions should leverage this technology proactively for instructional purposes [40]. Moreover, it has been put forward that the immersive 3D digital environment enhances user interaction and communication through avatars, which augments the sense of presence [41]. In 2006, a collaborative effort was undertaken at the Stanford Research Institute International to envision the future of Metaverse technology. This summit assembled academics, technology architects, entrepreneurs, and futurists to forecast the trajectory of the Internet in the upcoming decade.

The Metaverse offers a canvas for innovation across different sectors [42]. The use of immersive technologies, such as VR, MR, AR, and XR, has increased the popularity of the Metaverse in educational applications. One benefit of the Metaverse is that it allows students to attend virtual classes and interact with teachers and classmates through avatars, providing an immersive learning experience that can improve motivation [15,16]. Another advantage is that the Metaverse can enhance collaboration among students inside and outside the classroom and school, leading to an inclusive and interactive learning experience and developing teamwork and problem-solving skills. Studies have also shown that using Metaverse in subjects such as maintenance and mathematics can enhance students' learning outcomes [14]. Researchers have identified different worlds within the educational Metaverse, such as survival, maze, multi-choice, racing/jump, and escape room [43]. While several Metaverse technologies are being used or proposed in education, there are still gaps in their implementation within the education sector. However, the Metaverse can bridge the divide between the virtual and real world through its immersive environment [44].

2.3. Virtual, augmented, and mixed reality

The Metaverse relies heavily on technological advancements, such as virtual, augmented, and mixed reality, to fully develop and provide an immersive experience [45–47]. These technologies can help the Metaverse to create a realistic simulation experience in virtual environments [48,49]. Both virtual and augmented reality offer different levels of immersion [50,51], but share similar characteristics in immersion, presence, and engagement [52]. Immersion measures the technology's virtual, augmented, and mixed reality capability to deliver a realistic environment [53]. Presence is the user's perception of being in that environment [54,55]. Engagement refers to the increase of interest, concentration, and enjoyment of the learners, further divided into behavioral, emotional, and cognitive engagement [56]. The use of virtual, augmented, and mixed reality technologies in education has positively impacted learning outcomes. Due to the immersive nature of these technologies, they allow learners to engage with simulated real-life situations, improving learning efficiency [50]. Additionally, repeating learning scenarios in these technologies improves students' ability to absorb and understand new information [56].

Furthermore, the use of virtual reality and augmented reality technologies allows for enhanced experiential learning by providing a broad range of sensory-motor interactions that might not be possible in real-life scenarios due to high costs or risks [57]. Allcoat et al. [58] have shown that virtual reality produces a higher sense of presence and immersion than mixed reality, which leads to a better learning experience. Besides, using virtual, augmented, and mixed reality in education has increased learners' engagement, motivation, and dedication. Results of research conducted by Marks and Thomas showed that 71.5% of subjects reported improved learning performance when using virtual and augmented reality for the first time [59]. It has also been found that studying physics subjects in a mixed reality environment can lead to higher levels of engagement and positive learning attitudes [60]. Additionally, mixed reality has been shown to improve students' abilities in certain subjects. Virtual reality and mixed reality have been found to lead to higher engagement levels than traditional methods, with virtual reality producing higher positive emotions [58].

From the Metaverse viewpoint, the Metaverse has the potential to enhance educational and social accessibility for students with disabilities. Providing an immersive learning environment through virtual reality and augmented reality can help students with autism, special needs, and social interaction difficulties to improve their interpersonal and learning skills [61]. They can engage with material and instructors safely without feeling overwhelmed. Using virtual and augmented reality visuals in the Metaverse allows students to practice skills and interact with others in a controlled environment. Additionally, the Metaverse enables students to explore various worlds through storytelling and visualization, such as virtual tours and 360-degree storytelling on global issues like education, public health, urban development, climate change, and international trade [61].

2.4. Mirror world

A Mirror World, such as Google Earth or Microsoft Virtual Earth, is a digital representation of real-life where information from physical space is replicated in virtual form, often with additional simulated elements [62]. The concept of the Metaverse can be traced back to the 1992 book “Mirror Worlds” by David Gelernter [63]. Mirror Worlds, Metaverse, Multiverse, and Digital Terraforming are related concepts, but their meanings may differ depending on the context and can overlap in certain aspects [62]. In other words, the Mirror Worlds Metaverse is described as extending the real-world context through GPS and networking technology to address spatial and physical limitations in teaching and learning [64]. Only one study was identified as a Mirror World Metaverse type [65]. The study implemented game-based immersive learning by assembling students in a lecture hall, and the lecture was simultaneously “mirrored”

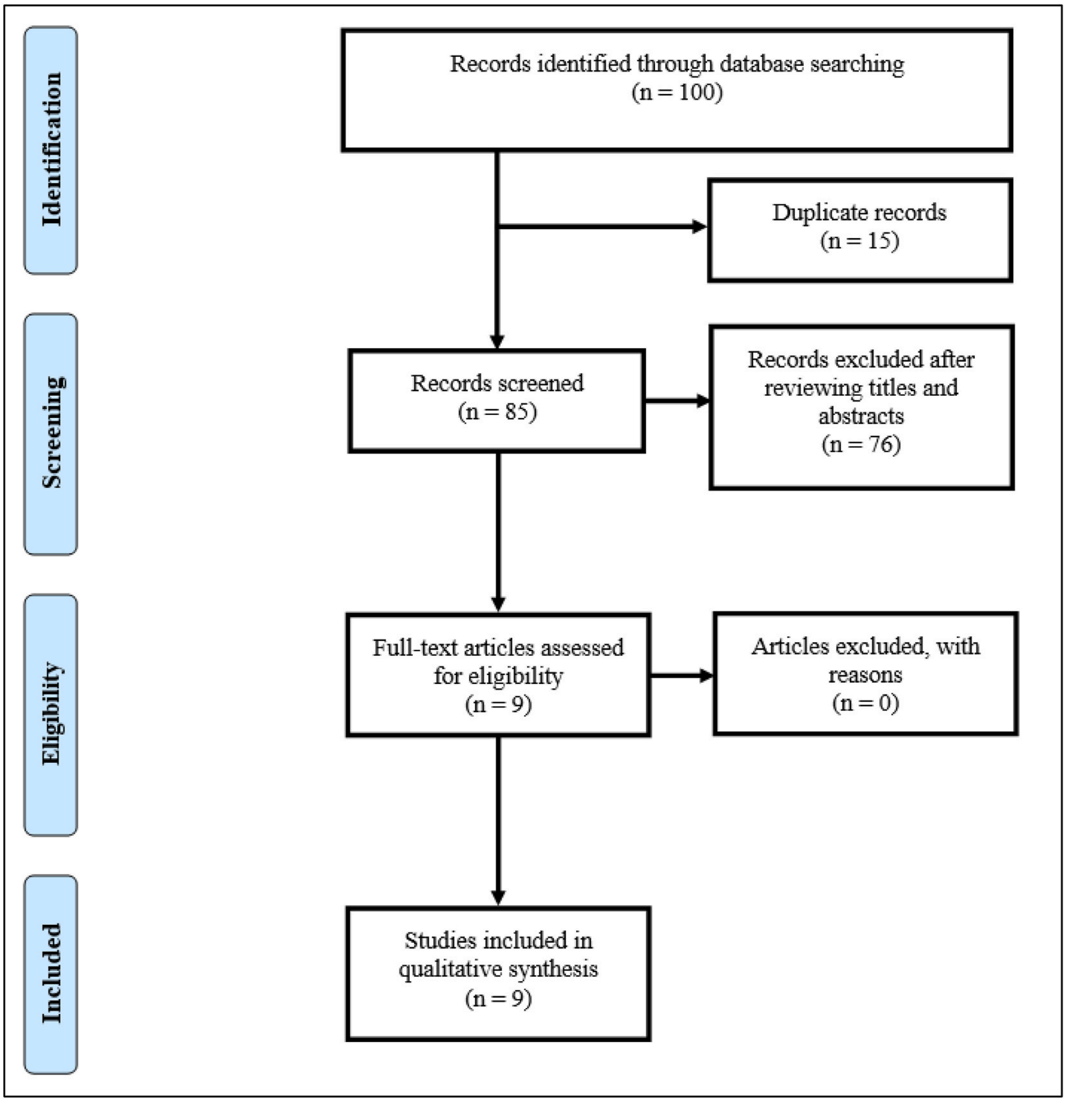

Fig. 1. PRISMA flowchart.

onto an online platform. Although the study showcased an "efficient expansion" of the real world, it did not fully exploit the potential of the Mirror World Metaverse. For example, in Mirror World, users can interact with others from remote locations by playing games and accomplishing meaningful tasks. However, the students in the study, who were convened in the lecture hall, could have engaged in the game collectively with another group of students at a different university or even another country.

According to Tlili et al. [66], who focused on the studies related to the various types of the Metaverse, they found that most of the studies reviewed focused on the Virtual Worlds Metaverse. In contrast, fewer studies explored augmented reality, and even fewer explored Lifelogging and Mirror Worlds. Although the studies discuss the use of 3D technologies in virtual environments, they do not delve into the technology to a high level of complexity [66]. For example, none of the studies address communication and collaboration with AI characters. Furthermore, the studies do not fully exploit the explicit technology of Lifelogging and Mirror Worlds to a high level in educational settings. Future studies should focus on exploring these areas with a higher level of sophistication, particularly in integrating augmented reality with Lifelogging or Mirror Worlds with simulation technologies.

3. Methods

This research aims to identify the key factors influencing the Metaverse adoption in education through a systematic literature review. This type of review follows a systematic, open, and repeatable approach to identifying, analyzing, and combining the findings of previous studies [67]. The study was carried out using the PRISMA 2020 guidelines [68], which provide a framework for creating a well-organized and structured report on systematic reviews and analyses of international literature. Furthermore, the formulation of the research objectives plays a critical role in the systematic review process as it sets the foundation and scope of the research. Fig. 1 illustrates the stages of the review methodology that were used in this study.

3.1. Eligibility criteria

The inclusion and exclusion criteria were used to determine the suitability of the studies to be included in the systematic review. Studies had to be written in English and that at least answer one potential of the research objectives are eligible for inclusion. In addition, all papers that discussed Metaverse in education and were published up to December 2022 were considered. Empirical studies that examined relevant factors were given priority over other types of publications. On the other hand, papers that did not have any connection to the research objectives, grey papers (i.e., papers excluding Metaverse with no relevance to research objectives or incomplete papers), publications whose text was not accessible through research engines or via the authors themselves for verification, and short papers with less than three pages were excluded from the review. This helped ensure the review results were based on high-quality, relevant, and reliable studies. Table 1 presents the eligibility criteria for the review selection.

3.2. Source of information and search strategy

The empirical studies in this review were obtained by searching databases for information on Metaverse adoption. The literature was searched using appropriate keywords. We utilize substitute terms and combine them by using Boolean operators. The term "metaverse" AND ("adoption" OR "acceptance" OR "intention" OR "behavior" OR "behaviour") AND ("education" OR "learning") were used in the search. The Web of Science and Scopus databases, recognized for their vast academic literature collections, were used in this review to collect studies. These databases were selected based on their high impact, extensive disciplinary coverage, and established reputation in supporting rigorous systematic literature reviews [69]. These databases encapsulate all high-quality papers published across numerous esteemed platforms, such as the ACM Digital Library, Emerald, Google Scholar, IEEE, ScienceDirect, Springer, Taylor and Francis, and Wiley Online Library. This encompassing scope secures a comprehensive and diverse body of literature relevant to the research topic. The selection strategy mitigates potential bias and oversight by aligning with the inclusion and exclusion criteria. Given their role in appraising journal productivity and citation impact, reliance on these databases helps incorporate diverse studies that are pivotal to understanding the Metaverse's adoption in education while minimizing potential bias and omissions.

Table 1
Eligibility criteria.

Criteria	Inclusion	Exclusion	Rationale
Language	The study is written in English.	The study is written in a language other than English.	To ensure the research team can fully comprehend and analyze the studies.
Relevance	The study addresses at least one of the research objectives and discusses the Metaverse in an educational context.	The study has no connection to the research objectives or the Metaverse.	To ensure the paper's content is directly relevant to the study's research objectives.
Type of study	Empirical studies that examined relevant factors affecting Metaverse adoption in education were prioritized.	Theoretical papers, reviews, or opinion pieces that do not present empirical findings.	To prioritize studies that provide concrete evidence on the factors influencing Metaverse adoption in education.
Access	The full text of the publication is accessible through our chosen databases or directly from the authors.	Full text is not accessible.	To ensure the research team can conduct a thorough analysis of each study.
Paper length	The study is of standard length (more than three pages).	The study is too short (less than three pages).	To exclude studies that do not provide sufficient data or analysis.

The process of searching is summarized in Fig. 1, showing the number of papers left at each stage. The initial search of the databases resulted in 100 papers. After eliminating duplicates ($n = 15$), 85 papers were left for the screening process. During the screening process, the abstracts, introductions, and conclusions were checked, which resulted in the exclusion of 76 articles. Thus, nine papers remained for the eligibility assessment. There was no exclusion of any articles during the eligibility assessment. A total of nine articles were finally selected for data extraction and synthesis.

3.3. Data extraction and analysis

We have collected and compiled the data from the studies included in the review into a Microsoft Excel spreadsheet. Information such as the names of authors, year of publication, sample size, sampling method, study group, data collection methods, country, and study design were all gathered for each study. We have also collected independent, dependent, and moderator variables. To further ensure the robustness and reliability of the data extraction and analysis process, an in-depth analysis of each included article was undertaken by the first and fourth authors of this review. We adopted a rigorous approach, where any discrepancies identified in the analyses were promptly addressed through deliberations and supplemental evaluations of the disputed research during the screening process. This methodological approach underscores our commitment to presenting a comprehensive and reliable literature review. During the screening process, both reviewers consistently and unanimously concurred on whether to include or exclude articles, adhering to the predefined eligibility criteria. In every instance, complete consensus was reached regarding the suitability of each article for inclusion in the systematic review.

4. Results and discussion

4.1. Characteristics of included studies

This section describes the characteristics of the studies included in the final systematic review. The review included nine studies investigating the adoption of Metaverse, virtual reality, and augmented reality in education [19,31–38]. These studies were conducted between 2021 and 2022, and participants primarily consisted of students and learners from various countries. Most of the studies (6 out of 9) employed either the Technology Acceptance Model (TAM) or the Unified Theory of Acceptance and Use of Technology (UTAUT/UTAUT2) as their theoretical framework. Other theories included the Self-Determination Theory (SDT), the Information Systems (IS) Success Model, and the Cognitive-Affective Model (CAM). All nine studies utilized surveys as their primary data collection method, with seven of them employing online surveys. The study populations were mainly students and learners, focusing on individual-level analysis in various countries, including Indonesia, China, South Korea, the United Arab Emirates (UAE), Saudi Arabia (KSA), and Oman.

4.2. Key factors affecting the adoption of metaverse in education

This section summarizes the primary research findings related to the key factors influencing Metaverse adoption in education, as identified through a systematic literature review. This review aims to consolidate existing knowledge and provide a foundation for developing the Metaverse adoption framework in education. The identified key factors were categorized into four main groups: 1) psychological and motivational factors, 2) quality factors, 3) social factors, and 4) inhibiting factors. Each category is presented separately in the following subsections.

Table 2
Summary of psychological and motivational factors.

Variable	Frequency	Studies
Perceived ease of use/Effort expectancy	4	[33–36]
Facilitating conditions/Compatibility	5	[19,31,32,36,37]
Perceived trialability	2	[36,37]
Perceived usefulness/Performance expectancy	8	[19,31–37]
Habit	2	[31,32]
Attitude	1	[32]
Hedonic motivation/Enjoyment	4	[31,32,34,38]
Immediate retention	1	[38]
Immersion	1	[38]
Interest	1	[38]
Satisfaction	3	[19,36,37]
Perceived autonomy	1	[33]
Perceived competence	1	[33]
Perceived flow	1	[33]
Perceived relatedness	1	[33]
Presence	1	[38]
Personal innovativeness	3	[34,36,37]

4.2.1. Psychological and motivational factors

The examined studies included a variety of factors relating to individuals' psychological and motivational states that influence the Metaverse adoption or acceptance in education. Psychological factors refer to the mental and emotional processes that impact human behavior [70,71]. These include beliefs, attitudes, personality traits, motivations, thoughts, and emotions. These factors are crucial in comprehending behavior and can influence how individuals react to and perceive their surroundings. The factors are listed in Table 2 and described in detail in the following subsections.

4.2.1.1. Perceived ease of use. Perceived ease of use (PEOU) refers to an individual's perception of the effort required to use a particular product, process, or system [72]. It is imperative to report that the terms effort expectancy and perceived ease of use have similar meanings. Both terms refer to the degree of ease or difficulty individuals perceive when using new technologies. This includes aspects like ease of installation, implementation, maintenance, and operation. Studies have shown that ease of use is critical in predicting technology acceptance and intention to use technologies like the Metaverse in different educational contexts [33–36]. One of the studies indicated a notable relationship between perceived usefulness and PEOU in adopting the Metaverse for learning purposes [36]. It was observed that a higher level of perceived usefulness and PEOU was associated with a greater likelihood of adopting the Metaverse [36].

4.2.1.2. Facilitating conditions. Facilitating conditions (FC) in the context of the Metaverse refer to learners' perceptions of the technical and organizational resources available to support their use of the platform [31]. It can be noted that the terms facilitating conditions and compatibility have similar meanings. Several articles reported the significant role of facilitating conditions in affecting the adoption of the Metaverse in the educational sector [19,31,32,36,37]. For instance, a study by Yang et al. [32] investigated the intention of college students to utilize the Metaverse for basketball education using the UTAUT2 framework. Their findings revealed that college students' attitudes towards learning basketball via Metaverse technology are significantly impacted by facilitating conditions. These conditions pertain to the accessibility of essential resources and information required for basketball education.

4.2.1.3. Perceived trialability. The perception of trialability is strongly connected to an individual's intention to use technology. Multiple studies have supported that trialability positively impacts the adoption of new systems [36,37]. The term trialability pertains to the ease of experimenting with new technology. It also encompasses other related ideas, such as the degree of effort required and the potential risks involved, including the ease of undoing and recovering operations if necessary [73]. How a technology is perceived in terms of its trialability can greatly affect whether an individual is willing to adopt and utilize it effectively. For example, Almarzouqi et al. [36] suggested that perceived trialability is a significant predictor of Metaverse adoption among students in medical education.

4.2.1.4. Perceived usefulness. Perceived usefulness refers to an individual's belief in how much their use of a particular information technology can enhance their work performance, such as by improving efficiency, productivity, or accuracy [32,35]. Usefulness is a critical factor that affects whether people adopt and continue to use new technologies [31,34]. The selected studies in this review have used the terms perceived usefulness and performance expectancy interchangeably to refer to the same construct. It is imperative to mention that this construct was examined by almost all the selected studies [19,31–37]. For example, Akour et al. [37] conducted a study to examine students' attitudes toward utilizing the Metaverse for educational applications in the Gulf region. In addition to TAM's constructs, the research evaluated user satisfaction and personal innovativeness. Moreover, the study developed a conceptual model linking personal characteristics with technology-based features. The study's findings revealed that perceived usefulness emerged as a significant predictor of users' intention to engage with the Metaverse platform.

4.2.1.5. Habit. A habit is a learned behavior that becomes progressively automatic and active in an individual's learning process [74]. The extent of one's interaction and familiarity with a technology determines the development of habits, which can occur at varying degrees over time [75]. The results of the study [32] suggested that there is a positive cause-and-effect relationship between habit and the behavioral intention of college students who are using the Metaverse to learn basketball. The results also indicated that habit has the strongest influence on behavioral intention, which suggests that it is a crucial factor for using the Metaverse platform to learn basketball. Sunardi et al. [31] also discovered that habit is a crucial variable significantly affecting behavioral intention to use augmented reality in video conference-based learning in higher education. This indicates that the use of augmented reality in the learning process has the potential to become habitual for the participants. In addition, the notable influence of habit on behavioral intention implies that individuals are more inclined to use augmented reality regularly and include it in their learning procedures.

4.2.1.6. Attitude. Attitude is the extent to which a person has a positive or negative evaluation or appraisal of the behavior in question [25]. Another definition refers to the attitude as an interaction in memory between a particular subject and a summary evaluation of the subject [76]. When an individual assesses the consequences of using a product or adopting a particular behavior positively, it inspires them to have a favorable attitude and engage in that behavior [77]. The findings of a study conducted by Yang et al. [32] suggested that attitude is one of the critical variables that significantly impacts the usage behavior and behavioral intention of college students using the Metaverse to learn basketball. When students have a positive attitude towards using the Metaverse to learn basketball, it improves their learning outcomes and motivates them to use the platform in other courses.

4.2.1.7. Hedonic motivation. Hedonic motivation is an individual's feeling of pleasure or happiness when using new technology [78].

It refers to how learners perceive that the Metaverse can impact their emotional feelings and responses. The desire for pleasure and enjoyment can impact a consumer's purchase intent for products advertised on social media. Marketers, for example, can design more creative and engaging advertisements that increase their intrinsic effectiveness and interactivity, ultimately promoting consumers' hedonic motivation [79]. The terms hedonic motivation and enjoyment are used interchangeably in the included studies and have similar meanings [31,32,34,38]. Several studies underscore the role of hedonic motivation in the domain of Metaverse adoption in education. For instance, Sunardi et al. [31] discovered that hedonic motivation substantially influences the acceptance of augmented reality in video conferences among university students. Complementing this, another investigation established that enjoyment significantly contributes to the efficacy of immersive multimedia learning [38].

4.2.1.8. Immediate retention. The immediate retention factor represents a learner's capacity to recall and retain information shortly after its presentation [80]. This factor is frequently employed to assess the short-term effectiveness of learning materials or teaching methods by measuring the degree to which information is assimilated and preserved in the learner's memory immediately following exposure. Various factors can influence immediate retention, such as enjoyment and interest, as well as the quality and organization of learning materials [38]. Evaluating immediate retention enables educators and instructional designers to identify areas for improvement in their teaching strategies or learning materials, ultimately aiming to enhance the overall learning experience and outcomes [81].

4.2.1.9. Immersion. Immersion indicates how well a system creates a realistic virtual environment and blocks out the physical world [82]. In the context of Metaverse gaming, immersion can be used as a metric to evaluate technology-enabled extended reality contexts, and it is not based solely on the game's aesthetics [83]. Immersion in Metaverse gaming can positively impact a player's sense of usefulness [83]. Makransky and Mayer [38] conducted a study examining and exploring the immersion principle in multimedia learning. The research indicated that students who used a head-mounted display (HMD) for a virtual field trip had higher immediate and delayed post-test scores than those who used an onscreen video with lower immersion. Moreover, the same student group with HMD expressed greater levels of presence, interest, and enjoyment, which supports the immersion principle in multimedia learning.

4.2.1.10. Interest. The interest factor in learning refers to the level of curiosity, fascination, and enjoyment a learner feels when participating in a learning activity [84]. Learners interested in a topic or activity are likelier to interact with it, remember information better, and perform better on tests. Makransky and Mayer's study examines whether higher-immersion environments promote greater interest levels among students and the potential correlation between interest and presence [38]. According to their results, the use of HMD in a virtual field trip proved to be more beneficial than a 2D video version in terms of presence, enjoyment, interest, short-term, and long-term retention. The findings also indicated that immediate post-test results were affected by enjoyment, while delayed post-test results were influenced by interest.

4.2.1.11. Satisfaction. Satisfaction is essential in motivating users to use specific technologies, products, or brands. Users' satisfaction refers to the affirmative emotions that users associate with using new technology, as it aligns with their expectations and anticipated uses [37]. Teng et al. [19] explored the factors that affect the adoption of an educational Metaverse platform called "Eduverse" using an extended UTAUT model. The results demonstrated that performance expectancy, facilitating conditions, social influence, and effort expectancy had a significant positive impact on learners' satisfaction with the Eduverse. Furthermore, learners' satisfaction was positively associated with their continued usage intention, but their intention to use the Eduverse decreased when they perceived risks [19]. Another study [36] found that user satisfaction is an essential determinant of users' intention to use the Metaverse in medical education. Akour et al. [37] also investigated the relationship between adoption-based properties and users' satisfaction. The results showed that complexity, observability, compatibility, and trialability strongly influenced students' adoption of the Metaverse in higher education.

4.2.1.12. Perceived autonomy. Perceived autonomy is defined as an individual's perception of having the ability to make choices and exert control over their actions and behaviors [85]. Gim et al. [33] developed a research model that combines several theories to explore variables affecting learner satisfaction in VR education, highlighting the importance of self-directed learning and flow in achieving optimal educational practices in the Metaverse. Upon examining the obtained results, it can be concluded that the hypothesis proposing a positive correlation between perceived autonomy and perceived ease of use is unsupported. This indicates that the participants of the study already had prior experiences using VR and AR-based content autonomously, and therefore perceived autonomy did not significantly affect ease of use. The results suggested that people tend to go for VR and AR-based educational courses due to their convenience in comparison to other online content.

4.2.1.13. Perceived competence. Individuals' desire for control and leverage when striving for important goals leads to the need for perceived competence, which is the subjective perception of their ability to accomplish a task or attain a goal [30]. A study [33] discovered several variables, including perceived competence encompassed by self-determination theory, positively influenced learner satisfaction when utilizing Metaverse-based VR content. This impact was particularly evident in perceived usefulness, ease of use, and flow experience. The results highlighted the importance of self-determination theory as a foundational framework for studies measuring learner satisfaction in VR education.

4.2.1.14. Perceived flow. Perceived flow is the personal perception or subjective experience of being in a flow state. It is a psychological construct that reflects how individuals perceive their engagement, enjoyment, and satisfaction while engaging in a specific activity [86]. In this context, learning flow refers to a state where learners are fully engaged and absorbed in the learning process, enjoying the content and experiencing optimal learning, which can result in increased motivation, engagement, and focus [33]. Gim et al. [33] found that self-determination theory significantly impacts VR-based education in the Metaverse, indicating its importance in virtual education, similar to online education. Surprisingly, the study found that information and service quality did not affect learners' flow, but system quality did. This suggests that the stability of VR-based content in the Metaverse is crucial in determining learners' flow.

4.2.1.15. Perceived relatedness. The psychological concept of perceived relatedness is associated with an individual's sense of belongingness and subjective connection to others in a social environment [87]. Perceived relatedness is a crucial factor affecting learner satisfaction in Metaverse-based education [33]. A study indicated that learners who perceive a greater sense of relatedness in the virtual environment are more likely to experience positive effects in their perceived flow, ease of use, and usefulness of the content [33].

4.2.1.16. Presence. Presence in the context of virtual simulations refers to the psychological sensation of feeling present or "being there" in the simulated environment, as described by Slater [88]. In the framework of Metaverse education, social agency theory suggests that when students have a higher sense of presence, they tend to engage in more profound cognitive processing and put in more cognitive effort to comprehend material [89]. Makransky and Mayer [38] revealed that generating immersive educational experiences that foster a high level of presence can positively impact learning through cognitive and affective processes, including enjoyment and interest, which are crucial for capable and enthusiastic learners. Moreover, matching the affordances of immersive technology with appropriate instructional design is vital to enhancing learning outcomes. The study applied evidence-based instructional design principles to both the HMD and 2D versions of a virtual field trip. The immersive HMD experience increased presence, enjoyment, interest, and immediate and long-term retention.

4.2.1.17. Personal innovativeness. Personal innovativeness is defined as the willingness of users to accept and use new technology, which includes readiness as an external factor to measure the acceptance of technology [90]. Alawadhi et al. [34] investigated the determinants influencing the adoption of Metaverse in medical training. The findings revealed significant associations between personal innovativeness, which is influenced by perceived ease of use, and perceived usefulness of the technology. Similarly, another study [36] suggested that personal innovativeness is essential in adopting Metaverse-based medical training. Students more willing to embrace technological innovations are likelier to have a positive attitude toward Metaverse adoption. Those students tend to perceive uncertainty positively and view it as an opportunity for learning and growth. Therefore, personal innovativeness can be considered an essential factor in the adoption of innovative technologies in medical education.

4.2.2. Quality factors

Quality refers to "the measures that determine the perceived quality of an information system (IS) or technology" [91]. In the IS success model proposed by DeLone and McLean (1992), quality factors are deemed integral predictors of IS success. The model encompasses three quality factors most frequently referred to in IS research: information quality, service quality, and system quality. The acceptance or sustained utilization of new technology hinges upon the user's perception of its quality. Numerous studies have underscored the significant role of quality factors in comprehending users' continuous usage of various technologies [92]. Table 3 summarizes the quality factors affecting the Metaverse adoption in education. The subsequent subsections describe each of these factors.

4.2.2.1. Information quality. Information quality pertains to the degree of excellence in the attributes of information that an information system produces, such as accuracy, usefulness, and timeliness [33]. Evaluating information quality based solely on content and accuracy can sometimes lead to conflicting evaluations, depending on the intended use and timing of the information. In this context, information quality refers to the accuracy, reliability, relevance, timeliness, and overall trustworthiness of the information and resources available within the Metaverse environment for educational purposes. As educational institutions and learners begin integrating Metaverse technologies into their learning experiences, ensuring that the information shared and used is of high quality to facilitate effective learning outcomes is essential.

4.2.2.2. System quality. System quality refers to "the degree of technological excellence of an information system that users evaluate

Table 3
Summary of quality factors.

Variable	Frequency	Studies
Information quality	1	[33]
Service quality	1	[33]
System quality	1	[33]

while using the system as it acquires and processes information to facilitate communication" [33]. This encompasses the system's hardware, software, and network components' quality, in addition to the accessibility of the system, the degree to which it fulfills user requirements, its response time, and its capacity for flexibility and adaptability with user needs. System quality in this context refers to the effectiveness, efficiency, and overall performance of the Metaverse platforms used for educational purposes. As educators and institutions consider implementing Metaverse technology for learning and teaching, assessing the system's quality is essential to ensure a positive impact on the educational experience.

4.2.2.3. Service quality. Service quality refers to the level of excellence in an information system's services or the extent to which it satisfies user needs concerning its benefits [93]. Gim et al. [33] found that system quality is a crucial factor in learners' flow or their state of immersive engagement and enjoyment. In contrast, neither information quality nor service quality had a significant impact on flow. This unexpected finding underscores the significance of system stability in VR-based education within the Metaverse. It implies that guaranteeing superior quality and stability in the technical components of virtual content is essential for fostering an immersive and productive learning experience.

4.2.3. Social factors

Social factors refer to how individuals within a social group impact each other's actions and decisions regarding using and accepting new technologies [94]. Social factors can greatly influence the adoption of a specific technology. The social context in which technology is introduced can impact its adoption, particularly in communities with limited access to digital tools and education. In this review, two social factors were found to influence the adoption of Metaverse in education, as specified in Table 4. The following subsections describe each of these factors.

4.2.3.1. Perceived observability. Perceived observability is a term used in the context of innovation diffusion, which refers to the extent to which the results of an innovation are visible to others [95]. It is the degree to which individuals can observe and understand the benefits of new technology or innovation by observing others who have already adopted it. For example, it was found by Almarzouqi et al. [36] that perceived observability positively influences students' satisfaction in adopting the Metaverse for medical educational purposes. Similarly, Akour et al. [37] stated that the more positive perceived observability is, the higher the learners' satisfaction in adopting the Metaverse in educational systems.

4.2.3.2. Social influence. Social influence is how other individuals influence a person's attitudes, beliefs, and actions. It encompasses how someone is swayed by the views, conduct, or prospects of others and can be either through personal interactions or through various forms of media. When it comes to using the Metaverse in education, social influence pertains to the extent to which an individual's choice to adopt or employ the Metaverse is swayed by the viewpoints or judgments of others, like teachers, relatives, or peers. Research has revealed that social influence considerably impacts learners' satisfaction, thereby influencing their continuous engagement with the Metaverse platform for educational objectives [19]. On the other hand, Sunardi et al. [31] studied the acceptance of augmented reality in video conferences to motivate and inspire learners. They found that social influence is positive but has little significance since this technology is still new and requires time to persuade relevant influence partners [31]. Furthermore, the use of the Metaverse for learning basketball by college students is not significantly impacted by social influence [32].

4.2.4. Inhibiting factors

Inhibiting factors hinder the adoption or implementation of a particular technology, process, or innovation [19]. Adopting the Metaverse in education can be impeded by two inhibiting factors, as found in this systematic review. The inhibiting factors are listed in Table 5 and described in the following subsections.

4.2.4.1. Perceived risk. Perceived risk is the subjective assessment of the potential loss or harm associated with a decision or action [96]. In electronic services, perceived risk often involves concerns about the safety and security of personal information, which can lead to reduced adoption rates, lower levels of engagement, and reduced trust in service providers [97]. Even if users are satisfied with a product or service, their trust in the provider may be compromised if they perceive the risk of harm or loss as high, leading to a reluctance to continue using the service [98]. Therefore, addressing user concerns about safety and security is crucial for building trust, increasing adoption rates, and promoting positive user experiences in electronic services. Teng et al. [19] found that learner's intention to use the Eduverse platform was decreased significantly after they perceived risks, such as providing personal information (e.g., mobile phone numbers) upon registration on the platform. Therefore, addressing user concerns and minimizing perceived risk are pressing issues that require a solution.

Table 4
Summary of social factors.

Variable	Frequency	Studies
Perceived observability	2	[36,37]
Social influence	3	[19,31,32]

Table 5
Summary of inhibiting factors.

Variable	Frequency	Studies
Perceived risk	1	[19]
Perceived complexity	1	[37]

4.2.4.2. Perceived complexity. Perceived complexity refers to an individual's subjective assessment of the difficulty and technical expertise required to use a particular technology [99]. The more complex a technology appears, the more difficult it may be to adopt or integrate into an organization [100]. Perceived complexity can create a sense of uncertainty and lead to a lack of confidence in the effectiveness of the technology [100]. As an emerging technology like the Metaverse, its complexity is an essential factor to be addressed to ensure learner satisfaction. Akour et al. [37] studied the students' perceptions of adopting the Metaverse for educational purposes in the Gulf area. The results showed that students evaluate the importance of less complexity as a positive and significant factor in adopting the Metaverse for instructional purposes. Therefore, simplicity is the most effective means of promoting Metaverse adoption.

4.3. Proposed Metaverse adoption framework in education

The objective of this study was to conduct a systematic and in-depth review of the literature to identify the main factors that contribute to predicting the adoption of the Metaverse in the education sector. The study's outcomes are not geographically constrained and can be applied on a worldwide scale. The literature review involved analyzing various studies to identify the critical factors to consider when adopting the Metaverse in education. This review identified 23 factors, grouped into four main categories, including psychological and motivational factors, quality factors, social factors, and inhibiting factors. Based on these four categories and their interrelationships in the analyzed literature, we proposed a Metaverse adoption framework that includes the intention to use, learner stratification, long-term retention, and usage behavior as target variables. The proposed adoption framework is depicted in Fig. 2. This provides a comprehensive framework for understanding the complex relationships between various factors and their effects

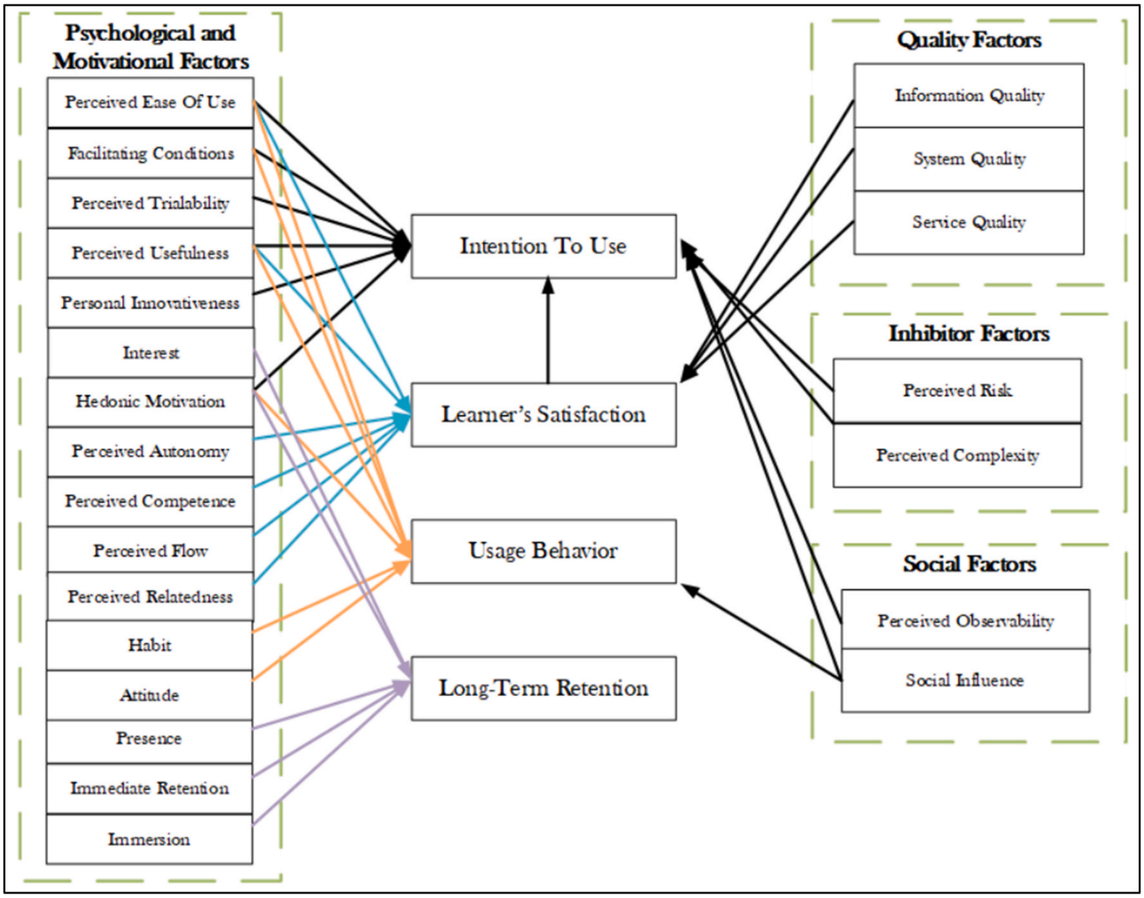

Fig. 2. Proposed Metaverse adoption framework.

on successfully integrating the Metaverse environment in educational settings.

This study highlights the critical target variable found in the literature review: the intention to use the Metaverse. The intention to use the Metaverse is a crucial factor in higher education and has been identified as the dependent variable in six studies [19,31,34–37]. Several independent variables have been identified to influence the intention to use the Metaverse, including perceived usefulness, facilitating conditions, perceived ease of use, and hedonic motivation. These factors significantly affect the intention to use the Metaverse in different aspects of education [19,31,34–37]. The intention to use the Metaverse in education is determined by the perceived value and benefits students can gain. This result is similar to Ref. [50]'s findings, which suggest that perceived usefulness significantly impacts users' intention to use. Students are more inclined to adopt the Metaverse if they believe it is beneficial, simple, and entertaining. External variables like the availability of technology and technical help can also influence the intent to use [31]. In other words, students are more inclined to adopt the Metaverse if they believe it will assist them in accomplishing their objectives and improve their learning experience. To ensure the success and acceptance of Metaverse in educational contexts, educators must consider these elements when developing and implementing it.

Additionally, perceived trialability, personal innovativeness, and learner satisfaction are other psychological factors influencing the intention to use the Metaverse in education. However, their impact may be less important than those of other variables. Although perceived trialability can influence students' eagerness to experiment with new technology, personal innovativeness may not be as important in deciding intent to employ the Metaverse, and learner satisfaction may not be as effective as other variables. Two inhibiting variables that can have a detrimental impact on the intention to use the Metaverse in education are perceived risk and perceived complexity. Students may be less inclined to adopt the Metaverse if they believe that using it would result in undesirable effects or that it is too complicated to operate [19]. This can reduce people's desire to use the Metaverse environment and reduce its usefulness in educational contexts.

On the other side, perceived observability and social influence are two social factors influencing the desire to employ the Metaverse positively. When students perceive that using the Metaverse is encouraged by social norms, they are likelier to use it [31,36]. As a result, while adopting the Metaverse in education, educators need to consider these factors. By lowering perceived risk and complexity, educators may foster a more welcoming atmosphere that increases student involvement and technology adoption. Furthermore, educators can increase perceived observability and social influence by emphasizing the benefits of technology and building a culture of support and encouragement for its use. By addressing these social and inhibiting aspects, educators can boost the intention to use the Metaverse environment in education and optimize its potential to improve student performance.

Learner's satisfaction is another target variable found in this study. Various psychological factors related to how students perceive and interact with the Metaverse environment can affect this dependent variable. These variables include how easily students can use the technology, how valuable they believe it to be for their learning goals, how much control they have when using it, how competent they perceive when using it, and how easily they can reach a state of immersive concentration when using the Metaverse [33]. Therefore, when developing educational experiences that incorporate the Metaverse environment, educators need to consider these psychological factors and strive to create environments that render the technology easy to use, useful, autonomous, competence-enhancing, and capable of fostering flow, which can lead to higher learner's satisfaction and acceptance of the technology. In addition to psychological factors, quality factors of information, system, and service are other critical variables that affect the learner's satisfaction in adopting the Metaverse in education. High-quality information, system performance, and supportive services are required to maximize learner satisfaction and, as a result, technology adoption [33]. Thus, maintaining these quality factors requires ongoing monitoring and development and providing students with appropriate training and assistance to improve their experience.

Usage behavior is another outcome variable identified in this review. It can be influenced by some psychological and social factors. Only one study examined the usage behavior of the Metaverse in learning [32]. This systematic review showed that psychological and motivational factors are important in determining usage behavior. For example, learners are more likely to adopt and continue using the Metaverse if they find it simple to use. Moreover, access to necessary resources and support, for example, is important in determining usage behavior. Students are more inclined to utilize technology effectively and continue to use it if they have access to the required tools and support. Another key aspect that can influence usage behavior is perceived usefulness. Students are more willing to use technology regularly if they believe it will improve their learning outcomes. Hedonic motivation can also influence user behavior [32]. Students have a greater opportunity to continue using technology if they enjoy it. Offering engaging and exciting learning opportunities via the Metaverse platform can improve hedonic motivation.

While not equally important as the previously mentioned factors, habits and attitudes towards the Metaverse can also impact usage behavior. If students habitually use the Metaverse in their lessons or other educational activities, they are more likely to continue using it in the future. In addition to psychological factors, only one of the two social factors was found to affect the usage behavior, which is the social influence. According to Ref. [32], students who believe their colleagues are utilizing the Metaverse platforms are more inclined to use them, and those who receive good feedback from their peer group are likelier to keep using them. Apart from that, none of the quality and inhibiting factors were found to have any direct or indirect effect on usage behavior. However, quality and inhibiting factors should be considered in future research as they can increase the probability of adopting the Metaverse in education among students.

The long-term retention as a target variable is a significant aspect that can be influenced by a variety of psychological and motivational factors. These factors include hedonic motivation, presence, immediate retention, immersion, and interest [38]. Similar to our findings, previous research indicated that students with high levels of these variables are more likely to retain the knowledge they acquired and keep using the Metaverse platforms in their education activities over an extended period [101]. Educators can use these findings to create immersive and interesting Metaverse learning experiences that stimulate good feelings, improve presence, encourage immediate retention, and include material pertinent to students' interests. Education professionals can encourage long-term retention in students who use Metaverse platforms for learning by considering these psychological and motivational variables.

5. Future research agenda

The Metaverse is a rapidly evolving technology with the potential to revolutionize education. However, much research still needs to be investigated to understand how the Metaverse can be effectively used in the classroom. Table 6 lists key areas that need to be considered in future research.

6. Conclusion

In conclusion, this systematic review thoroughly examined the current state of Metaverse adoption in education, outlining crucial influencing factors categorized into four categories: psychological and motivational factors, quality factors, social factors, and inhibiting factors. Based on this taxonomy, we have proposed a framework for Metaverse adoption to comprehensively understand how these factors intertwine within educational settings. The proposed framework also emphasized that educational institutions should consider not only the technical prerequisites but also the social, psychological, and motivational aspects of the Metaverse. The aim was to bring these insights to the forefront, thus providing several critical research agendas to enhance our understanding of Metaverse adoption in education. The following subsections delve deeper into the theoretical contributions, practical implications, and the current review's limitations and future work.

6.1. Theoretical contributions

This study makes several noteworthy theoretical contributions to the existing knowledge on Metaverse adoption in education. First, it proposed a comprehensive framework that identifies the key factors influencing the adoption and use of Metaverse in education, providing a coherent understanding of the interplay between various factors and their impact on Metaverse adoption. Second, the study integrates multiple theories and models from technology adoption literature, such as the TAM, UTAUT, and DOI. This integration allows for a more holistic perspective on Metaverse adoption in education, which can be leveraged in future research and practice. Third, the systematic review highlights current research on Metaverse adoption in education, identifying gaps that warrant further investigation. By outlining these gaps, this study encourages researchers to explore under-researched aspects of Metaverse adoption, contributing to a more comprehensive understanding of the phenomenon.

Fourth, by focusing specifically on the education sector, this study contextualizes its findings, contributing to understanding

Table 6
Key areas for future research agendas.

Key areas	Description
Balancing innovation and privacy/ security	Explore how educators, administrators, policymakers, and Metaverse developers can balance fostering innovation while ensuring user privacy and security in the Metaverse.
Challenges of using the Metaverse in education	Identify challenges associated with Metaverse implementation in educational settings and propose strategies to overcome these obstacles.
Effectiveness of Metaverse-based learning activities	Examine the types of learning activities most effective within the Metaverse and provide insights for teachers on designing and implementing Metaverse-based learning experiences that maximize student outcomes.
Ethical implications of using the Metaverse	Address the ethical implications of Metaverse usage in education, such as data privacy, digital divide, and content moderation, and develop guidelines promoting technology's responsible and ethical use in educational contexts.
Impact on student learning outcomes	Investigate how the Metaverse compares to traditional learning methods in terms of student engagement, motivation, and achievement, helping educators make informed decisions about incorporating Metaverse environments into their teaching practices.
Inclusivity, diversity, equity, and inclusion	Explore how the Metaverse can be designed and managed to promote inclusivity, diversity, equity, and inclusion among its users.
Interoperability standards	Identify standards that facilitate seamless user movement between different Metaverse platforms and investigate effective implementation strategies.
Regulatory and ethical considerations	Investigate potential regulatory and ethical considerations that could impact the development and deployment of the Metaverse and propose effective ways to address them.
Role of the teacher in the Metaverse	Explore how teachers can effectively facilitate learning within the Metaverse and identify the new skills and knowledge they need to succeed in this novel learning environment.
Social and ethical implications	Investigate the social and ethical ramifications of the Metaverse, including issues related to inequality, diversity, and digital citizenship.
User preferences, motivations, and behavior patterns	Examine what drives users to engage with the Metaverse and identify their preferences and behavior patterns within this digital environment.
Using Metaverse technologies for immersive learning	Investigate how Metaverse technologies, such as virtual and augmented reality, can be utilized to create immersive and interactive learning experiences for students, enhancing their engagement and understanding of complex concepts.
Integrating Metaverse technology in the classroom	Explore the most effective ways to integrate Metaverse technology into the classroom and curriculum, considering factors like technical infrastructure, teacher training, and alignment with learning objectives.
Personalized learning experiences using Metaverse	Examine how Metaverse platforms can create personalized learning experiences for students, allowing them to learn at their own pace, explore topics of interest, and receive tailored feedback and support.

Metaverse adoption in a unique context. These findings can help researchers and practitioners understand how the Metaverse can be effectively implemented in educational settings and how it may differ from other contexts. Fifth, this study serves as a foundation for future research on Metaverse adoption in education. By outlining key factors and their interrelationships, researchers can build upon these findings to investigate new research questions, develop novel theoretical models, and advance the field of Metaverse adoption in education. Sixth, the proposed framework suggests that institutions need to consider not only the technical requirements but also the social, psychological, and motivational aspects of adoption.

6.2. Practical implications

The insights from this review provide valuable guidance for various stakeholders, including educators, administrators, policymakers, and technology developers, who implement the Metaverse in educational settings. By identifying critical factors affecting the Metaverse adoption, this study informs pedagogical approaches and enables educators to optimize the potential of the Metaverse in enhancing student learning outcomes, engagement, and motivation. The insights gained also facilitate the design and delivery of professional development programs for educators, ensuring they possess the necessary skills, knowledge, and support to integrate Metaverse platforms effectively into their teaching practices. The findings also support policymakers and administrators in developing informed policies and strategic plans for implementing the Metaverse in educational institutions. This ensures that resources are allocated effectively and potential challenges are addressed. Additionally, the results of this review assist technology developers in designing and developing Metaverse platforms, tools, and applications tailored to users' specific needs, preferences, and expectations in educational settings. Overall, the practical implications of this systematic review extend across multiple dimensions, enabling stakeholders to make informed decisions, develop effective strategies, and optimize the potential of Metaverse platforms to transform teaching and learning experiences.

6.3. Limitations and future work

Although the study provides an extensive compilation of current research on the factors influencing Metaverse adoption, it is not without limitations. First, the review focuses on literature published up to December 2022, potentially excluding the most recent studies on Metaverse adoption in education. Given the rapidly evolving Metaverse environment landscape, it is essential for future research to continually update the findings to remain current. Second, the study is based on a systematic literature review, inherently constrained by the search strategy and the selection criteria. The study included only English publications and peer-reviewed literature, while non-scientific studies, grey literature, and literature in other languages were excluded. The authors searched specific databases (Scopus and WoS), which may have omitted potentially important sources of information. To address these limitations, future research should consider studying articles from indexed and non-indexed journals, literature in other languages, and alternative databases such as Google Scholar to obtain more extensive evidence on Metaverse adoption in education.

Third, the study relies on systematic literature concentrating on empirical studies with theoretical models and results, thus excluding conceptual and qualitative studies. Future research should consider incorporating conceptual and qualitative studies to enhance the understanding of Metaverse adoption in education. Such an approach would enable a deeper exploration of the complex and dynamic nature of the adoption and use, enriching the existing body of knowledge in the field. Fourth, this review collected studies related to Metaverse adoption only and discarded studies exploring Metaverse technical perspectives to meet the research objective of this review. Consequently, future research might also examine the technical aspects of the Metaverse in education to provide a more holistic understanding of its implementation, challenges, and potential benefits. This approach would contribute to the broader knowledge base and help guide the development of effective strategies for successfully integrating Metaverse environments in educational settings.

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Data availability

The data presented in this study are available on request from the authors.

CRediT authorship contribution statement

Safwan Maghaydah: Writing – original draft, Validation, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Mostafa Al-Emran:** Writing – review & editing, Supervision, Resources, Project administration, Formal analysis, Conceptualization. **Piyush Maheshwari:** Writing – review & editing, Supervision, Formal analysis, Conceptualization. **Mohammed A. Al-Sharafi:** Writing – review & editing, Writing – original draft, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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