International Journal of Technology in Education and Science

www.ijtes.net

Evidence on the Metaverse's Impact in Higher Education: A Systematic Review and Meta-Analysis

Ayman Mohammed Zohdi [1], Rayan Saad Dajam [2], Fahad Saleem Al-Hafdi [3], Waleed Salim Alhalafawy [4*]

[1] Department of Educational Technology, Faculty of Education, King Abdulaziz University, Jeddah, Saudi Arabia, 0009-0001-0373-9121
[2] National eLearning Center, Riyadh, Saudi Arabia, 0009-0005-1610-1070
[3] Department of Educational Technology, Faculty of Education, King Abdulaziz University, Jeddah, Saudi Arabia, 0000-0002-6994-5972
[4] Department of Educational Technology, Faculty of Education, King Abdulaziz University, Jeddah, Saudi Arabia, 0000-0002-1798-2536
* Corresponding author: Waleed Salim Alhalafawy (welhlafawy@kau.edu.sa)

Article Info

Article History

Received:
28 February 2026

Revised:
15 May 2026

Accepted:
7 June 2026

Published:
15 June 2026

Keywords

Metaverse
Virtual reality
Augmented reality
Extended reality
Immersive environments
Higher education

Abstract

This study presents a systematic review and meta-analysis of twenty peer-reviewed empirical studies that examined the use of Metaverse technologies in higher education. The study aims to examine current research trends, academic fields, benefits, challenges, and the overall impact of Metaverse applications on student learning outcomes. The meta-analysis results indicate that Metaverse-based educational interventions have a significant positive impact on learning effectiveness (Hedges' $g = 0.758$, $p < .001$), with varying effect sizes across different academic disciplines. The strongest effects were detected in arts and humanities, health and welfare, and business, administration and law. The included studies revealed several educational benefits, most notably improved learning outcomes, increased student motivation, and enhanced engagement and interaction within immersive learning environments. On the other hand, several challenges emerged, including technical issues, high implementation costs, and cognitive overload. Moreover, the results highlighted significant research gaps, including a limited number of studies addressing the needs of students with disabilities or gifted students, and insufficient attention to issues related to inclusion and accessibility. The results generally indicate that the Metaverse has promising potential for reshaping learning experiences in higher education, but further longitudinal and experimental studies are needed to explore its effectiveness across diverse disciplines and educational contexts.

Citation: Zohdi, A. M., Dajam, R. S., Al-Hafdi, F. S., & Alhalafawy, W. S. (2026). Evidence on the metaverse's impact in higher education: A systematic review and meta-analysis. *International Journal of Technology in Education and Science (IJTES), 10*(4), 784-815. https://doi.org/10.46328/ijtes.8626

Introduction

Metaverse is a term derived from the combination of "meta," meaning beyond, and "verse," short for universe (Wang et al., 2022). Expanded applications of metaverse have begun to emerge across various sectors. The term represents a convergence of the physical and digital worlds, allowing users to seamlessly move between them for work, training, healthcare, exploring interests, and social interaction, including education, which has seen increasing interest in it in recent years at both the academic and applied levels (Akhil et al., 2024; Buhalis et al., 2023). Metaverse is an advanced type of Internet application with an integrated digital ecosystem, combining a variety of modern technologies. It is considered the next generation of digital and social interaction environments (Akhil et al., 2024; Wang et al., 2023). It is a new digital environment based on intelligent, computing-enabled interaction, comprised of virtual worlds in which individuals can interact and communicate with each other through avatars (Hennig-Thurau et al., 2023).

Studies indicate the importance of using Metaverse in many fields. A study by Wang et al. (2023) confirmed that the Metaverse system combines cutting-edge technologies, including 5G, cloud computing, blockchain, and artificial intelligence (AI). This makes it applicable to multiple areas such as video games, art, business, tourism, marketing, entertainment, work, social communication, and education (Buhalis et al., 2023; Chanda et al., 2024; Dwivedi et al., 2023; Zallio & Clarkson, 2022).

Using Metaverse in education has developed quickly, moving from recreational games to serious educational games, gaining increasing attention as an innovative technology with potential benefits in the field of education (W. Chen et al., 2023). It provides immersive and interactive learning environments that enhance student engagement and participation in the educational process. It also enables the design of appropriate learning environments, flexible classroom layouts, and advanced teacher training programs, and promotes the design of interactive learning models for both teachers and students (Panda et al., 2024). Besides, it integrates human interaction skills and personalization, creating an enjoyable and interactive environment that benefits students, who are at the center of the educational process, by offering new, exploration-based learning pathways (Suiçmez & Ozansoy, 2024). Furthermore, the personalized learner experience and interactive elements of Metaverse provide effective opportunities for researchers in the context of teaching and learning (Chanda et al., 2024).

Higher education has benefited from metaverse technology because of its ability to radically transform teaching and learning methods (Panda et al., 2024). Given the importance of metaverse and its relevance to higher education, comprehensive studies are needed to generate a range of findings that enrich the research and educational landscape. A review of the literature reveals a scarcity or limited number of studies that have addressed metaverse in higher education in depth. Villalonga-Gómez et al. (2023) highlighted the importance of analyzing the current scientific literature to understand the state of research and the extent of metaverse's impact as a tool in higher education. Likewise, Hwang et al. (2023) emphasized the need for studies that allow learners to express their opinions on the use of metaverse in higher education from various perspectives. Shi and Park (2024) advocated for future studies with stronger experimental designs to measure the impact of metaverse on education, focusing on student experiences, learning outcomes, and assessment methods. Panda et al. (2024)

further elaborated on this point and noted that despite the development of bibliometric studies on metaverse, no study has attempted to measure the relationship between metaverse in higher education using the bibliometric framework Theories, Context, Characteristics, and Methodology (TCCM), highlighting the need for a comprehensive work that provides a holistic view of the field. In this context, López-Belmonte et al. (2023) recommended further research on integrating metaverse into learning spaces across all educational stages, focusing on supporting students with special needs and analyzing metaverse's ability to improve accessibility and the learning experience. Alfaisal et al. (2024) strongly advised researchers to move beyond the approaches used in current studies and expand the scope of research in terms of data sources, theories employed, and research methodologies to ensure a more comprehensive and rigorous study of metaverse techniques in education and other fields. Roy et al. (2023) demonstrated this. A review of previous literature found very few studies that discussed metaverse in the education sector.

To underscore the importance of this current study, the use of advanced methodologies such as systematic review and meta-analysis is essential for a deeper understanding of metaverse in higher education (Mercan & Selçuk, 2024). These methodologies provide a range of important outputs that allow for detailed information on studies collected over a specific period (Shi & Park, 2024). This contributes to the advancement of scientific knowledge about metaverse techniques and offers recommendations on their application in higher education (Mingyu et al., 2024).

Based on the above, this systematic review aims to expand the literature on the impact of metaverse use in higher education by addressing the following research questions:

- RQ1: What are the current trends in metaverse use in higher education?
- RQ2: In which educational fields are metaverse applications most used?
- RQ3: What are the benefits of using metaverse in educational settings?
- RQ4: Have the specific needs of learners been considered in these applications?
- RQ5: What are the disadvantages associated with using Metaverse in higher education?
- RQ6: What is the impact of metaverse on student learning effectiveness?
- RQ7: What are the current research gaps in metaverse studies in higher education, and what are the proposed future directions?

Seven research questions have been formulated to discuss metaverse in higher education. The first research question aims to understand how the use of metaverse in higher education is currently evolving, helping to identify prevailing trends and changes in the field over time. The second research question helps to categorize and identify the subjects or disciplines that have benefited most from metaverse applications, providing insight into the disciplines where this technology could expand in the future. The third research question highlights the positive aspects of using metaverse, such as improved interaction, increased student motivation, or the provision of realistic learning experiences. The fourth research question addresses an important aspect related to the inclusiveness of design and the extent to which metaverse applications can accommodate diverse needs, including those of students with disabilities or different learning styles. It is important to study the negative aspects, such as high costs, technical issues, or privacy challenges, to understand the obstacles that may hinder the implementation of this technology; this is the subject of the fifth research question. The sixth research question aims to evaluate educational outcomes, providing evidence of how successful metaverse is in improving student performance compared to traditional methods. Metaverse is one of the many new trends and technologies that appear daily. Nevertheless, it is not like many other technologies that will fade away over time. On the contrary, metaverse will continue for a very long time. Consequently, the seventh research question aims to identify aspects that have not received sufficient attention in current studies on metaverse in higher education, while suggesting new research areas that can contribute to the development of this field and enhance understanding of the impact of this technology on the educational process.

The rest of this paper is organized as follows: Section 2 discusses previous studies related to metaverse in higher education. Section 3 presents the literature related to metaverse in the educational process, and Section 4 discusses the methodology used in developing the research, including an explanation of the work carried out in each of the three phases (planning the review, conducting the review, and preparing the review report). Section 5 reviews the most relevant findings of the systematic review to answer the study's questions. Section 6 discusses the meaning of the results, and Section 7 clarifies the study's limitations. Finally, Section 8 concludes the paper and suggests potential paths for future research related to metaverse in higher education. In this study, we use the term metaverse in its broadest sense to encompass virtual reality (VR), extended reality (XR), and immersive 3D environments, which represent the core of metaverse in higher education.

Related Work

Several previous reviews have examined Metaverse technologies in educational contexts, but they differ from the present study in scope, focus, and analytical approach. For example, Simsek and Baltaci(2024) focused specifically on Second Life as a Metaverse environment in higher education and summarized its uses, benefits, challenges, and limitations. However, their review did not provide a quantitative meta-analysis of learning outcomes. George-Reyes et al. (2023) offered a broader review of Metaverse-related research, including algorithm design, virtual reality, and technological frameworks, but their focus was not specifically on higher education learning effectiveness. Geng and Su(2024) conducted a meta-analysis of Metaverse effects on students' achievement and perceptions, but their review focused on K–12 STEM education rather than higher education. Accordingly, the present study extends previous work by combining systematic review and meta-analysis focused specifically on higher education. It not only maps current applications, benefits, disadvantages, and research gaps, but also provides a quantitative estimate of the impact of Metaverse-based interventions on students' learning effectiveness across broad academic fields.

Table 1. Summary of Some Systematic Reviews Related to the Use of Metaverse in Educational Environments

Study	Purpose of Study	Reviewed Studies	Key Results
Simsek and Baltaci(2024)	Studies published between November 2019 and May 2023 from the Web of Science, Scopus,	24	The review showed that Second Life contributes to improved skills, creativity, interaction, specialized learning, and

Study	Purpose of Study	Reviewed Studies	Key Results
	and ERIC databases were analyzed. This review focused on the uses, benefits, challenges, limitations, and effectiveness of Second Life as a Metaverse environment in higher education.		language acquisition, with benefits in virtual teaching. However, users faced challenges such as anxiety, technical difficulties, and usability issues. The study recommends expanding the use of metaverse technologies in higher education and addressing the technical challenges to enhance their effectiveness.
George-Reyes et al. (2023)	This study analyzed 234 studies published in various databases, including Scopus and Web of Science, between 2022 and later. It focuses on exploring metaverse, its intersection with complex reasoning components, its prevalence in algorithm design and segmentation, and its relationship to virtual reality technology.	234	Metaverse has seen intense exploration since 2022, relating to algorithm design, retail, and virtual reality, while also developing frameworks for its operation. Analyzing it from a critical and scientific perspective offers opportunities to enhance understanding of immersive technologies and digital systems.
Geng and Su (2024)	This study analyzed 49 studies to assess the impact of Metaverse on the academic achievement and perceptions of kindergarten-grade through twelfth-grade students in online and blended learning environments. It focuses on its uses, effectiveness, factors influencing STEM learning, and the impact of educational technologies and methods on learning outcomes.	49	Metaverse demonstrated a significant impact on student achievement in STEM (0.821) and a moderate impact on their perceptions (0.575), with the greatest improvement observed among elementary school students in science. VR, AR, and inquiry-based learning played a pivotal role. The study recommended that teachers actively utilize Metaverse in STEM teaching.

Literature Review

Metaverse is considered as a new environment based on advanced digital systems, consisting of virtual worlds where individuals interact and communicate with each other in real time through digital representatives known as avatars (Hennig-Thurau et al., 2023). The term itself is composed of the words "meta," meaning beyond, and "verse," derived from "universe," reflecting the idea of integrating virtual worlds into the Internet in a continuous and synchronous manner (Camilleri, 2024). The origin of the term metaverse dates back to 1992 when author

Neal Stephenson used it in his novel Snow Crash to describe a virtual world that people could enter and interact with through their digital characters (avatars) (Wang et al., 2022). The emergence of powerful Metaverse platforms such as Second Life and OpenSim in 2003 shaped the development of many Internet-related technological fields. Metaverse was initially developed as an interactive online electronic game where social interaction was possible in the virtual world. So, Second Life is seen as an ancestor to Metaverse. Modern interactive platforms such as Roblox, Minecraft, and Fortnite have become a model for the development of the next generation of Metaverse (Chua & Yu, 2024).

Metaverse, as well, combines innovative technologies, the Internet of Things, artificial intelligence, augmented reality, virtual reality, extended reality, Web 3.0, and blockchain, integrating them to create a massive, integrated, real-time environment (Johri et al., 2024). It represents a new social form, encompassing economic, cultural, and legal systems closely linked to reality as a parallel virtual world (Wang et al., 2023). It is an immersive digital environment (Zallio & Clarkson, 2022) where immersion is a key feature of Metaverse. In addition, it relies on social interaction, where the presence in the same virtual environment enhances communication, cooperation, and participation through avatars (Hadi et al., 2024). One of the important foundations of Metaverse is the availability of a high-speed Internet infrastructure, as well as supporting devices, which include mixed reality (MR) and virtual reality (VR) glasses, touch gloves, and devices that enable interaction within the virtual environment in a natural way through advanced platforms such as Horizon World, Sandbox, and Roblox, where users can interact, work, and entertain (Buhalis et al., 2023).

Metaverse has had a varied impact across various sectors. It is a digital interactive environment that transcends geographical and social barriers, presenting a significant opportunity for companies to create more interactive marketing experiences (Sung et al., 2023). Games and simulations are among the most commonly used areas for metaverse services (Park & Kim, 2022). In healthcare environments, metaverse enables the simulation of virtual states, making education more interactive and engaging (Bernardes et al., 2024). Besides, it can create virtual travel experiences, allowing visitors to explore tourist destinations without physical travel. Content creators and artists can reach a global audience more efficiently, and virtual reality-based interactive environments can enhance learning opportunities, potentially improving the quality and inclusivity of education by providing easier access for learners (Dwivedi et al., 2023).

One of the most important areas for Metaverse is education, as it possesses significant and influential potential (Zhang et al., 2022). Maghaydah et al. (2024) indicated that the benefits of using Metaverse in education include providing an immersive learning experience, fostering collaboration among students, and contributing to improved learning outcomes. Metaverse enables unrestricted interaction among students, regardless of their geographical location, using digital identities in diverse social activities such as discussions, collaborative projects, games, and problem-solving (X. Chen et al., 2023). It allows for the creation of virtual environments based on teacher-prepared lesson plans, providing improved learning opportunities and leading to a more productive and effective learning experience for students (Jagatheesaperumal et al., 2024). Jafari (2023) suggests that Metaverse can be highly effective in STEM (science, technology, engineering, and mathematics) classrooms, particularly in applied and experimental science classes. A study by (Chua & Yu, 2024) indicates that Metaverse technology promotes self-directed and independent learning, and that an augmented reality (AR)-based math game within the Metaverse environment makes the math learning process more enjoyable and less stressful, which contributes to improved concept comprehension and reduced anxiety related to the subject.

Using Metaverse in higher education enables the creation of virtual classroom experience, giving students chance to explore all types of classroom activities from different perspectives. Students can take virtual tours, visit classrooms, laboratories, dormitories, and other university facilities, use avatars to interact within the learning environment, and even pay tuition fees using cryptocurrency (Jafari, 2023). The findings of Ji-yoon and Han-sol (2024) indicate that integrating Metaverse technology into university arts education can significantly enhance creativity, critical thinking, and interdisciplinary skills, providing a sustainable and innovative approach to modern education. The results of Shu and Gu (2023) showed that students who participated in a Metaverse-enabled smart learning model scored higher in spoken English, vocabulary, grammar, reading comprehension, translation, and writing skills compared to students who relied on traditional teaching methods. Metaverse is considered an effective tool for developing teaching and assessment strategies, providing students and teachers with the opportunity to explore new teaching methods and interact with the academic community through virtual reality simulations (Sá & Serpa, 2023). The findings of Suiçmez and Ozansoy (2024) indicate that a sustainable education and training program integrating Metaverse technologies at the undergraduate level is indeed effective. It also provides ongoing opportunities to explore new dimensions, create customized learning materials for students, and develop inclusive and accessible teaching methods (Panda et al., 2024).

Earlier studies have approached metaverse from various angles. For example, Hwang et al. (2023) used drawing techniques to explore students' perceptions of metaverse in higher education, with fluctuating levels of motivation, providing a valuable reference for designing and developing future metaverse-based learning and training environments. In the meantime, the systematic bibliographic review in Villalonga-Gómez et al. (2023) aimed to review research efforts in studying and applying metaverse techniques in higher education, focusing on teaching and learning methods and seeking to provide a reference framework that could be useful to contemporary educators and researchers. Moreover, López-Belmonte et al. (2023) found that metaverse has significant potential for improving education and enhancing student engagement. As an emerging technique, it warrants further research to assess its impact and improve its effectiveness, along with the development of reliable assessment tools to measure learning experiences within it. Kshetri et al. (2022) also discovered Metaverse technology offers unprecedented opportunities in higher education, helping to overcome resource constraints, expand learning opportunities for students in remote areas, improve student performance, and enable learning experiences impossible in the real world, thus driving universities to adopt this cutting-edge technology. Meanwhile, Pujasari et al. (2024) concluded that the benefits of using Metaverse technology in higher education are wide-ranging, the most important being increased student engagement through the provision of a virtual environment where students can interact with course materials and with each other.

Given that the integration of education and digital technologies is a vital feature of the future of education, metaverse is viewed as a powerful and influential learning environment. Hence, some theories, such as the theory of experience preference (IPOP), which utilizes its characteristics of interaction and experience to explain the transformation of metaverse in future education (Yuan et al., 2024), have been proposed. The study by Al-kfairy et al. (2024) confirms the connection between scientific theories and the adoption of metaverse in higher education through technology acceptance and use models such as the Technology Acceptance Model (TAM), the Theory of Planned Behavior (TPB), and the Unified Theory of Acceptance and Use of Technology (UTAUT). These theories explain how individual, technological, and environmental factors influence users' intention to adopt technology. The study by Al-Adwan et al. (2023) also confirms this. This study showed that the Technology Acceptance Model (TAM) is linked to Metaverse by explaining the factors that influence student adoption in education. Usefulness and ease of use affect acceptance, while personal innovation and self-efficacy promote adaptation. Fan (2023) study explained that Cumulative Prospect Theory is used to assess the importance of future course instruction after the introduction of the Metaverse concept in education. This involves analyzing learners' behavior toward virtual learning environments in higher education, which helps in understanding their learning decisions and preferences within higher education systems. Another theory supporting the use of Metaverse technology in education is Situated Learning Theory, which asserts that learners are more willing to learn when they are in real-world contexts that allow them to experiment and explore. This is precisely what Metaverse provides through realistic virtual environments (Çelik, 2026). In the same way, Social Constructivism suggests that knowledge is constructed through interaction with others, and this is the potential offered by Metaverse, where learners are engaged in interacting with their peers and teachers, as well as exploring and acquiring knowledge in virtual environments (Zhou et al., 2024). Experiential Learning Theory also emphasizes that learning occurs through experience, and Metaverse is a suitable option for achieving the goals of experiential learning (Hwang & Chien, 2023).

Methods

Systematic Review

The current study followed the guidelines suggested by Kitchenham and Charters (2007), who indicate that systematic reviews involve three main phases: planning, implementation, and reporting.

Planning the Review

This phase involved defining the strategy for selecting the most relevant literature to answer the research questions. A double iterative review was conducted, focusing on scientific journals indexed in the Social Sciences Citation Index (SSCI) and conference proceedings indexed in the Conference Proceedings Citation Index-Science (CPCI-S) database. The Web of Science (WoS) website was used for the search.

The following search terms were used in different combinations: (“Metaverse” OR “Second Life” OR “Virtual Worlds” OR “Virtual Reality” OR “Extended Reality” OR “Immersive Learning” OR “3D Virtual Environments” OR “Immersive Environment” OR “Virtual Environment” OR “Digital Twins” OR “Virtual Campus” OR “Simulation Training” OR “Computer Simulation” OR “Avatar-Based Learning” OR “Roblox Education” OR “Horizon Worlds” OR “Meta Horizon Worlds” OR “AltspaceVR” OR “Spatial” OR “Mozilla Hubs” OR “VictoryXR”) AND (“Higher Education” OR “University Education” OR “Post-Secondary Education” OR

“Tertiary Education” OR “College Students” OR “University Students” OR “Adult Education” OR “Distance Education” OR “Online Education” OR “E-learning”) AND (“experimental” OR “case study” OR “intervention” OR “study” OR “research” OR “evaluation” OR “analysis” OR “quasi-experimental”).

The search parameters were set as follows: Document type: Scientific article. Language: English. The initial search yielded 2,026 articles. We then created categories: "Education and Educational Research," "Education and Scientific Disciplines," and "Interdisciplinary Applications of Computer Science." After applying these new filters, we found 698 articles (see Figure 1).

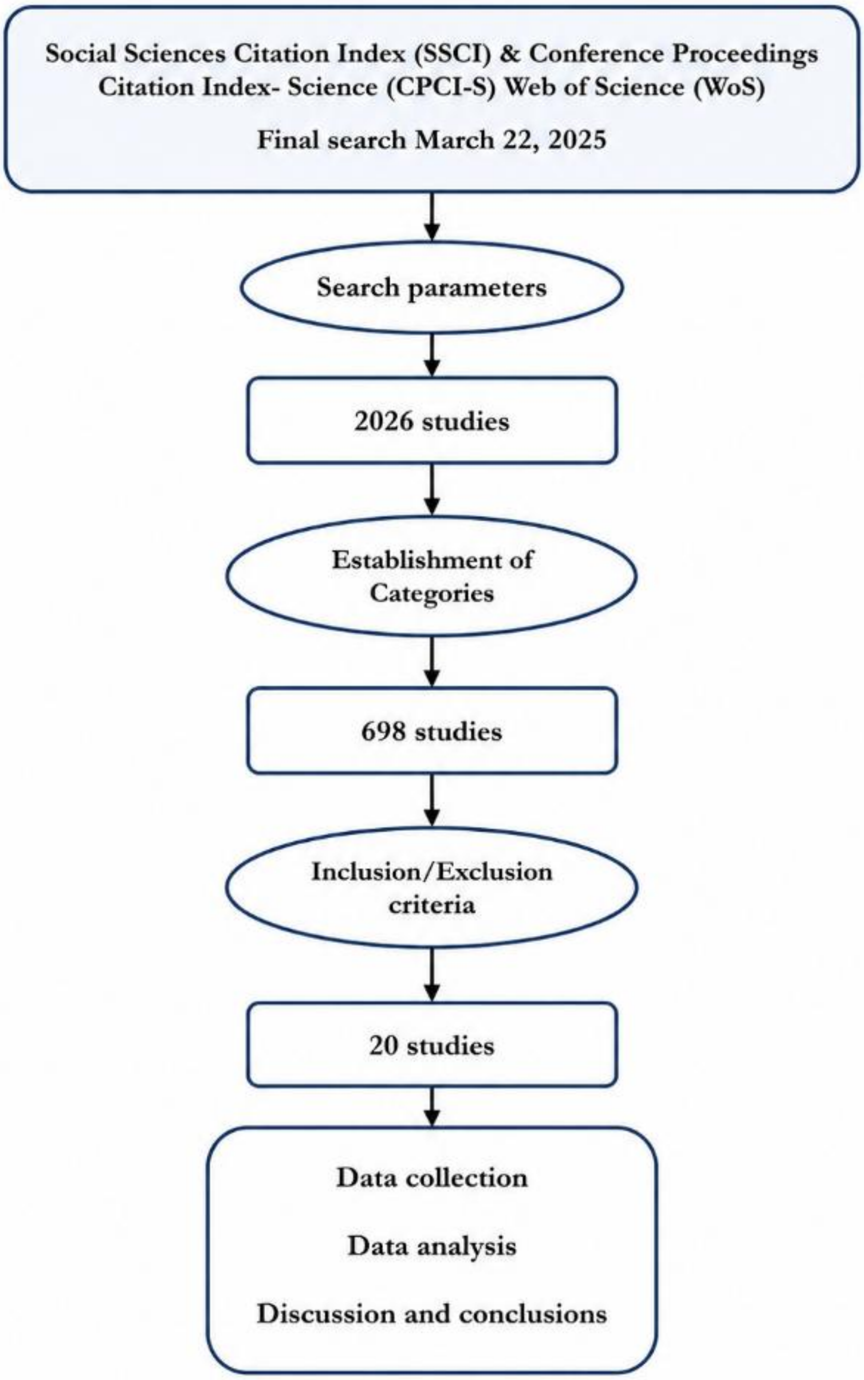

Figure 1. Diagram of the Selection of Metaverse Studies

The researchers carefully reviewed these articles to determine their relevance to the study. Articles that did not meet the inclusion and exclusion criteria were excluded. Ultimately, 20 studies were identified as relevant to the systematic review and meta-analysis, based on the following inclusion criteria:

- Studies relevant to the research questions
- Studies that included case studies
- Studies that underwent a qualified peer-review process
- Studies that included a pre-test and post-test design for meta-analysis purposes
- Studies that included experimental and control groups for meta-analysis purposes. Because the systematic review focused on educational settings, studies that did not focus on higher education were excluded, even if they met all the above criteria. Additionally, any study not conducted in English or lacking a clear meta-analytical approach was excluded. Figure 1 illustrates the process for identifying the studies included in the current study.

Conducting the Review

This stage was applied after the review planning stage was completed. A data extraction model was designed using a spreadsheet document containing the following elements: study title, publication year, journal, sample size, target group, field of education, stated benefits, stated drawbacks, time frame, and main findings. Researchers read each paper individually and extracted the relevant data. Cohen's kappa statistic was used to measure the reliability of the coding among researchers, with a value of 0.94, which is considered near-perfect agreement according to Cohen (1968). Any occasional disagreements were discussed and resolved unanimously.

Reporting the Review

At this stage, the most relevant information that answered the research questions identified in the planning stage was analyzed, summarized, and presented. The study results were summarized in the Results Section. The scope of this review included studies that used one of the metaverse technologies or its components, such as virtual or extended reality, provided they were in the context of higher education and met the specified inclusion criteria.

Meta-analysis

A meta-analysis was conducted to measure students' learning advantages when using Metaverse. Glass (1976) defined meta-analysis as: the statistical analysis of a large set of results from individual studies with the aim of combining the findings. The meta-analysis included 20 studies that used a pre-test-post-test design with a pre-post-control (PPC) group. In this research design, students are divided into two groups: experimental and control, and each student is assessed before and after the intervention (Morris & DeShon, 2002). The PPC design provides a more effective framework for estimating the effect of the intervention compared to studies that rely solely on post-testing or those that do not include a control group. Therefore, other research designs were not considered in the meta-analysis. In addition, the field of education was selected as an independent variable. The effect size by field of education indicates the extent to which each academic discipline benefits from these systems. Learning gains were assessed based on the bias-corrected effect size (Hedges's g), which is a modification of Cohen's d and is preferred for small sample sizes to obtain a more accurate estimate (Hedges & Olkin, 1985).

To estimate the corrected effect size, the difference in learning gains between the experimental and control groups was first calculated and standardized using the pooled pretest standard deviation. This calculation produced Hedges' g after applying the bias correction coefficient Cp, as shown in Equation (1).

$$g = \frac{(M_{POST-E} - M_{PRE-E}) - (M_{POST-C} - M_{PRE-C})}{SD_{PRE}} \times C_p$$

The pooled pretest standard deviation was then calculated using the pretest standard deviations and sample sizes of the experimental and control groups. This value was used as the standardizing denominator in the effect size calculation, as shown in Equation (2).

$$SD_{PRE} = \sqrt{\frac{(N_E - 1)SD_{PRE-E}^2 + (N_C - 1)SD_{PRE-C}^2}{N_E + N_C - 2}}$$

Finally, the bias correction coefficient Cp was calculated to reduce small-sample bias in the standardized effect size. This coefficient adjusts the standardized mean difference to obtain a less biased estimate, as shown in Equation (3).

$$c_P = 1 - \frac{3}{4(N_E + N_c - 2) - 1}$$

In these equations, $M_{POST-E}$and M_{PRE-E}represent the posttest and pretest means of the experimental group, respectively, whereas $M_{POST-C}$and M_{PRE-C}represent the posttest and pretest means of the control group, respectively. SD_{PRE}denotes the pooled pretest standard deviation. $N_E$and $N_C$represent the sample sizes of the experimental and control groups, respectively. $SD_{PRE-E}$and SD_{PRE-C}denote the pretest standard deviations of the experimental and control groups, respectively. Finally, $C_p$represents the small-sample bias correction coefficient used to obtain the corrected effect size, Hedges' g.

To interpret the effect size values, the standard classifications proposed by Cohen (1992) and expanded by Sawilowsky (2009) were used, based on Hedges's g scale, which is a corrected version of Cohen's d that reduces bias due to small sample sizes. Accordingly, g = 0.2 is a small effect, g = 0.5 is a medium effect, g = 0.8 is a large effect, g = 1.20 is a very large effect, and g = 2.0 is a huge effect.

Findings

Trends of Metaverse

This subsection shows trends related to the adoption of metaverse techniques in higher education by addressing two main aspects. First, it reviews the chronological development in the number of publications in scientific journals and conferences. Then, it highlights higher education as the most prominent educational level where metaverse techniques are applied.

Evolution over Time

This subsection presents trends related to the adoption of metaverse technologies in higher education by addressing two main aspects. First, it reviews the chronological development in the number of publications in scientific journals and conferences. Then, among 20 selected literature review studies, two studies were published in 2016 (10%), one in 2017 (5%), one in 2019 (5%), one in 2020 (5%), one in 2021 (5%), four in 2022 (20%), one in 2023 (5%), six in 2024 (30%), and three in 2025 (15%). Still, these percentages do not represent the total number of studies published annually. To determine the actual development over time regarding the application of metaverse techniques in higher education, the preliminary research results were used, as Figure 2 shows the annual distribution of 508 articles from 2016 to 2025 out of a total of 698 articles. Higher education was highlighted as the most prominent educational level where metaverse techniques are applied.

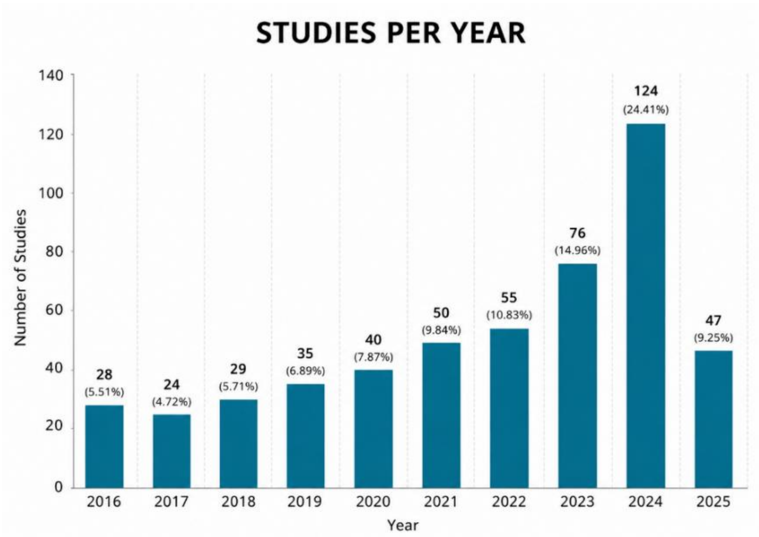

Figure 2. Studies related to the Metaverse in Higher Education per Year (WoS)

Focus on Higher Education

The systematic review revealed that higher education is a fertile educational environment for the application of metaverse technologies, with universities and academic institutions being the most common level of adoption of these technologies, including virtual reality, extended reality, and immersive 3D environments. These technologies have been used in several diverse educational fields within higher education institutions, including: teaching English language and writing skills using virtual reality environments tailored to learners with different personality types, such as introverts and extroverts (Khodabandeh, 2022); teaching art and aesthetic appreciation using immersive reality platforms to develop students' attitudes toward art and increase cognitive attention during activities (Yang et al., 2024); and healthcare training and clinical skills exercises, as in the study by Chang et al. (2022), which integrated a specialized virtual reality environment in nursing for midwifery skills and resulted in improved performance and clinical competence. Teaching chemistry and engineering using platforms like Second Life allows for the safe and effective replication of chemical experiments and engineering practices (Vrellis et al., 2016; Winkelmann et al., 2017; Winkelmann et al., 2020). Teaching complex medical problem-solving skills, such as responding to coma, is done using virtual reality-based educational games (Mansoory et al., 2021). Interaction in vocational training utilizes simulation and virtual reality (Justo et al., 2022). Consequently, it can be concluded that higher education has become a leading model in developing and evaluating the effectiveness of these technologies in supporting experiential, interactive, and self-directed learning. Therefore, the prevailing trend is to intensify the use of metaverse technologies in higher education, particularly in fields requiring simulation, live interaction, and practical training without real-world risks.

Education Field

Regarding the fields of education, we used the broad fields proposed by the ISCED-F 2013 classification of fields of education, which is the accompanying classification to the ISCED 2011 classification, and was developed and officially issued by the UNESCO Institute for Statistics to identify the field of metaverse applications in higher education included in the selected studies (UNESCO, 2014). The data collected indicate that most uses of metaverse techniques in higher education are related to the field of Arts and Humanities, where they have contributed to enhancing English language learning, such as the study by Luan et al. (2025) and the study by Chen (2025), Italian language learning (Nicolaidou et al., 2023), English paragraph writing skills among undergraduate students (Khodabandeh, 2022), and the arts (Yang et al., 2024). Metaverse applications in the field of health and welfare are among the most prominent modern educational models, ranking as the second most widely adopted educational field. These applications are particularly concentrated in nursing, medicine, and long-term care. Metaverse technologies have contributed to improving students' learning of assistive technology for the elderly (Chen et al., 2024). They have also proven effective in developing neonatal resuscitation skills among nursing students (Yang & Oh, 2022). Additionally, they have demonstrated superiority in training medical students to manage coma cases compared to traditional methods (Mansoory et al., 2021). Metaverse has also had a positive impact on enhancing nursing students' obstetric training through virtual realistic learning scenarios (Chang et al., 2022).

Among the fields highlighted in the selected study are natural sciences, mathematics, and statistics. These studies pointed to the advantages of using metaverse and virtual environments in teaching natural sciences, as they provide a safe and interactive environment that enables students to perform complex or dangerous experiments without exposure to real risks. They also allow for easy and cost-effective replication of the experiment. These environments contribute to a greater sense of presence and immersion, which increases motivation to learn and leads to a deeper understanding of abstract concepts (Makransky et al., 2019; Vrellis et al., 2016; Winkelmann et al., 2017; Winkelmann et al., 2020).

Another field that has benefited from Metaverse technologies in higher education is the field of education itself. Wang and Pan (2025) study focused on improving learning outcomes, particularly emotional intelligence, using this innovative educational technology. Shadiev et al. (2024) study focused on developing intercultural competence among university students. Tüzün and Özdinç (2016) study tested the effectiveness of guiding using a 3D environment via the Active Worlds MUVE platform for first-year students, demonstrating the superiority of the virtual environment in supporting spatial and conceptual understanding compared to real-world guiding.

Table 2. Percentage of Studies analyzed per Higher Education Field

Broad field	Number of studies	Percentage (%)
Arts and Humanities	5	25.0
Health and Welfare	4	20.0
Natural Sciences, Mathematics and Statistics	4	20.0
Education	3	15.0
Services	2	10.0
Engineering, Manufacturing and Construction	1	5.0
Business, administration and law	1	5.0
Social Sciences, Journalism and Information	0	0.0
Information and Communication Technologies	0	0.0
Agriculture, Forestry, Fisheries, Veterinary	0	0.0

As shown in Table 2 and Figure 3, arts and humanities represented the largest share of the studies included (25%), followed by health and welfare (20%) and natural sciences, mathematics, and statistics (20%). In contrast, some fields, such as social sciences, information and communication technologies, and agriculture-related fields, were not represented in the selected studies. This imbalance indicates the need for broader empirical investigation of Metaverse applications across less-represented higher education disciplines.

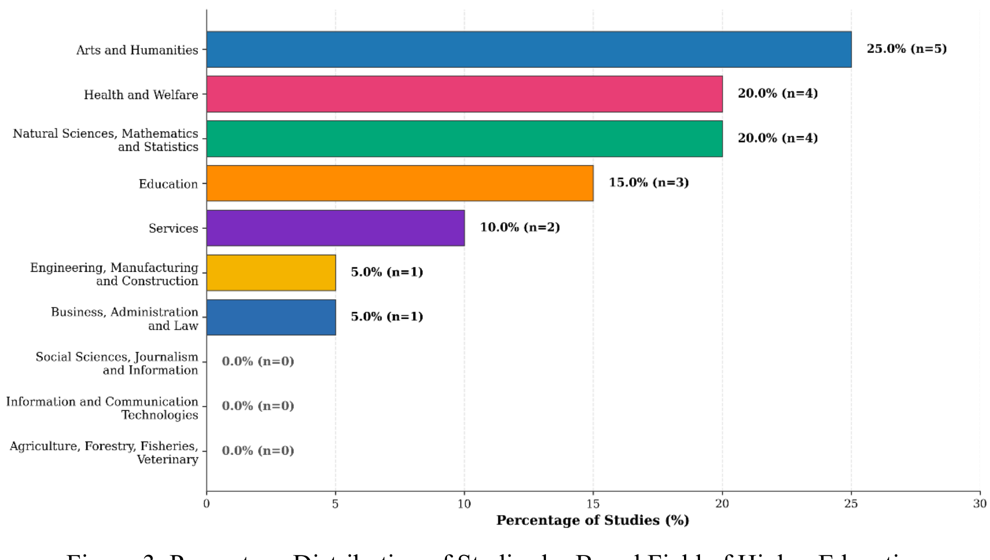

Figure 3. Percentage Distribution of Studies by Broad Field of Higher Education

Advantages of Using Metaverse

All the selected studies stated certain advantages when using Metaverse techniques in higher education. Table 3 summarizes the advantages reported in the 20 selected studies. It is significant to note that these are only some of the most common advantages reported in the studies, and similarly, most studies reported more than one advantage. Improved learning outcomes were the most common benefit, as studies showed that Metaverse techniques contribute to improved academic achievement in higher education through interactive environments that promote understanding and application. Medical students excelled in learning about coma scenarios (Mansoory et al., 2021), chemistry students in virtual experiments (Winkelmann et al., 2020), nursing students scored higher on midwifery tests (Chang et al., 2022), and language students excelled on vocabulary tests (Luan et al., 2025).

The results showed that students trained using Metaverse techniques achieved better scores or performance compared to students trained using traditional methods. Motivation ranked highly among the most frequently observed learning benefits, ranking as the second most frequently reported benefit in meta-analytical studies of meta-technologies in higher education. These studies demonstrated that the use of meta-technologies significantly enhanced learner motivation within immersive learning environments, whether in the arts, health, or language fields. Students expressed high levels of enthusiasm and engagement during learning and demonstrated a willingness to repeat the learning experience using these technologies (Khodabandeh, 2022; Makransky et al., 2019; Mansoory et al., 2021; Nicolaidou et al., 2023; Yang & Oh, 2022; Yang et al., 2024). This motivation may be a direct result of another crucial benefit identified in the selected studies: sensory interaction. Metaverse environments rely on sensory immersion, enabling learners to see three-dimensional objects, hear sounds, and interact with elements as if in the real world, even without actual touch. The visual, auditory, and interactive design in metaverses stimulates other senses to provide a sense of presence and participation (Justo et al., 2022; Winkelmann et al., 2017; Winkelmann et al., 2020). This leads to increased interaction and focus, an important advantage in the learning process (Nicolaidou et al., 2023).

Table 3. Percentage of Studies analyzed per Reported Advantages

Advantages	Number of studies	Percentage (%)
Improved Learning Gains	14	70
Enhanced Motivation	13	65
Better Understanding of Abstract Concepts	10	50
Increased Engagement and Focus	12	60
Sensory Interaction	8	40
Safe Simulation of Dangerous Scenarios	7	35
Realistic Practice for Medical/Nursing Skills	6	30
Immediate Feedback	5	25
Cross-Cultural Competence & Empathy	5	25
Creativity	4	20
Accessibility	4	20
Temporal and Spatial Flexibility	3	15

As shown in Figure 4, improved learning gains were the most frequently reported advantage (70%), followed by enhanced motivation (65%), increased engagement and focus (60%), and better understanding of abstract concepts (50%). These findings indicate that the educational value of Metaverse applications lies not only in improving learning outcomes but also in enhancing motivational, cognitive, and interactive aspects of learning.

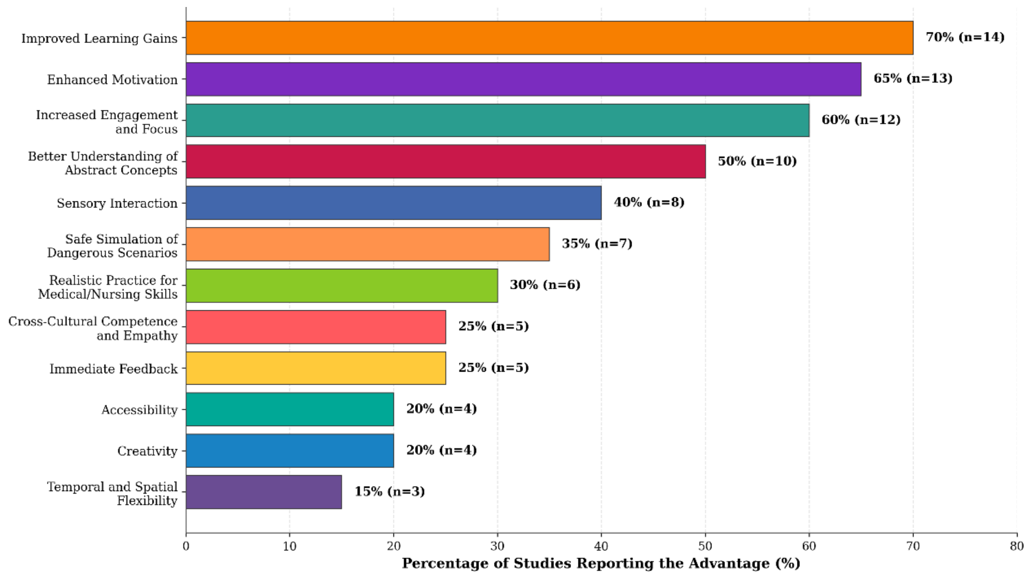

Figure 4. Percentage Distribution of Reported Advantages of Metaverse Applications in Higher Education.

Consideration of the Users' Special Needs

While the 20 studies analyzed did not directly address the needs of learners with special needs, such as those with disabilities or gifted students, other studies outside the selected sample have highlighted the importance of designing flexible, responsive virtual learning environments that accommodate these groups and provide equitable opportunities for interaction and learning within Metaverse (Avcu & Yaman, 2024; Yenduri et al., 2023). This stresses the importance of designing flexible and adaptive virtual learning environments that take into account the cognitive and emotional characteristics of this group.

Disadvantages of Using Metaverse in Higher Education

More than 30% of studies have identified at least some drawbacks or problems when using Metaverse technologies in higher education. Table 4 summarizes the main drawbacks mentioned in the selected studies. Technical difficulties, cost, hardware requirements, and distraction are among the most common challenges in using Metaverse in higher education, given the strong infrastructure, technical skills, and advanced equipment required by these environments, which may not be available to all users (Chang et al., 2022; Makransky et al., 2019; Winkelmann et al., 2017). These studies have shown that technical and financial challenges can affect the effectiveness of the learning experience and learner engagement.

The data indicates that 80% of the studies reported technical problems, while 55% pointed to difficulties related to cost and equipment. The same percentage reported a negative impact on learner concentration due to distraction within virtual environments. Other drawbacks included excessive complexity (50%), multitasking (45%), cognitive overload (40%), and poor accessibility (35%). As shown in Figure 5, technical difficulties represent the most frequently reported disadvantage, followed by distraction and cost-related issues, highlighting the importance of infrastructure readiness and careful instructional design when integrating Metaverse environments in higher education.

Table 4. Percentage of Studies Analyzed per Reported Disadvantages

Disadvantages	**Number of studies**	**Percentage (%)**
Technical difficulties	16	80%
Distraction	11	55%
Cost and equipment	11	55%
Complexity	10	50%
Multitasking	9	45%
Cognitive overload	8	40%
Lack of accessibility	7	35%

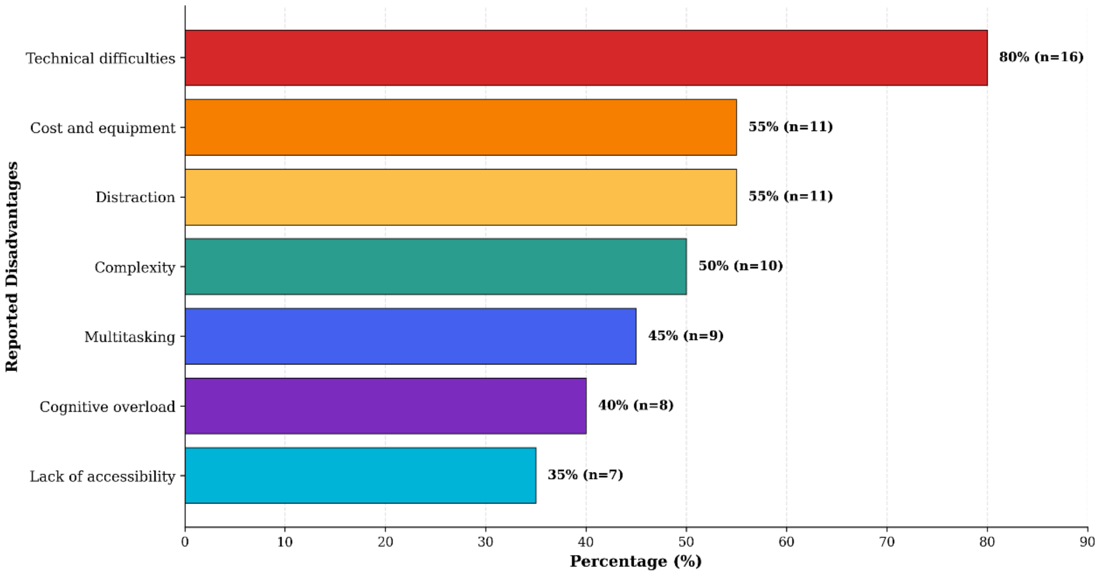

Figure 5. Percentage Distribution of Reported Disadvantages of Metaverse Applications in Higher Education

The Impact of Metaverse on Students' Learning Effectiveness

To determine the effect of metaverse techniques on student learning effectiveness, Hedges's effect size (g) was calculated for each quantitative study using the means and standard deviations of the experimental and control groups (see Table 5). In studies with multiple outcomes, the mean and standard deviations were used to calculate the effect size, as recommended by Bernard et al. (2004). Table 5 presents the descriptive statistics of the studies included in the meta-analysis, including the sample sizes, pretest and posttest means, and standard deviations for the experimental and control groups.

Table 5. Studies analyzed in the Meta-analysis

References	**N**	**Experimental**					**Control**				
		M_{PRE}	S_{PRE}	M_{POST}	S_{POST}	N	M_{PRE}	S_{PRE}	M_{POST}	S_{POST}	N
Luan et al. (2025)	68	2.70	1.90	20.91	4.35	33	4.2	3.23	15.09	5.28	35
Wang and Pan (2025)	356	5.37	0.90	5.69	0.84	178	5.19	0,81	5.28	0.83	178
Chen (2025)	80	62.53	6.28	83.29	6.95	40	61.22	6.75	68.13	4.12	40

References	N	Experimental					Control				
		M_{PRE}	S_{PRE}	M_{POST}	S_{POST}	*N*	M_{PRE}	S_{PRE}	M_{POST}	S_{POST}	*N*
Yang et al. (2024)	96	3.73	0.52	4.19	0.63	48	3.41	0.72	3.55	0.81	48
Shadiev et al. (2024)	40	3.09	0.66	4.75	0.49	20	3.09	0.66	3.85	0.31	20
Ronaghi and Forouharfar (2024)	100	1.83	1.52	3.634	0.40	50	2.10	0.44	2.84	0.54	50
Lin et al. (2024)	60	8.07	2.41	14.83	2.41	30	7.33	2.4	10.83	4.15	30
Chen et al. (2024)	60	66.33	17.71	87	13.17	30	63	10.88	66.67	16.68	30
Hakim et al. (2024)	70	69.38	12.49	83.12	12.9	35	67.61	17.92	74.4	14.62	35
Nicolaidou et al. (2023)	40	1.28	2.04	3.78	2.25	20	1.93	1.99	4.66	2.45	20
Chang et al. (2022)	42	80.76	4.67	88.38	6.34	21	81.81	6.23	81.81	6.23	21
Justo et al. (2022)	198	3.68	1.57	6.18	1.88	104	3.41	1.55	6.01	1.98	94
Yang and Oh (2022)	55	12.52	4.38	18	2.55	29	10.81	4.35	11.85	4.08	26
Khodabandeh (2022)	52	16.63	0.82	18.9	1.30	26	16.67	0.63	17.11	0.66	26
Mansoory et al. (2021)	50	8.35	1.49	14.05	1.27	25	8.5	1.48	12.02	3.45	25
Winkelmann et al. (2020)	279	1.6	1	2.7	1	138	1.8	1	2.7	1	141
Makransky et al. (2019)	77	2.15	1.35	3.69	1.49	52	2.15	1.35	4.84	1.49	25
Winkelmann et al. (2017)	122	2	1	3.3	1	55	2.2	0.9	2.8	0.9	67
Vrellis et al. (2016)	150	2.82	1.12	14.61	2.01	78	2.21	1.23	14.22	2.2	72
Tüzün and Özdinç (2016)	55	4.64	2.1	12.24	1.96	25	3.67	1.54	12.3	2.23	30

Note. M_{PRE} and M_{POST} are the mean scores of the pretests and post-tests for experimental and control groups. S_{PRE} and S_{POST} are the standard deviations of the pretests and post-tests for experimental and control groups.

The overall mean effect size derived from the 20 studies included in the analysis was Hedges's effect size (g) = 0.758, with a 95% confidence interval (CI) of 0.466–1.050. According to Cohen's criteria, this value indicates a meaningful positive impact, demonstrating that metaverse-based educational interventions have a moderate-to-large positive effect on student learning outcomes in higher education.

In order to examine the consistency of results between studies, tests for covariance of results were conducted. The Q test proposed by Cochran (1954) yielded a value of Q = 182.265, exceeding the critical value of the chi-squared distribution (χ^2 = 30.144 degrees of freedom (df = 19)), indicating statistically significant inter-study variance. Because the Q test does not reveal the magnitude of the variance, the I^2 index proposed by Higgins and Thompson was also calculated to measure the degree of inter-study variance.

The I^2 value reached 89.576%, indicating very high inter-study variance, as noted by (Huedo-Medina et al., 2006). Furthermore, the Z = 5.093 and $p < 0.001$ results supported the statistical significance of the effect size. Taken together, these values support the use of the random-effects model, as recommended by Borenstein et al. (2010), which accounts for differences in effect sizes between studies.

Table 6 summarizes the overall results of the meta-analysis, including the number of studies, total sample size, pooled effect size, statistical significance, heterogeneity indices, and confidence intervals. Figure 6 presents the forest plot of the included studies, showing the effect size and 95% confidence interval for each study, together with the pooled effect size based on the random-effects model. As shown in the figure, the effect sizes varied considerably across studies, but the pooled estimate remained positive and statistically significant, supporting the overall effectiveness of metaverse-based interventions in higher education.

Table 6. Summary of Meta-analysis Results

Variable	Value
Number of samples (K)	20
Total sample size (N)	2050
Effect size (Hedges' *g*)	0.758
p (*g*)	< .001
Heterogeneity test (*Q*)	182.265
Critical value (χ^2, df = 19)	30.144
I^2	89.576%
Z	5.093
95% Lower limit	0.466
95% Higher limit	1.050

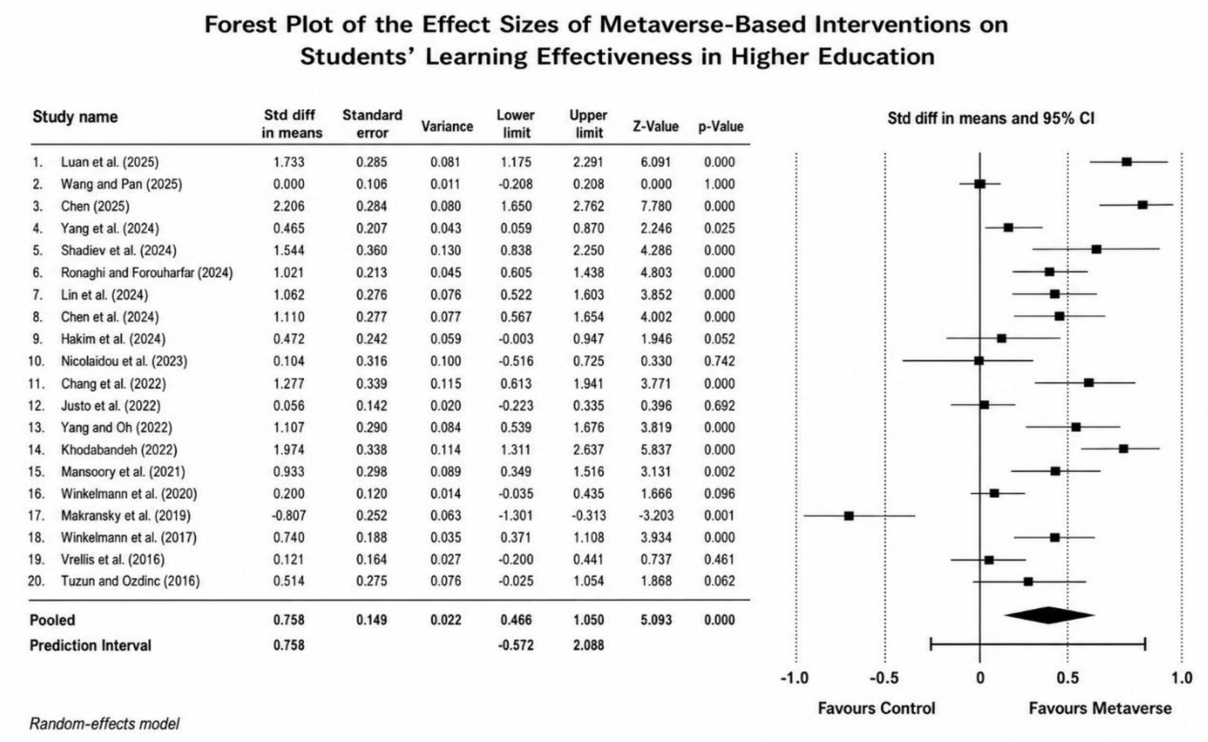

Figure 6. Forest Plot of the Effect Sizes of Metaverse-based Interventions on Students' Learning Effectiveness in Higher Education

To determine the effectiveness of metaverse learning across different educational domains, the average effect size (Hedges' g) was calculated for each major educational domain according to the ISCED-F 2013 classification, based on quantitative data extracted from the included studies. Although the number of studies in each domain is relatively limited, the results provide important insights into the impact of metaverse technologies on learning across different disciplines.

The analyses reveal that metaverse technologies have a significant effect on improving learning outcomes in the fields of business administration and law ($g = 1.021$, $p < 0.001$, $Z = 4.803$), as well as in the arts and humanities ($g = 1.289$, $p < 0.01$, $Z = 3.044$), and health and social care ($g = 1.097$, $p < 0.001$, $Z = 7.351$). These large effect sizes indicate a substantial improvement in learning outcomes when metaverse technologies are integrated into these fields.

Also, the results showed a moderate effect in the fields of services ($g = 0.752$, $p < 0.011$, $Z = 2.550$) and education ($g = 0.630$, $p =.136$, $Z = 1.492$), indicating promising but less stable benefits. In contrast, the fields of natural sciences, mathematics, and statistics showed a small effect ($g = 0.089$, $p = 0.716$, $Z = 0.364$), while engineering, manufacturing, and construction showed a very small effect ($g = 0.056$, $p =.692$, $Z = 0.396$), suggesting a limited impact in these disciplines.

Table 7 summarizes the results of the meta-analysis for each educational field, including the number of studies (K), the total sample size (N), the effect size (g), the statistical significance value (p), and the Z-value. These results support the need for further experimental studies, particularly in disciplines that have not been adequately represented, such as engineering and natural sciences, to verify the reliability and expansion of the use of metaverse techniques in higher education.

Table 7. Summary of Meta-analysis per Broad Field of Education

Variable	**K**	**N**	**Effect Size (g)**	**p (g)**	**Z**
Arts and Humanities	5	336	1.289	0.002	3.045
Health and Welfare	4	207	1.097	< .001	7.351
Natural Sciences, Mathematics and Statistics	4	628	0.089	0.716	0.364
Education	3	451	0.630	0.136	1.492
Services	2	130	0.752	0.011	2.550
Business, administration and law	1	100	1.021	< .001	4.803
Engineering, Manufacturing and Construction	1	198	0.056	0.692	0.396

Note. Categories with K = 1 represent single-study effect sizes rather than pooled meta-analytic estimates.

Figure 7 presents the funnel plot used to visually assess potential publication bias. The plot shows some degree of asymmetry in the distribution of studies around the pooled effect size, which may suggest the presence of publication bias or small-study effects. However, this interpretation should be treated cautiously because the number of included studies was relatively limited and the meta-analysis showed substantial heterogeneity. Therefore, the funnel plot should be interpreted as a visual indication of possible asymmetry rather than conclusive evidence of publication bias.

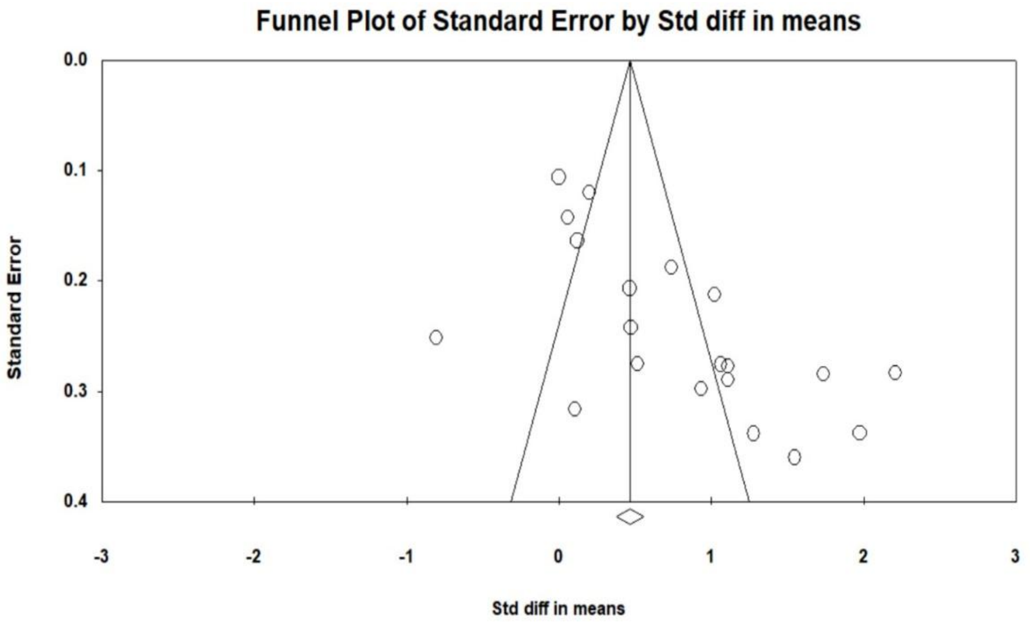

Figure 7. Funnel Plot for Visual Inspection of Potential Publication bias based on Hedges' g

Research Gaps and Future Directions in Metaverse Studies in Higher Education

None of the 20 selected studies directly addressed the needs of learners with disabilities or gifted students, either in terms of design or educational adaptation, except for some out-of-sample studies. Moreover, most studies did not address the privacy, safety, or ethical considerations associated with using metaverse technologies in educational settings, despite their importance in immersive environments. The studies also failed to adequately highlight faculty resistance or attitudes toward metaverse adoption, nor did they discuss faculty preparedness or training. Most studies focused on fields such as medicine, nursing, chemistry, and the arts, while metaverse use in social sciences, information and communication technology, and agriculture was not explored. So, suggested future directions include designing inclusive learning environments that cater to special needs groups, particularly those with disabilities and gifted students; expanding the scope to include new disciplines; conducting longitudinal studies to track the impact of metaverse on achievement and skills over extended periods; and integrating the perspectives of educators and policymakers to identify implementation challenges and ensure institutional acceptance.

Discussion

The results of this systematic review indicate that Metaverse is an emerging technology that is gradually maturing, with increasing applications in educational settings, particularly in higher education. Metaverse technologies—such as virtual reality, extended reality, and immersive 3D environments—have been employed in diverse fields including language teaching, medical training, arts education, engineering, and others, reflecting a significant expansion in its academic uses (Chang et al., 2022; Khodabandeh, 2022; Winkelmann et al., 2020; Yang et al., 2024). Studies have revealed that higher education is the most fertile environment for the application of these technologies, as it provides immersive learning experiences, enables virtual social interaction, and enhances critical thinking and self-directed learning skills, demonstrating metaverse's transformation into an integral component of the digital education system (Jafari, 2023; Panda et al., 2024; Shu & Gu, 2023). Hence, it can be said that metaverse is on its way to becoming one of the future pillars in the development of university education and vocational training.

Metaverse technologies have witnessed increasing adoption in recent years, supported by the rapid development of digital infrastructure and the adoption of smart devices and virtual environments in education, particularly in higher education. The expansion of technologies such as virtual reality, extended reality, and digital twins, along with advancements in devices like VR headsets and simulation platforms, have facilitated the integration of these technologies into academic activities (Buhalis et al., 2023; Wang et al., 2023). Part of this growth is attributed to the global trend towards interactive and digital learning, which has led to a significant increase in the number of studies and publications on metaverse in education since 2020, as observed in recent bibliometric analyses (Akhil et al., 2024; W. Chen et al., 2023). The undergraduate level (Bachelor's degree or equivalent) is the target group in the analyzed studies, as the 17-24 age group has shown a readiness to use metaverse techniques effectively, with a need for pedagogical support to maximize educational benefit (Panda et al., 2024; Shu & Gu, 2023). The results of pilot studies have shown that undergraduate students who have had learning experiences within metaverse environments have achieved significant improvements in comprehension and understanding, particularly in applied disciplines such as nursing, medicine, and engineering (Chang et al., 2022; Winkelmann et al., 2020). Nevertheless, using these environments requires advanced technical skills and may cause distraction or cognitive overload for some learners (Makransky et al., 2019).

Most of the studies applied to the broad field of Arts and Humanities, contributing to the enhancement of English language learning (Chen, 2025; Luan et al., 2025), Italian language learning (Nicolaidou et al., 2023), English writing skills (Khodabandeh, 2022), and the arts (Yang et al., 2024). On the other hand, some educational fields were not represented in the twenty studies analyzed, most notably: Social Sciences, Journalism and Information, Information and Communication Technologies, Agriculture, Forestry, Fisheries, and Veterinary Medicine. This absence reflects a clear research gap in the application of metaverse techniques within these disciplines, opening promising avenues for researchers to explore the potential of this technology and develop innovative educational applications that serve these fields.

Although the 20 studies included in this review did not explicitly address the needs of learners with special needs, such as students with disabilities or gifted students, some external studies have emphasized the need to develop flexible, accessible virtual learning environments within Metaverse that are responsive to the specific needs of these groups and provide equal opportunities for learning and participation. The analysis indicates that the use of Metaverse technologies in educational settings contributes to enhancing several educational and psychological aspects of students' learning. The evidence from the 20 selected studies demonstrates multiple benefits of this technology when applied in higher education (Chang et al., 2022; Makransky et al., 2019; Panda et al., 2024). Based on previous studies, no new benefits beyond those already mentioned were identified, with learning gains remaining the most common benefit, followed by increased student motivation. Remarkably, each new study continues to point to a range of benefits that extend beyond academic achievement to include the development of personal attributes such as focus, interaction, creativity, collaboration, and independence. Besides, the enhanced motivation and academic performance resulting from the use of Metaverse environments can contribute to reducing failure and dropout rates, which in turn reduces the costs associated with repeating courses and the social challenges related to these phenomena (Khodabandeh, 2022; Nicolaidou et al., 2023; Yang et al., 2024). These findings highlight the potential of Metaverse to bring about a sustainable positive transformation in the university learning experience through immersive and interactive environments that stimulate the senses and engage learners in a more dynamic and effective learning process.

Despite the numerous benefits associated with using Metaverse technologies in higher education, this technology still faces several technical and pedagogical challenges that need to be overcome. The studies included in this review have shown recurring difficulties in integrating Metaverse into university learning environments. Technical difficulties are among the most common challenges, followed by high costs and hardware requirements, and the problem of distraction and poor concentration issues largely attributed to the emerging and complex nature of this immersive environment (W. Chen et al., 2023; Makransky et al., 2019; Winkelmann et al., 2017). Despite these challenges, they essentially reflect the evolving nature of technology. Thus, it can be argued that as metaverse tools and technologies advance and the supporting infrastructure improves, many of these problems will gradually diminish.

The meta-analysis revealed promising educational potential for Metaverse technologies in higher education. Educational interventions based on Metaverse demonstrated a significant impact on improving student learning outcomes compared to traditional methods. This impact can be attributed to the immersive and interactive nature of Metaverse environments. These environments provide simulation-based learning experiences, virtual presence, and multi-user interaction, fostering active participation, cognitive engagement, and the development of practical skills among learners. The literature indicates that these characteristics are among the key educational pillars of Metaverse, particularly given its ability to integrate virtual reality, augmented reality, and artificial intelligence within a unified interactive learning environment (Hwang & Chien, 2023; Park & Kim, 2022; Zhang et al., 2022). Also, the high effect size observed in the current study appears to be higher than the average effect sizes reported in previous studies on educational technology in general, such as Tamim et al. (2011) and Chauhan (2017), which indicates that Metaverse is not just an extension of traditional digital tools, but a more profound educational environment in terms of immersion, interaction and real-world experience.

On the contrary, the high degree of variability among studies suggests that the effectiveness of Metaverse depends less on the technology itself and more on how it is applied pedagogically. Learning outcomes can vary depending on the instructional design, the level of engagement, participant characteristics, the academic context, and the type of learning outcomes targeted. This aligns with recent literature emphasizing that the success of Metaverse applications in education depends on the integration of technological capabilities with appropriate pedagogical foundations, rather than on the abstract use of the virtual environment (Jagatheesaperumal et al., 2024; López-Belmonte et al., 2023; Roy et al., 2023). Consequently, the high variability among studies may reflect differences in the quality of design of Metaverse-based learning experiences rather than a contradiction in the effectiveness of the technology itself.

The results also showed differences in the effectiveness of Metaverse across academic disciplines. The effects were most pronounced in business and management, the humanities, and health science fields that rely heavily on human interaction, simulation, decision-making, and situational learning. This can be explained by Metaverse's ability to provide immersive and contextual experiences that are difficult to achieve through traditional methods, as demonstrated in several studies that employed virtual environments in health training, language education, and professional skills development (Chen et al., 2024; Ronaghi & Forouharfar, 2024; Yang & Oh, 2022). On the other hand, the lower effect size in some natural sciences and engineering fields may be attributed to the fact that these disciplines require high levels of procedural or mathematical and experimental modelling rigor, which current Metaverse applications may still struggle to effectively represent.

The results also presented differences in the effectiveness of Metaverse across different academic disciplines. The effects were more pronounced in business and management, humanities, and health sciences, fields that rely heavily on human interaction, simulation, decision-making, and situational learning. This can be explained by Metaverse's ability to provide immersive and contextual experiences that are difficult to achieve with traditional methods. These results collectively indicate that Metaverse has a real potential to support learning in higher education, but its effectiveness appears to be linked to the suitability of the virtual environment to the nature of the discipline and the targeted learning objectives. Thus, the successful implementation of Metaverse should not be based on fascination with the technology itself, but rather on the quality of instructional design, the level of integration between interaction and immersion elements, and the extent to which these environments are used to deliver meaningful and genuinely educational learning experiences. This contrasts with traditional methods, as demonstrated in several studies that have employed virtual environments in health training, language education, and professional skills development (Chen et al., 2024; Ronaghi & Forouharfar, 2024; Yang & Oh, 2022). On the contrary, the lower impact size in some areas of natural science and engineering may be attributed to the fact that these disciplines require high levels of procedural or mathematical and experimental modelling accuracy, which current metaverse applications may still be limited in representing effectively.

Future research should examine Metaverse-based learning environments as part of a broader digital learning ecosystem rather than as isolated immersive platforms. Learning analytics can support the monitoring of learner engagement and help identify dropout risks in digital learning environments (Al-Hafdi & Alhalafawy, 2026). Similarly, IoT-enabled educational infrastructures may enhance connectivity, responsiveness, and data-driven adaptation within immersive learning systems (Najmi et al., 2024). From a learner-centered perspective, Metaverse environments should also integrate support for self-regulated learning and metacognitive engagement, as learners' ability to plan, monitor, and evaluate their learning remains essential in technology-mediated contexts (Zaki, El-Refai, Alharthi, et al., 2024; Zaki, El-Refai, Najmi, et al., 2024). In addition, gamified learning designs may provide useful insights for enhancing learner ambition and sustained participation in immersive learning experiences (Alrashedi et al., 2024).

Limitations of the Study

Although this systematic review and meta-analysis offered significant quantitative evidence on the impact of metaverse in higher education, the interpretation of the results should be approached with some limitations. The meta-analysis relied on a relatively small number of experimental and quasi-experimental studies, and the high degree of variability among the studies revealed clear differences in the nature of the interventions, participant characteristics, measurement tools, and learning outcomes, necessitating caution when generalizing the overall effect size. Moreover, the included studies did not provide a balanced representation of all academic fields, being concentrated in some disciplines such as health, nursing, arts, and chemistry, while others, such as social sciences, information technology, and agriculture, remained underrepresented. This may limit the ability to accurately assess the effectiveness of metaverse across different higher education disciplines.

Another important limitation is that most studies did not adequately address the needs of special groups, such as students with disabilities or gifted students, nor did they demonstrate design strategies that promote accessibility and inclusion within metaverse environments. Additionally, the majority of studies focused on short-term learning outcomes, with limited attention to long-term impact, retention of learning, higher-order skills development, and social interaction. Finally, institutional and ethical aspects, such as faculty readiness, training requirements, infrastructure, privacy, data security, and digital safety, have not received sufficient attention. Therefore, the study recommends more diverse, longitudinal, and empirical future research that considers different disciplines and target groups and integrates the dimensions of holistic design, institutional readiness, cybersecurity, and digital ethics.

Conclusion and Future Work

The current study provides a systematic review and meta-analysis of Metaverse applications in higher education. Its findings demonstrate that the Metaverse has become an emerging digital technology with a growing presence in university settings, particularly in the fields of medicine, nursing, arts, and languages. This expansion reflects the increasing interest in immersive environments and interactive learning experiences that support simulation-based, interactive, and practice-driven learning. The meta-analysis also indicates that the Metaverse has a statistically significant, moderate-to-large positive effect on student learning effectiveness, making it more than just a technological tool; it represents a learning environment that can reshape some aspects of higher education learning experiences.

The study stresses that the effective and sustainable integration of the Metaverse requires a multi-stakeholder approach. At the level of educational institutions, funding bodies, and technology companies, there is a need to invest in developing reliable and scalable learning platforms that consider educational objectives and learner characteristics. At the design and development level, technical challenges and accessibility issues must be addressed to ensure broader benefit for learners, especially those with disabilities or limited technical expertise. At the level of scientific research, there is a need for more diverse experimental and longitudinal studies that measure the impact of the Metaverse on different learning outcomes and test its effectiveness in less-represented university disciplines and contexts, while analyzing the design and institutional factors that enhance its educational success. Therefore, the study concludes that the true value of Metaverse in higher education lies not only in its technological innovation but also in its ability to deliver immersive and meaningful learning experiences, provided it is employed within a clear instructional design, a supportive institutional structure, and a sustainable research vision.

Statements and Declarations

Acknowledgments/Notes: Not applicable.

During the preparation of this article, the authors did not use ChatGPT.

Supplementary Materials: Not applicable.

Author Contributions: All authors contributed equally. All authors have read and agreed to the published version of the manuscript.

Funding: The authors received no funding for the research.

Data Availability: Not applicable.

Ethics Approval: The study was performed in accordance with the study protocol and ethical guidelines and regulations.

Informed Consent: Not applicable.

Conflicts of Interest: The authors declare no conflicts of interest.

References

Akhil, M., Lathabhavan, R., & Mathew, A. M. (2024). Exploring research trends of metaverse in education: a bibliometric analysis. *Higher Education, Skills and Work-Based Learning*. https://doi.org/10.1108/HESWBL-06-2023-0156

Al-Adwan, A. S., Li, N., Al-Adwan, A., Abbasi, G. A., Albelbisi, N. A., & Habibi, A. (2023). "Extending the Technology Acceptance Model (TAM) to Predict University Students' Intentions to Use Metaverse-Based Learning Platforms". *Education and Information Technologies, 28*(11), 15381-15 .413 https://doi.org/10.1007/s10639-023-11816-3

Al-Hafdi, F. S., & Alhalafawy, W. S. (2026). Learning analytics for reducing student dropout in digital video platforms. *PeerJ Computer Science, 12*, e3532. https://doi.org/10.7717/peerj-cs.3532

Al-kfairy ,M., Ahmed, S., & Khalil, A. (2024). Factors impacting users' willingness to adopt and utilize the metaverse in education: A systematic review. *Computers in Human Behavior Reports, 15*, 100459. https://doi.org/10.1016/j.chbr.2024.100459

Alfaisal, R., Hashim, H., & Azizan, U. H. (2024). Metaverse system adoption in education: a systematic literature review. *Journal of Computers in Education, 11*(1), 259-303. https://doi.org/10.1007/s40692-022-00256-6

Alrashedi, N. T., Alsulami, S. M. H., Flatah, A. I., Najmi, A. H., & Alhalafawy, W. S. (2024). The Effects of Gamified Platforms on Enhancing Learners' Ambition. *Journal of Ecohumanism, 3*(8), 3393-3304. https://doi.org/10.62754/joe.v3i8.5004

Avcu, Y. E., & Yaman, Y. (2024). Differentiated Science Instruction in the Metaverse with Gifted Students: Let's Visit Kaz Mountains National Park! *Journal of Inquiry Based Activities, 14*(2), 46-65. https://www.ated.info.tr/index.php/ated/article/view/216

Bernard, R. M., Abrami, P. C., Lou, Y., Borokhovski ,E., Wade, A., Wozney, L., Wallet, P. A., Fiset, M., & Huang, B. (2004). How Does Distance Education Compare With Classroom Instruction? A Meta-Analysis of the Empirical Literature. *Review of Educational Research, 74*(3), 379-439. https://doi.org/10.3102 00346543074003379/

Bernardes, A., Gardim, L., Araujo, A. A. C., Jensen, R., Motta, R. A., de Almeida, D. M., de Lima, R. R., & Peres, H. H. C. (2024). Exploring the metaverse in the education of healthcare students: A scoping review. *Revista Latino-Americana De Enfermagem, 32*, Article e4347. https://doi.org/10.1590/1518-8345.7256.4347

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2010). A basic introduction to fixed-effect and random-effects models for meta-analysis. *Research Synthesis Methods, 1*(2), 97-111. https://doi.org/https://doi.org/10.1002/jrsm.12

Buhalis, D., Leung, D., & Lin, M. (2023). Metaverse as a disruptive technology revolutionising tourism management and marketing. *Tourism Management, 97*, 104724. https://doi.org/10.1016/j.tourman.2023.104724

Camilleri, M. A. (2024). Metaverse applications in education: a systematic review and a cost-benefit analysis. *Interactive Technology and Smart Education, 21*(2), 245-269. https://doi.org/10.1108/ITSE-01-2023-0017

Çelik, F .(2026) .The impact of game-based metaverse on language learning motivation, anxiety, and vocabulary. *International Journal of Applied Linguistics, 36*(2), 1305-1322. https://doi.org/10.1111/ijal.12858

Chanda, R. S., Pabalkar, V., & Sharma, S. (2024). Attitude and behavioral intention for using metaverse in education: learner's perspective. *Journal of Applied Research in Higher Education*. https://doi.org/10.1108/JARHE-07-2023-0307

Chang, C.-Y., Patcharin, P., & and Chang, S.-C. (2022). Effects of integrating maternity VR-based situated learning into professional training on students' learning performances. *Interactive Learning Environments, 32*(5), 2121-2135. https://doi.org/10.1080/10494820.2022.2141263

Chauhan, S. (2017). A meta-analysis of the impact of technology on learning effectiveness of elementary students. *Computers & Education, 105*, 14-30. https://doi.org/10.1016/j.compedu.2016.11.005

Chen, P.-H., Ho, H.-W., Chen, H.-C., Tam, K.-W., Liu, J.-C., & Lin, L.-F. (2024). Virtual reality experiential learning improved undergraduate students' knowledge and evaluation skills relating to assistive technology for older adults and individuals with disabilities. *BMC Medical Education, 24*(1), 101. https://doi.org/10.1186/s12909-024-05085-y

Chen, Q. (2025). Enhancing cross-cultural educational awareness: Experimental study on immersive experiences using virtual reality. *British Educational Research Journal, 51*(2), 687-704. https://doi.org/10.1002/berj.4089

Chen, W., Zhang, J & ,.Yu, Z. (2023). A bibliometric analysis of the use of the metaverse in education over three decades. *International Journal of Information and Communication Technology Education (IJICTE), 19*(1), 1-16. https://doi.org/10.4018/IJICTE.322101

Chen, X., Zou, D., Xie, H., & Wang, F. L. (2023). Metaverse in Education: Contributors, Cooperations, and Research Themes. *IEEE Transactions on Learning Technologies, 16*(6), 1111-1129. https://doi.org/10.1109/TLT.2023.3277952

Chua, H. W., & Yu, Z. (2024). A systematic literature review of the acceptability of the use of Metaverse in education over 16 years. *Journal of Computers in Education, 11*(2), 615-665. https://doi.org/10.1007/s40692-023-00273-z

Cochran, W. G. (1954). The Combination of Estimates from Different Experiments. *Biometrics, 10*(1), 101-129. https://doi.org/10.2307/3001666

Cohen, J. (1968). Weighted kappa: nominal scale agreement with provision for scaled disagreement or partial credit. *Psychol Bull, 70*(4), 213-220. https://doi.org/10.1037/h0026256

Cohen, J. (1992). A power primer. *Psychol Bull, 112*(1), 155 .https://doi.org/10.1037/0033-2909.112.1.155

Dwivedi, Y. K., Hughes, L., Wang, Y., Alalwan, A. A., Ahn, S. J., Balakrishnan, J., Barta, S., Belk, R., Buhalis, D., & Dutot, V. (2023). Metaverse marketing: How the metaverse will shape the future of consumer research and practice. *Psychology & Marketing, 40*(4), 750-776. https://doi.org/10.1002/mar.21767

Fan, J. (2023). RETRACTED: Theory and method for evaluating the importance of college course teaching for future education: From virtual reality to metaverse. *Journal of Intelligent & Fuzzy Systems, 44*, 5893-5919. https://doi.org/10.3233/JIFS-220931

Geng, X. Y., & Su, Y. S. (2024). Enhancing K-12 Students' STEM Learning Through the Integration of the Metaverse Into Online and Blended Environments: A Meta-Analysis. *International Journal of Science and Mathematics Education, 22*(SUPPL1), 111-143. https://doi.org/10.1007/s10763-024-10484-0

George-Reyes, C. E., Sánchez, I. C. P., Glasserman-Morales, L. D., & López-Caudana, E. O. (2023). The Metaverse and complex thinking: opportunities, experiences, and future lines of research. *Frontiers in Education, 8*, Article 1166999. https://doi.org/10.3389/feduc.2023.1166999

Glass, G. V. (1976). Primary, Secondary, and Meta-Analysis of Research1. *Educational Researcher, 5*(10), 3-8. https://doi.org/10.3102/0013189X005010003

Hadi, R., Melumad, S., & Park, E. S. (2024). The Metaverse: A new digital frontier for consumer behavior. *Journal of Consumer Psychology, 34*(1), 142-166. https://doi.org/10.1002/jcpy.1356

Hakim, V. G. A., Yang, S. H., Wang, J. H., Lin, H. H., & Chen, G. D. (2024). Digital Twins of Pet Robots to Prolong Interdependent Relationships and Effects on Student Learning Performance. *IEEE Transactions on Learning Technologies* .1857-1843 ,17 ,https://doi.org/10.1109/TLT.2024.3416209

Hedges, L. V., & Olkin, I. (1985). Statistical Methods for Meta-Analysis .Academic Press. https://doi.org/10.1016/C2009-0-03396-0

Hennig-Thurau, T., Aliman, D. N., Herting, A. M., Cziehso, G. P., Linder, M., & Kübler, R. V. (2023). Social interactions in the metaverse: Framework, initial evidence, and research roadmap. *Journal of the Academy of Marketing Science, 51*(4), 889-913. https://doi.org/10.1007/s11747-022-00908-0

Huedo-Medina, T. B., Sánchez-Meca, J., Marín-Martínez, F., & Botella, J .(2006) .Assessing heterogeneity in meta-analysis: Q statistic or I² index? *Psychological Methods, 11*(2), 193-206. https://doi.org/10.1037/1082-989X.11.2.193

Hwang, G.-J., & Chien, S.-Y. (2023). Broad sense and narrow sense perspectives on the metaverse in education: roles of virtual reality, augmented reality, artificial intelligence and pedagogical theories. *International Journal of Mobile Learning and Organisation, 18*(1), 1-14. https://doi.org/10.1504/IJMLO.2024.135179

Hwang, G.-J., Tu, Y.-F., & Chu, H.-C. (2 .(023Conceptions of the metaverse in higher education: A draw-a-picture analysis and surveys to investigate the perceptions of students with different motivation levels. *Computers & Education, 203*, 104868. https://doi.org/10.1016/j.compedu.2023.104868

Jafari, E. (2023). The outlook of learning through metaverse technology from the perspective of teachers in the science education: Association for Learning Technology Journal. *Research in Learning Technology, 31*, 1-15. https://doi.org/10.25/304rlt.v31.2933

Jagatheesaperumal, S. K., Ahmad, K., Al-Fuqaha, A., & Qadir, J. (2024). Advancing Education Through Extended Reality and Internet of Everything Enabled Metaverses: Applications, Challenges, and Open Issues. *IEEE Transactions on Learning Technologies, 17*, 1120-1139. https://doi.org/10.1109/TLT.2024.3358859

Ji-yoon, K., & Han-sol, K. (2024). Innovative Integration of Poetry and Visual Arts in Metaverse for Sustainable Education. *Education Sciences, 14*(9), 1012. https://doi.org/10.3390/educsci14091012

Johri, A., Joshi, P., Kumar, S., & Joshi, G. (2024). Metaverse for Sustainable Development in a bibliometric analysis and systematic literature review. *Journal of Cleaner Production, 435*, 140610. https://doi.org/10.1016/j.jclepro.2024.140610

Justo, E., Delgado, A., Llorente-Cejudo, C., Aguilar, R., & Cabero-Almenara, J. (2022). The effectiveness of physical and virtual manipulatives on learning and motivation in structural engineering. *Journal of Engineering Education, 111*(4), 813-851. https://doi.org/10.1002/jee.20482

Khodabandeh, F. (2022). Exploring the applicability of virtual reality- enhanced education on extrovert and introvert EFL learners' paragraph writing. *International Journal of Educational Technology in Higher Education, 19*(1), 27. https://doi.org/10.1186/s41239-022-00334-w

Kitchenham, B., & Charters, S. (2007). Guidelines for performing Systematic Literature Reviews in Software Engineering. *2*. https://docs.edtechhub.org/lib/EDAG684W .

Kshetri, N., Rojas-Torres, D., & Grambo, M. (2022). The Metaverse and Higher Education Institutions. *IT Professional, 24*(6), 69-73. https://doi.org/10.1109/MITP.2022.3222711

Lin, Y.-C., Chien, S.-Y., & Hou, H.-T. (2024). A multi-dimensional scaffolding-based virtual reality educational board game design framework for service skills training. *Education and Information Technologies*. https://doi.org/10.1007/s10639-024-13243-4

López-Belmonte, J., Pozo-Sánchez, S., Moreno-Guerrero, A.-J., & Lampropoulos, G. (2023). Metaverse in Education: a systematic review. *Revista de Educación a Distancia (RED), 23*(73). https://doi.org/10.6018/red.511421

Luan, L., Gwo-Jen, H., Yanqing, Y., Zhihong, L., & and Jing, B. (2025). The effects of a self-developed virtual reality environment on college EFL learners' vocabulary learning. *Interactive Learning Environments, 33*(1), 335-346. https://doi.org/10.1080/10494820.2024.2344056

Maghaydah, S., Al-Emran, M., Maheshwari, P., & Al-Sharafi, M. A. (2024). Factors affecting metaverse adoption in education: A systematic review, adoption framework, and future research agenda. *Heliyon, 10*(7). https://doi.org/10.1016/j.heliyon.2024.e28602

Makransky, G., Terkildsen, T. S., & Mayer, R. E. (2019). Adding immersive virtual reality to a science lab simulation causes more presence but less learning. *Learning and Instruction, 60*, 225-236. https://doi.org/10.1016/j.learninstruc.2017.12.007

Mansoory, M. S., Khazaei, M. R., Azizi, S. M., & Niromand, E. (2021). Comparison of the effectiveness of lecture instruction and virtual reality-based serious gaming instruction on the medical students' learning outcome about approach to coma. *BMC Medical Education, 21*(1), 347. https://doi.org/10.1186/s12909-021-02771-z

Mercan, G & ,.Selçuk, Z. V. (2024). The Role of Metaverse Technology in Education: A Systematic Review of Opportunities, Challenges, and Educational Potential. *Sakarya University Journal of Education, 14*(2), 360-375. https://doi.org/10.19126/suje.1376341

Mingyu ,G., Yunus, M. M., & Rafiq, K. R. M. (2024). Using Metaverse-based Learning as a Strategy to Improve Higher Education: A Systematic Review (2019-2023). *International Journal of Academic Research in Progressive Education and Development, 13*(1). https://doi.org/10.6007/IJARPED/v13-i1/20856

Morris, S. B., & DeShon, R. P. (2002). Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs. *Psychological Methods, 7*(1), 105-125. https://doi.org/10.1037/1082-989X.7.1.10 5

Najmi, A. H., Alameer, Y. R., & Alhalafawy, W. S. (2024). Exploring the Enablers of IoT in Education: A Qualitative Analysis of Expert Tweets. *Journal of Infrastructure, Policy and Development, 8*(10), 5079. https://doi.org/10.24294/jipd.v8i10.5079

Nicolaidou, I., Petros, P., & and Boglou, D. (2023). Comparing immersive Virtual Reality to mobile applications in foreign language learning in higher education: a quasi-experiment. *Interactive Learning Environments, 31*(4), 2001-2015. https://doi.org/10.1080 10494820.2020.1870504/

Panda, G., Arora, M., Ghoshal, I., Garza-Reyes, J. A., & Kaswan, M. S. (2024). Application of metaverse in higher education: a systematic literature review and bibliometric analysis. *The TQM Journal*(ahead-of-print). https://doi.org/10.1108/TQM-08-2024-0279

Park, S. M., & Kim, Y. G. (2022). A Metaverse: Taxonomy, Components, Applications, and Open Challenges. *IEEE Access, 10*, 4209-4251. https://doi.org/10.1109/ACCESS.2021.3140175

Pujasari, R. S., Fatimah, A. S., Sri, M., & Sulastri, F. (2024). Potential Benefits of Metaverse Concept Implementation in English for Tourism Course: A Case Study in Indonesian Higher Education Contexts. *International Journal of Language Education, 8*(3), 520-532. https://doi.org/10.26858/ijole.v8i3.66494

Ronaghi, M. H., & Forouharfar, A. (2024). Virtual reality and the simulated experiences for the promotion of entrepreneurial intention: An exploratory contextual study for entrepreneurship education. *The International Journal of Management Education, 22* .100972 ,(2) https://doi.org/10.1016/j.ijme.2024.100972

Roy, R., Babakerkhell, M. D., Mukherjee, S., Pal, D., & Funilkul, S. (2023). Development of a framework for metaverse in education: a systematic literature review approach. *IEEE Access, 11*, 57717-57734. https://doi.org/10.1109/ACCESS.2023.3283273

Sá, M. J., & Serpa, S. (2023). Metaverse as a learning environment: Some considerations. *Sustainability, 15*(3), 2186. https://doi.org/10.3390/su15032186

Sawilowsky, S. S. (2009). New effect size rules of thumb. *Journal of modern applied statistical methods, 8*(2), 26. https://doi.org/10.22237/jmasm/1257035100

Shadiev, R., Wang, X., & Shen, S. (2024). Effects of immersion and interactive strategies on students' intercultural competence in virtual learning environments. *Education and Information Technologies, 30*(5), 5883-5919. https://doi.org/10.1007/s10639-024-13030-1

Shi, C., & Park, J. Y. (2024). A systematic review of the Metaverse in formal education. *Journal of Applied Research in Higher Education*. https://doi.org/10.1108/JARHE-04-2024-0162

Shu, X., & Gu, X. (2023). An Empirical Study of A Smart Education Model Enabled by the Edu-Metaverse to Enhance Better Learning Outcomes for Students. *Systems, 11*(2), 75. https://doi.org/10.3390/systems11020075

Simsek, E. I., & Baltaci, S. (2024). A systematic examination of metaverse technologies, with emphasis on second life as a pedagogical instrument. *Journal of Computers in Education*. https://doi.org/10.1007/s40692-024-00329-8

Suiçmez, İ & ,.Ozansoy, K. (2024). Development of Sustainable Education Environments in Higher Education with Metaverse Applications. *Sustainability, 16*(23), 10331. https://doi.org/10.3390/su162310331

Sung, E., Kwon, O., & Sohn, K. (2023). NFT luxury brand marketing in the metaverse: Leveraging blockchain-certified NFTs to drive consumer behavior. *Psychology & Marketing, 40*(11), 2306-2325. https://doi.org/10.1002/mar.21854

Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., & Schmid, R. F .(2011) .What Forty Years of Research Says About the Impact of Technology on Learning: A Second-Order Meta-Analysis and Validation Study. *Review of Educational Research, 81*(1), 4-28. https://doi.org/10.3102/0034654310393361

Tüzün, H., & Özdinç, F .(2016) .The effects of 3D multi-user virtual environments on freshmen university students' conceptual and spatial learning and presence in departmental orientation. *Computers & Education, 94*, 228-240. https://doi.org/10.1016/j.compedu.2015.12.005

UNESCO, I. (2014). ISCED Fields of Education and Training 2013 (ISCED-F 2013): manual to accompany the International Standard Classification of Education 2011. *Montreal: UNESCO IFS*. https://doi.org/10.15220/978-92-9189-150-4-en

Villalonga-Gómez, C., Ortega-Fernández, E., & Borau-Boira, E. (2023). Fifteen years of metaverse in Higher Education: A systematic literature review. *IEEE Transactions on Learning Technologies*. https://doi.org/10.1109/TLT.2023.3302382

Vrellis, I., Avouris, N., & Mikropoulos, T .A. (2016). Learning outcome, presence and satisfaction from a science activity in Second Life. *Australasian Journal of Educational Technology, 32*(1). https://doi.org/10.14742/ajet.2164

Wang, H., Ning, H., Lin, Y., Wang, W., Dhelim, S., Farha, F., Ding ,J., & Daneshmand, M. (2023). A survey on the metaverse: The state-of-the-art, technologies, applications, and challenges. *IEEE Internet of Things Journal, 10*(16), 14671-14688. https://doi.org/10.1109/JIOT.2023.3278329

Wang, Y., & Pan, L. (2025). Immersive virtual reality in education: impact on the emotional intelligence of university students. *Education and Information Technologies, 30*(4), 5283-5299. https://doi.org/10.1007/s10639-024-13013-2

Wang, Y., Su, Z., Zhang, N., Xing, R., Liu, D., Luan, T. H & ,.Shen, X. (2022). A survey on metaverse: Fundamentals, security, and privacy. *IEEE Communications Surveys & Tutorials, 25*(1), 319-352. https://doi.org/10.1109/COMST.2022.3202047

Winkelmann, K., Keeney-Kennicutt, W., Fowler, D., & Macik, M. (2017). Development, Implementation, and Assessment of General Chemistry Lab Experiments Performed in the Virtual World of Second Life. *Journal of Chemical Education, 94*(7), 849-858. https://doi.org/10.1021/acs.jchemed.6b00733

Winkelmann, K., Wendy, K.-K., Debra, F ,.Maria, L. M., Paola, P. G., & and Joan Ahlborn, C. (2020). Learning gains and attitudes of students performing chemistry experiments in an immersive virtual world. *Interactive Learning Environments, 28*(5), 620-634. https://doi.org/10.1080/10494820.2019 1696844.

Yang, S.-Y., & Oh, Y.-H. (2022). The effects of neonatal resuscitation gamification program using immersive virtual reality: A quasi-experimental study. *Nurse Education Today, 117*, 105464. https://doi.org/10.1016/j.nedt.2022.10546 4

Yang, X., Cheng, P.-Y., Liu, X., & Shih, S.-P. (2024). The impact of immersive virtual reality on art education: A study of flow state, cognitive load, brain state, and motivation. *Education and Information Technologies, 29*(5), 6087-6106. https://doi.org/10.1007/s10639-023-12041-8

Yenduri, G., Kaluri, R., Rajput, D. S., Lakshmanna, K., Gadekallu, T. R., Mahmud, M., & Brown, D. J. (2023). From Assistive Technologies to Metaverse—Technologies in Inclusive Higher Education for Students With Specific Learning Difficulties: A Review. *IEEE Access, 11*, 64907-64927. https://doi.org/10.1109/ACCESS.2023.3289496

Yuan, Y., Teng, W., Zhi, H., & Xu, J. (2024). Cognition, Experience & reaction: optimizing the Use of the Metaverse in Future Education from the perspective of the IPOP Theory. *International Communication of Chinese Culture, 11*(2), 239-257. https://doi.org/10.1007/s40636-024-00289-9

Zaki, M. Z. T., El-Refai, W. Y., Alharthi, M. A., Al-Hafdi, F. S., Najmi, A. H., Bakey, F. M. A. E., & Alhalafawy, W. S .(2024) .The Effect of Mobile Search Retrieval Types on Self-Regulated Learning Among Middle School Students. *Journal of Ecohumanism, 3*(8). https://doi.org/10.62754/joe.v3i8.5005

Zaki, M. Z. T., El-Refai, W. Y., Najmi, A. H., Al-Hafdi, F. S., Alhalafawy ,W. S., & Abd El Bakey, F. M. (2024). The Effect of Educational Activities through the Flipped Classroom on Students with Low Metacognitive Thinking. *Journal of Ecohumanism, 3*(4), 2476-2491. https://doi.org/10.62754/joe.v3i4.3770

Zallio, M., & Clarkson, P .J. (2022). Designing the metaverse: A study on inclusion, diversity, equity, accessibility and safety for digital immersive environments. *Telematics and Informatics, 75*, 101909. https://doi.org/10.1016/j.tele.2022.101909

Zhang, X., Chen, Y., Hu, L & ,.Wang, Y. (2022). The metaverse in education: Definition, framework, features, potential applications, challenges, and future research topics [Review]. *Frontiers in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.1016300

Zhou, Q., Wang, B., & Mayer, I .(2024) .Understanding the social construction of the metaverse with Q methodology. *Technological Forecasting and Social Change, 208*, 123716. https://doi.org/10.1016/j.techfore.2024.123716