Scientific Mapping of Research on Metaverse in Education

Jiaxin Ren
UCSI University Malaysia, Malaysia

Yee Hock Tan
UCSI University Malaysia, Malaysia

Juncheng Guo
UCSI University Malaysia, Malaysia

www.ijte.net

To cite this article:

Ren, J., Tan, Y.H., & Guo, J. (2025). Scientific mapping of research on metaverse in education. *International Journal of Technology in Education (IJTE), 8*(1), 1-21. https://doi.org/10.46328/ijte.986

International Journal of Technology in Education
2025, Vol. 8, No. 1, 1-21 https://doi.org/10.46328/ijte.986

Scientific Mapping of Research on Metaverse in Education

Jiaxin Ren, Yee Hock Tan, Juncheng Guo

Article Info

Article History

Received:
18 August 2024
Accepted:
11 November 2024

Keywords

Metaverse
Education
Systematic review
Bibliometric mapping analysis

Abstract

The metaverse is a virtual reality space that provides a novel and significant environment, fostering educational opportunities and serving as a rich platform for innovative forms of learning. This bibliometric analysis uses the Scopus database as a source for review, employing the PRISMA method to identify 270 articles, with visualisation analysis conducted using VOSviewer. The results show an increasing trend in the number of published articles since 2020, with significant contributions from South Korea, China, United States, and United Kingdom. Common keywords in the realm of metaverse and education research include "virtual reality," "augmented reality," and "artificial intelligence." Currently, the integration of augmented reality (AR) and virtual reality (VR) technologies has significantly enhanced educational outcomes and student motivation in medicine, engineering, and primary education. The potential of metaverse technology in education is highly promising. Through innovative and immersive experiences, the metaverse is poised to become a sustainable educational medium, unrestricted by time and space.

Introduction

With the rapid advancement of digital technology and the proliferation of 5G and other networks, the "Metaverse" has increasingly become a topic of widespread discussion. The term metaverse is a compound word derived from "meta" (meaning beyond or virtual) and "universe," referring to a new world represented through digital media such as smartphones and the internet (Al-Adwan et al., 2023). It is envisioned as a three-dimensional virtual reality in which avatars, acting as representations of individuals, participate in everyday activities and economic interactions (Go et al., 2021). Thereby merging the real world with virtual space and extending reality into the virtual realm. Hence, the metaverse offers users a diverse range of interactions with multiple roles and virtual services, making it a novel digital reality (Zhou et al., 2024).

From an educational perspective, the metaverse is an expansive digital space that enables highly interactive learning environments (Roy et al., 2023). The metaverse provides a new, meaningful reality and learning opportunities (Díaz, 2020), offering fertile ground for new forms of education. Numerous universities and educational institutions have conducted extensive research on the metaverse. For example, the metaverse platform is seen as a significant tool that learners can use to enhance their motivation and immersion in learning. It allows learners to experience innovative learning methods and gain autonomous learning experiences (Han et al., 2023). The metaverse can also function as a learning system for conducting educational activities. However, to transition

education to the metaverse, both students and teachers need to acquire the necessary knowledge and guidance (Suzuki et al., 2020). Moreover, as an educational tool, the metaverse encourages students to engage in research and interact with information in a virtual environment, thereby enhancing their interest and comprehension, which fosters a creative learning process (Huang et al., 2010; Merchant et al., 2014).

Moreover, in the context of the metaverse in education, the integration of emerging technologies into education has consistently faced challenges related to user acceptance and adoption. One prominent theoretical framework that has been widely employed to understand and predict the acceptance of new technologies is the Technology Acceptance Model (TAM), proposed by Davis (1989). TAM posits that two primary factors—perceived usefulness (PU) and perceived ease of use (PEOU)—significantly influence an individual's attitude towards adopting a technology, which in turn determines their behavioural intention to use it and, ultimately, their actual usage (Turner et al., 2010). In the context of the metaverse, TAM provides a valuable lens to analyse the factors influencing its adoption in education. The perceived usefulness of the metaverse might relate to its ability to create immersive, engaging, and interactive learning environments, enabling learners to achieve better educational outcomes. Meanwhile, perceived ease of use reflects the accessibility and user-friendliness of metaverse platforms, which can either facilitate or hinder their adoption by students and educators. For example, a lack of technical training or high complexity in platform navigation may negatively affect educators' and learners' willingness to use metaverse-based tools.

The metaverse is a cutting-edge technology that provides immersive and engaging educational experiences by allowing real-world users to interact and collaborate with others in a virtual space, revolutionising the way of learning (Nasir et al., 2023). There has been a significant rise in the volume of published research on this subject. In 2023, Bizel (2023) conducted a bibliometric examination of literature on the metaverse, evaluating the current landscape, identifying gaps, and suggesting future research directions. The study also reviewed and identified applications of this emerging educational technology, but was limited to the use of data from the Dimensions scientific database only, from a period of 2004 to 2022 (Bizel, 2023). Chamorro-Atalaya et al.(2023) analysed research on the use of the metaverse in university education, focusing particularly on the integration of the metaverse into the development of flipped classrooms within university settings.

Similarly, Tyagi et al.(2023) conducted research on the incorporation of the metaverse within the higher education system, assessing the current state of studies on the application of virtual universes in this sector. Their results indicate that most studies focused on the use of virtual universes in specific disciplines such as engineering, computer science, and game design. The most commonly used methods are case studies and surveys, with findings primarily addressing student engagement, collaboration, and learning outcomes. These previous studies provide a solid foundation and significant reference value for research on the metaverse in education. However, their studies are mostly confined to the educational system of higher education institutions.

Currently, despite the growing implementation of the metaverse into education, bibliometric studies in this domain, especially those employing the Scopus database, remain limited. Scopus is considered one of the largest curated databases, covering scientific journals, books, and conference proceedings (Singh et al., 2021).

Consequently, this study utilises a systematic review method to analyse academic research on the metaverse in education, with the goal of achieving a thorough understanding of the existing research landscape, trends, and key topics, thereby offering guidance for future studies. This study is driven by the following research questions:

(1) How have annual trends in research on the metaverse in education evolved, and what are the most productive countries?
(2) Which journals and articles have made significant contributions to the field of metaverse in education?
(3) What are the most prominent topics in the metaverse in education research, and what are the areas for future exploration?

Method

This study employs systematic review and descriptive bibliometric analysis design, utilising the Scopus database to examine the metadata and content of metaverse research in education during the last ten years. Scopus is renowned for its extensive collection of documents and abstracts, which enhances its capability for citation and abstract searches. It comprises considerably more publications—approximately 70% more—than the Web of Science and provides a broader range of products than other databases (Shareefa & Moosa, 2020). Therefore, Scopus has been an essential resource in database compilation for review research (Mongeon & Paul-Hus, 2016). This extensive coverage allows for a comprehensive analysis, offering a robust foundation for researchers focusing on the metaverse in education.

Bibliometric analysis is the graphical representation of a certain knowledge domain using quantitative data, which is critical for assessing research trends and the current level of academic investigation. This method allows researchers to evaluate scientific accomplishments and track academic progress within the research society. By mapping the relationships between authors, countries, and keywords, bibliometric analysis provides insights into the most influential studies, emerging research areas, and collaboration networks. This scientific mapping approach is widely used throughout numerous research areas, but its application in the study of metaverse technology within education is still developing (Okumuş Dağdeler, 2023). This analysis helps to identify key contributors, track the evolution of research topics, and highlight gaps in the current literature, making it an indispensable tool for guiding future research directions. It specifically centres on the application of mathematical and statistical techniques to books and other communication media (Pritchard, 1969). Bibliometrics entails the quantitative analysis of bibliographic features within a body of literature (Howkins, 1981).

In other words, bibliometrics uses quantitative analysis and statistical data to describe publication patterns in a specific field or literature and is considered an effective statistical method for evaluating scientific publications (Liu et al., 2021). Therefore, this study employs bibliometric methods to quantitatively analyse research related to the metaverse in education and provides an overall understanding of the topic, identifies knowledge gaps, and guides future research. VOSviewer, a network mapping software, is used to conduct the bibliometric analysis. This software has been commonly used in the scientific mapping in the educational research field (Effendi et al., 2021; Van Eck & Waltman, 2010).

Data Collection

The data were collected on 9th July 2024 from a search of journal articles published in Scopus. The search strings "metaverse and education," "metaverse and instruction," "metaverse and learning," and "Edu-metaverse" were used to screen the topic, including the title, abstract, and keywords to ensure relevance. The selection of these databases was driven by several factors, notably their extensive coverage and ability to incorporate influential articles on educational technology. This capability aligns directly with the focus of this study, ensuring that the most relevant and impactful research is considered (Lampropoulos et al., 2022). To determine which papers would be included in the systematic review, specific inclusion and exclusion criteria were established. These criteria involved assessing the quality and relevance of each study, such as the clarity of objectives, robustness of methodology, and significance of findings.

Table 1 details the inclusion and exclusion criteria used, including factors such as publication date, written language, the type of publication, and the relevance of the study's content to the research questions. Only studies published between 2015 and July 2024 were included, ensuring that the review captured recent and relevant developments in metaverse technology for education. Furthermore, to maintain consistency in interpretation and accessibility, only studies written in English were selected. Additionally, this systematic review focused exclusively on journal articles, as the majority of journal articles had undergone peer review (Kelly et al., 2014). Peer review serves as a primary indicator of quality within academic disciplines, helping to ensure that published research adheres to the values and standards of the field (Kaspar et al., 2017). In contrast, technical reports, online presentations, news items, brief surveys, notes, and conference abstracts were excluded to maintain the academic standards (Pradana et al., 2023). Additionally, studies were excluded if they did not explicitly discuss the concept of the metaverse or if their topics were too far removed from the fields of social sciences and education. This was to maintain a clear and relevant focus on the intersection of the metaverse and educational research. This rigorous selection process ensures a comprehensive and high-quality review of the literature, establishing an appropriate foundation for investigating the use of metaverse technologies in education.

Table 1. The Criteria for Inclusion and Exclusion

Inclusion Criteria	**Exclusion Criteria**
Articles published between January 2015 - July 2024	Articles that are publish before 2015
Articles written in English.	Articles that are written in other languages
Journal articles	Books, book chapters, and conference papers, technical reports, online presentations, news items, brief surveys, notes, and conference abstracts

This study follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards (Figure 1), which detail each step from initial identification to final inclusion of studies (Page et al., 2021). This rigorous selection process ensures a comprehensive and focused review of the most pertinent literature.

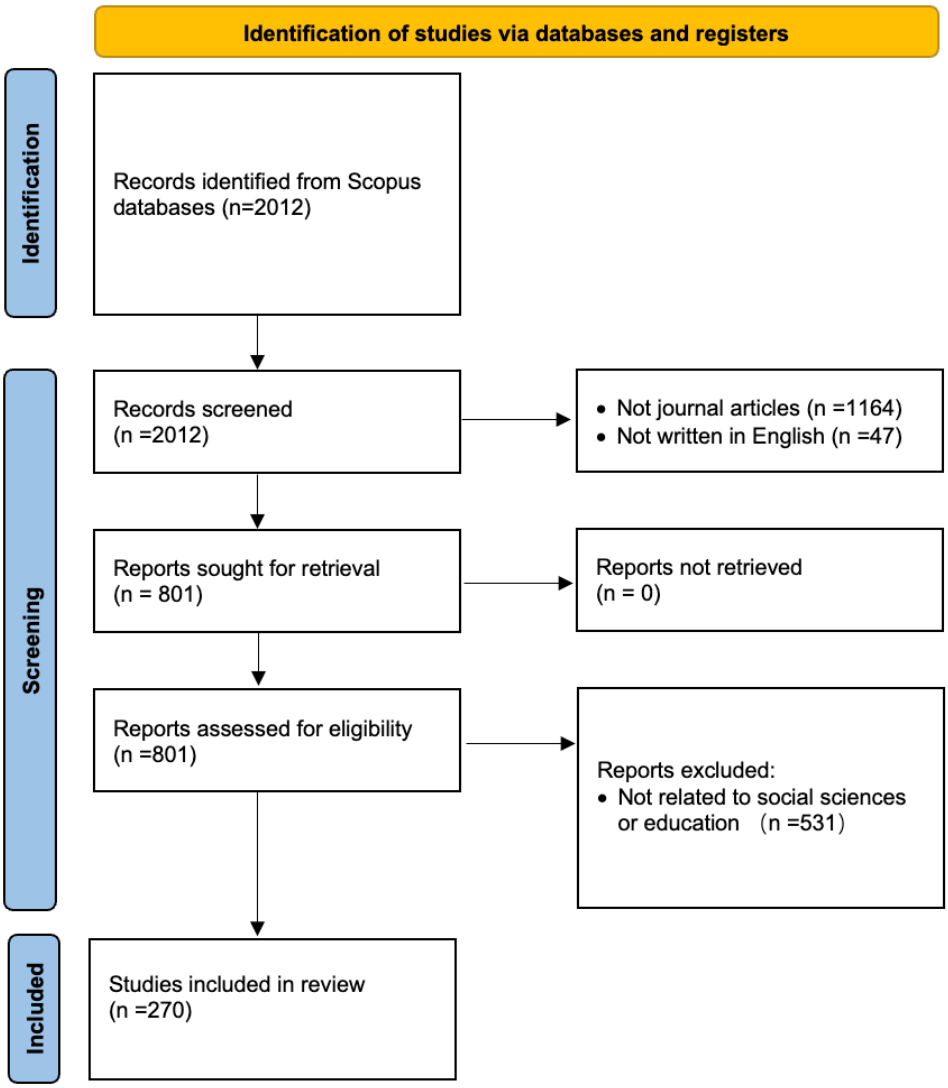

Figure 1. Research Flowchart based on PRISMA

Data Analysis

Through PRISMA analysis, a total of 270 articles were identified. The identified articles were downloaded in CSV format for further processing using VOSviewer (version 1.6.19), which facilitated a detailed bibliometric analysis of trends. The bibliometric analysis allowed for the examination of large datasets and enabled the extraction of meaningful patterns. The Visualisation of Similarities (VOS) viewer software was used due to its ability to simplify the visualisation of complex bibliometric maps (Tamala et al., 2022).

From the software, several visual representations were created to illustrate the data. These included publication maps illustrating the distribution of research outputs, author or journal networks identified through co-citation analysis, and keyword maps generated from co-occurrence data. The publication maps help identify prolific research areas and key contributors, while the author and journal networks reveal collaborative relationships and influential sources within the field. The keyword maps provide insights into the central themes and emerging

trends in the research domain (Donthu et al., 2021).

Results

To answer the study questions raised in the preceding section, networks were generated based on the co-occurrences of significant terms, from which visualisation maps were produced. The analysis results were presented through various methods, including annual publication trends, citation analysis of countries, most cited journals and articles, and co-occurrences of author keywords. Citation analysis of countries measures the academic influence of different countries within the metaverse in education research field by counting the number of times academic papers from those countries are cited. This type of analysis can reveal which countries hold dominant positions in specific fields and can be utilised to compare the research quality and impact of each country. Furthermore, such analysis can aid in understanding patterns and trends in global scientific collaboration. The identification of the most cited journals and articles highlights those with the highest citation counts within a particular research domain. Through this analysis, core literature and significant research outcomes within the field can be identified. Co-occurrence analysis of author keywords determines the relatedness of items based on the number of documents in which they appear together. By revealing the connections between various research topics and concepts, as well as research hotspots, this analysis contributes to understanding the knowledge structure, primary research directions, and core issues of interest to researchers in the field of metaverse in education.

Annual Trends of Publication and Most Productive Countries

The analysis of publication trends over time gives valuable insights into the current state and overall trends in the field (Wang et al., 2022). The number of studies on the metaverse in education published in the last ten years (January 2015 to July 2024) is shown in a graphical representation (Figure 2). As depicted in the figure, there were no publications in the field of metaverse in education before 2020. Despite that, research activity in this area had a notable increase from 2022 onwards. Specifically, the number of publications began to rise in 2020 and 2021, with four articles each year.

This number further increased significantly in 2022, reaching 36 articles and later reached a peak of 131 publications in 2023, indicating that metaverse in education had become a highly popular topic. This progressive increase may be attributed to technological advancements and growing interest in the application of the metaverse in education since the start of the decade. Although the data for 2024 is not yet complete, there have already been 91 articles published, suggesting that research interest in metaverse in education remains strong.

The upward trend in publications reflects the growing recognition and exploration of the metaverse's potential to revolutionise educational environments. This trend signifies not only an increased academic interest in the topic but also an acknowledgement of the transformative impact that metaverse technologies can have on teaching and learning practices. The growing body of literature highlights the diverse applications and benefits of metaverse technologies in education, from enhancing immersive learning experiences to fostering interactive and

collaborative educational settings. This sustained research interest underscores the metaverse's evolving role and its anticipated impact on the future of education.

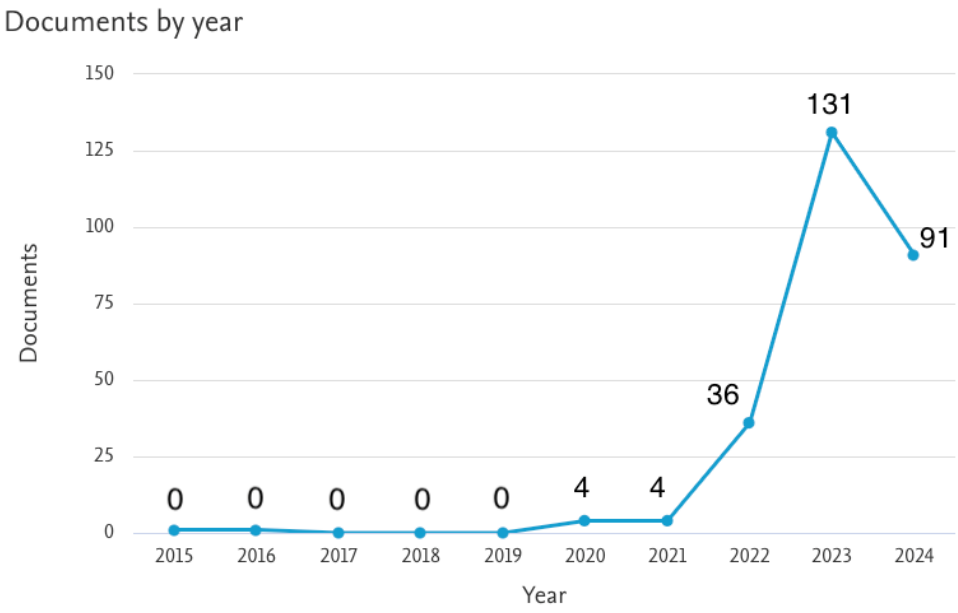

Figure 2. Annual Trends of Publication

In the process of examining the most productive countries, the minimum number of documents from a country was set at 5, and the minimum number of citations was set at 2 (Okumuş Dağdeler, 2023). The results, presented in graphical representation (see Figure 3-4), included data from 22 countries. The countries with the highest productivity in terms of publications on metaverse in education are South Korea (f = 40), China (f = 35), and the United States (f = 31) (see Figure 3).

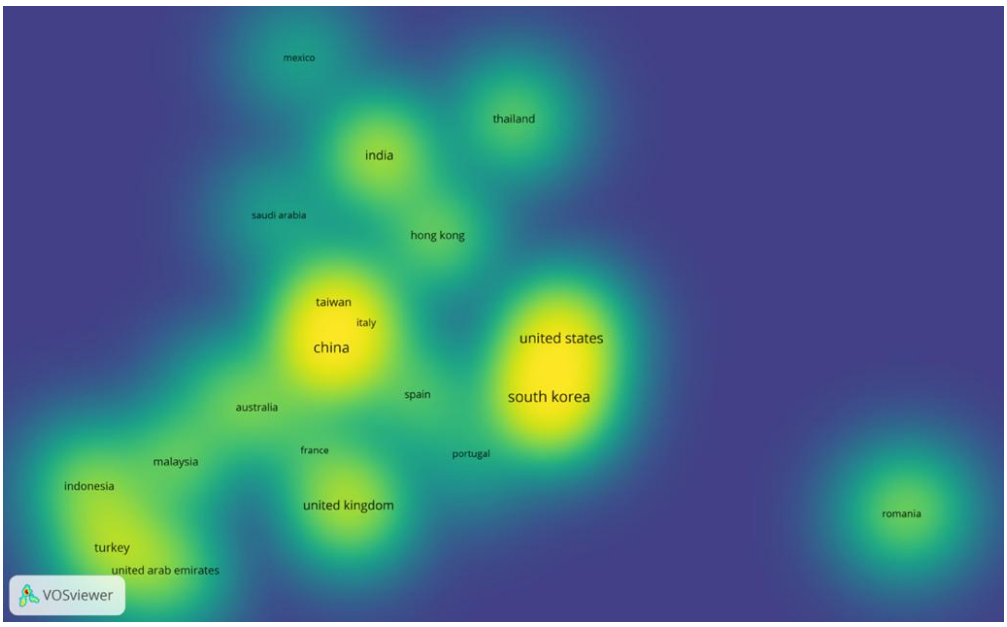

Figure 3. Countries with the Most Documents

As for citation counts (see Figure 4), South Korea again leads in terms of the number of citations, followed by the United Kingdom and China. This indicates that not only is South Korea producing a high volume of research in the field, but its work is also receiving significant recognition and impact within the academic community. Notably, both Figure 3 and 4 heat maps showed high agreement on the countries with the most documents and citations.

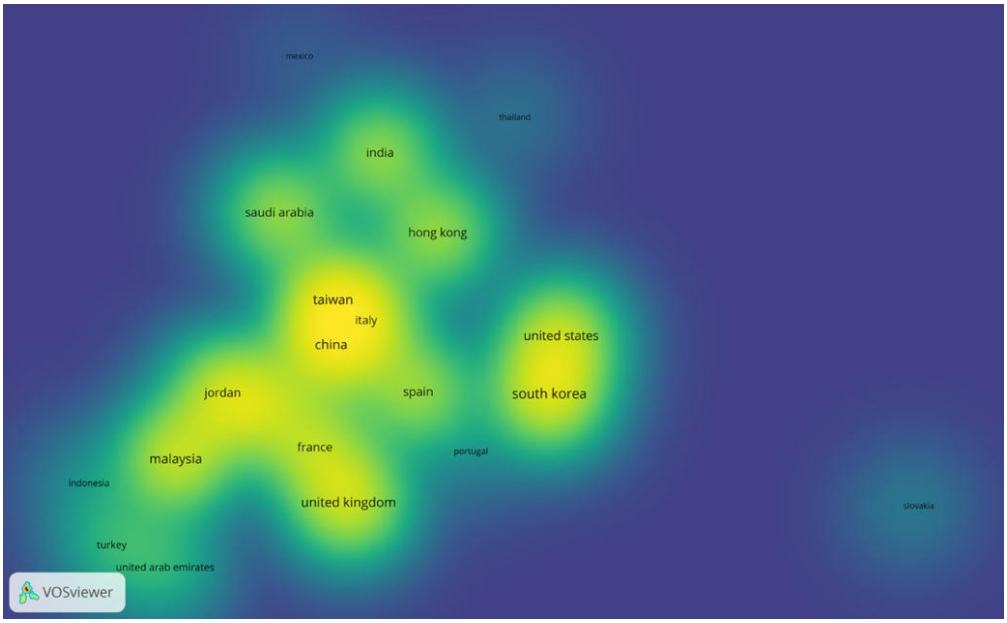

Figure 4. Countries with the Most Citations

Most Influential Journals and Articles

The second research question was to identify which journals and articles have made significant contributions to the field of metaverse in education?

To create the chart of the most cited journals, a citation analysis was conducted with a minimum of 5 documents per source of journal. This process resulted in 9 sources meeting the specified criterion. Furthermore, a minimum citation count of 50 was set for each source, with 7 sources meeting this requirement. Thus, Table 2 lists the 7 sources of journals that received greater than 50 citations. In particular, IEEE Transactions on Learning Technologies has the most articles on the metaverse in education (Number of articles =12), and these articles has accumulated 237 citations. The most cited journal, however, is Sustainability (Switzerland) (Number of citations = 447). These findings underscore the significant impact and scholarly attention that research on metaverse in education is receiving in as these journals are in the Quartile 1 category of Education and Computer Science respectively and are therefore key publications in the field.

A citation analysis was conducted to further examine the most influential articles in the field of metaverse in education, aiming to evaluate their impact. The influence of these articles was measured by the number of times they were cited in Scopus. Table 3 provides a list of articles that have been cited a minimum of 50 times, along

with any relevant details.

Table 2. The Most Influential Journals

Number	Journal Name	Number of Articles	Number of Citations
1	IEEE Transactions on Learning Technologies	21	237
2	Sustainability (Switzerland)	18	447
3	Linguistic and Philosophical Investigations	15	118
4	Education and Information Technologies	14	112
5	Journal of Metaverse	12	380
6	Interactive Learning Environments	8	133
7	International Journal of Human-Computer Studies	5	87

Table 3. The Most Influential Articles

Number	Author(s)	Article Title	Year of Publication	Number of Citation
1	Dwivedi, Y. K., Hughes, L., Baabdullah, A. M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M. M., ... & Wamba, S. F.	Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy	2022	890
2	Hwang, G. J., & Chien, S. Y.	Definition, roles, and potential research issues of the metaverse in education: An artificial intelligence perspective	2022	288
3	Akour, I. A., Al-Maroof, R. S., Alfaisal, R., & Salloum, S. A.	A conceptual framework for determining metaverse adoption in higher institutions of gulf area: An empirical study using hybrid SEM-ANN approach	2022	173
4	Díaz, J., Saldaña, C., & Avila, C	Virtual world as a resource for hybrid education	2020	146
5	Damar, M.	Metaverse shape of your life for future: A bibliometric snapshot	2021	134
6	Park, S., & Kim, S.	Identifying world types to deliver gameful experiences for sustainable learning in the metaverse	2022	112
7	Narin, N. G.	A content analysis of the metaverse articles	2021	109
8	Lee, H., & Hwang, Y.	Technology-enhanced education through	2022	106

Number	Author(s)	Article Title	Year of Publication	Number of Citation
		VR-making and metaverse-linking to foster teacher readiness and sustainable learning		
9	Suh, W., & Ahn, S.	Utilizing the metaverse for learner-centered constructivist education in the post-pandemic era: An analysis of elementary school students	2022	101
10	Thomason, J.	Metahealth-how will the metaverse change health care?	2022	101
11	Wang, M., Yu, H., Bell, Z., & Chu, X.	Constructing an edu-metaverse ecosystem: A new and innovative framework	2022	94
12	Al-Adwan, A. S., Li, N., Al-Adwan, A., Abbasi, G. A., Albelbisi, N. A., & Habibi, A.	Extending the technology acceptance model (TAM) to Predict University Students' intentions to use metaverse-based learning platforms.	2023	77
13	Estudante, A., & Dietrich, N.	Using augmented reality to stimulate students and diffuse escape game activities to larger audiences	2020	75
14	Salloum, S., Al Marzouqi, A., Alderbashi, K. Y., Shwedeh, F., Aburayya, A., Al Saidat, M. R., & Al-Maroof, R. S.	Sustainability model for the continuous intention to use metaverse Technology in higher education: a case study from Oman	2023	62
15	Ng, D. T. K.	What is the metaverse? Definitions, technologies and the community of inquiry.	2022	57
16	Aburayya, A., Salloum, S., Alderbashi, K., Shwedeh, F., Shaalan, Y., Alfaisal, R., ... & Shaalan, K.	SEM-machine learning-based model for perusing the adoption of metaverse in higher education in UAE	2023	52
17	Alawadhi, M., Alhumaid, K., Almarzooqi, S., Aljasmi, S., Aburayya, A., Salloum, S. A., & Almesmari, W.	Factors affecting medical students' acceptance of the metaverse system in medical training in the United Arab Emirates	2022	52

Most Prominent Topics in Metaverse in Education Research, and the Areas for Future Exploration

Researchers have recognised the importance of author keywords in identifying research trends and benchmarks (Duvvuru et al., 2012). These keywords are closely related to core concepts and can serve as indicators of the progress of research topics within a specific field, especially when they frequently appear in publications. To address the third research question, we conducted a co-occurrence analysis of author keywords. This analysis allows us to outline the thematic focus and overall development within the research area, systematically examining the progress and trends in the field. This method not only reveals the main directions of research but also helps identify hot topics and future research paths. For example, through co-occurrence analysis, we can observe a significant increase in the frequency of certain keywords in recent years, indicating that these topics are becoming focal points of research. Additionally, co-occurrence analysis can uncover relationships between different keywords, helping us understand how certain research topics are interrelated and evolving.

To identify the most frequently used author keywords, a co-occurrence analysis was conducted. From the data, there were 910 unique author keywords. To analyse these keywords, the minimal requirement for keyword occurrences was set at 5. The analysis revealed a total of 22 keywords in 6 clusters. A visualisation of the most frequent keywords is constructed (see Figure 5). The most common keywords were "metaverse" (f = 192), "virtual reality" (f = 54), "education" (f = 28), "augmented reality" (f = 23), and "artificial intelligence" (f = 18). Table 4 shows the frequency of keyword occurrences and their respective clusters.

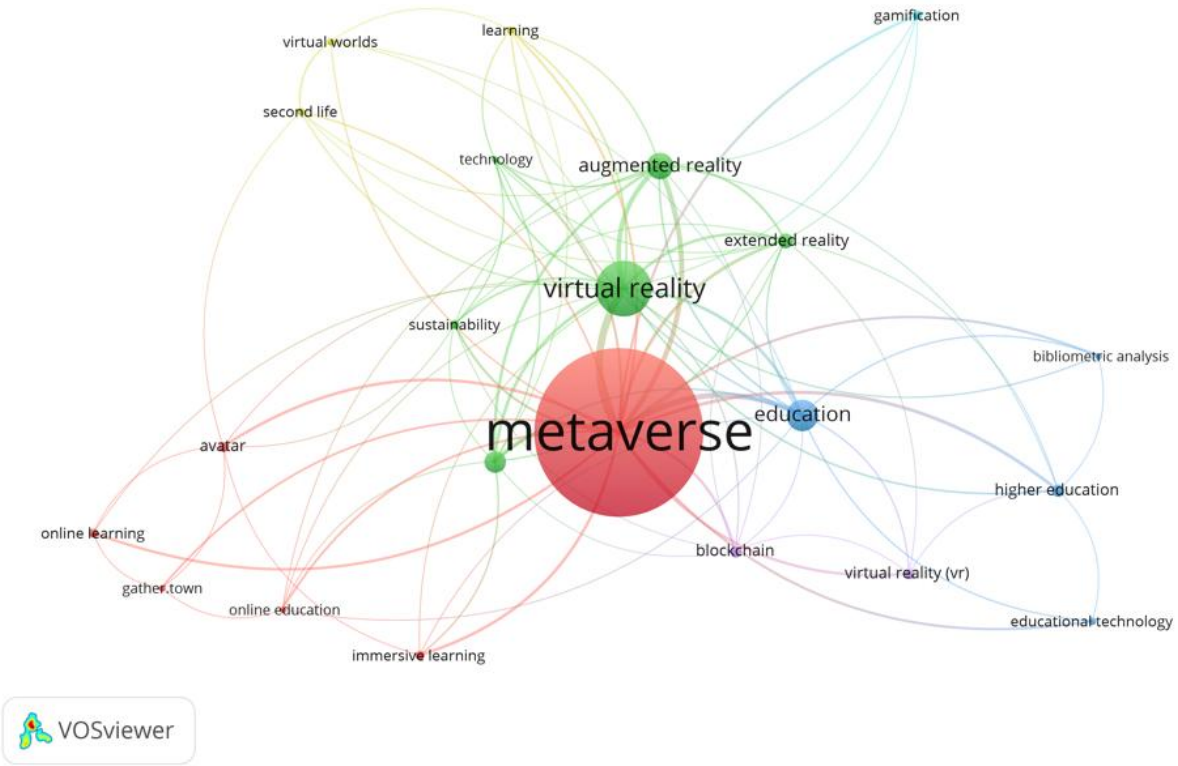

Figure 5. Visualization of the Most Frequent Keyword Connections

Table 4 The Most Frequent Keywords

Clusters	Items
Clusters 1 (6 items)	Metaverse (f=192), avatar(f=8), immersive learning(f=7), online learning(f=7), online education(f=5), gather.town(f=5)
Clusters 2 (6 items)	Virtual reality(f=54), augmented reality(f=23), artificial intelligence (f=18), extended reality(f=12), sustainability(f=7), technology(f=5),
Clusters 3 (4 items)	Education (f=28), higher education (f=10), educational technology (f=6), bibliometric analysis (f= 5)
Clusters 4 (3 items)	Learning (f=6), second life (f=6), virtual worlds (f=6),
Clusters 5 (2 items)	Blockchain (f=9), virtual reality (vr) (f=8),
Clusters 6 (1 item)	Gamification(f=7)

Furthermore, a visualisation of the keyword dispersion and spread in the recent years was obtained (see Figure 6). The visualization demonstrated that terms related to the metaverse, such as "virtual worlds," "second life," and "avatar," began appearing in 2021. By 2022, keywords like "augmented reality" and "gamification" became increasingly prominent in the context of the metaverse. By 2023, the metaverse was frequently associated with "education," "learning", and "technology".

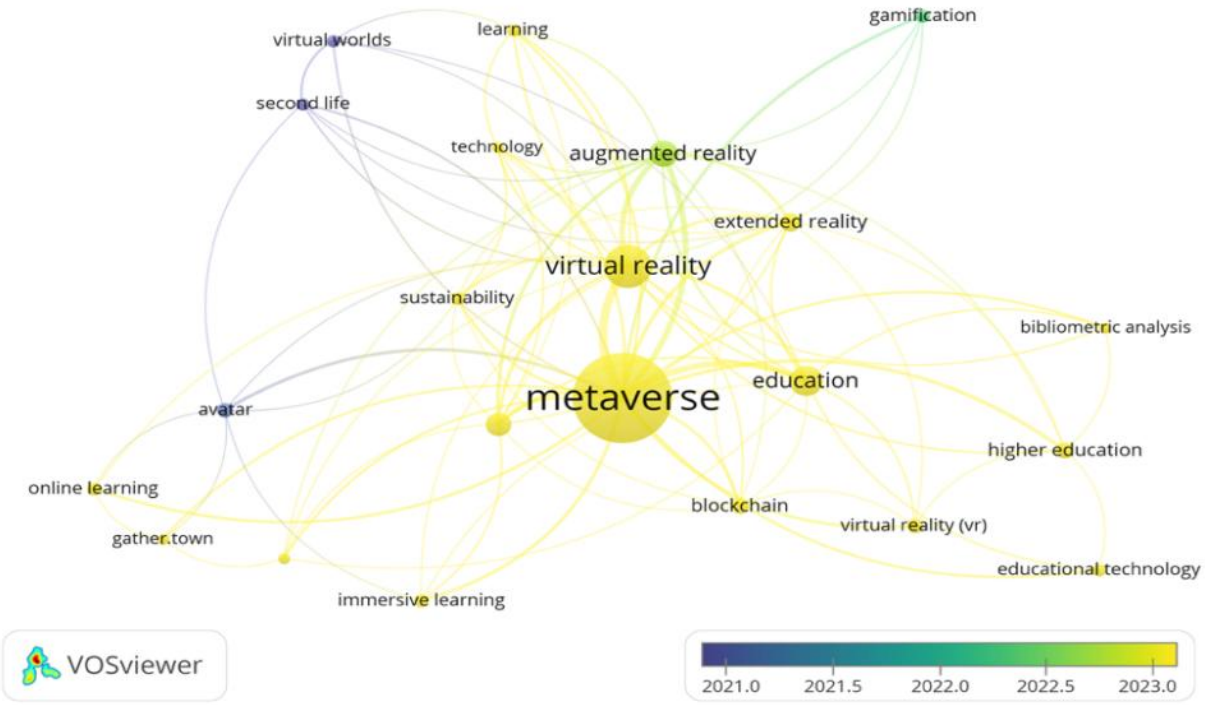

Figure 6. Visualization of the Most Frequent Keyword Timeline

These changes indicate that the rapid development of metaverse concepts and research is closely linked to advancements in technologies like virtual reality and augmented reality. These technologies provide the foundation for constructing and experiencing the metaverse. The appearance of keywords like education and online learning suggests that metaverse technology holds significant potential for broad applications in the educational sector.

Discussion

This study examined 270 articles to uncover trends in metaverse in education research over the past decade. Through using descriptive and quantitative statistics, an analysis on the development of annual trends, the most productive countries, significant contributions by journals and articles in the field of metaverse in education, as well as the most prominent topics in metaverse in education research was possible. These findings provide valuable insights for researchers, enhancing their understanding of the current state and trends in metaverse in education research.

Annual Trends of Publication and Most Productive Countries

The growth in publications on the topic of the metaverse in education began in 2020. A possible reason for this increase is the significant shift in global educational models due to the COVID-19 pandemic. Virtual reality (VR), augmented reality (AR), and video games (VG) have been employed as interventions to address the psychological impacts of COVID-19 (Pallavicini et al., 2021). During this period, educators recognised the importance of VR and AR, especially in facilitating education in a digital space, leading to a rise in publications on the application of the metaverse in education. Furthermore, the substantial increase in publications from 2022 to 2023 on the metaverse in education can be attributed to technological advancements. The progress in artificial intelligence and machine learning has made the processing and analysis of educational data more efficient. Additionally, the widespread adoption of 5G technology has provided a feasible pathway for implementing metaverse technologies in education (Rizvi, 2023; Zawish et al., 2024).

In terms of the number of publications and citations, South Korea and China are leading in the field of metaverse in education. South Korea is renowned for its high internet penetration rate and advanced technology industry, which supports extensive research on VR and AR as foundational technologies for the metaverse (Ji et al., 2022). Similarly, China’s significant investments in 5G and AI technologies have created a favourable environment for innovative educational research (Fan & Chiang, 2023).

Most Influential Journals and Articles

In the field of metaverse in education, 'IEEE Transactions on Learning Technologies' and 'Sustainability' (Switzerland) rank first in terms of the number of articles and citations, respectively. This phenomenon is likely attributed to both journals' significant emphasis on emerging technologies, such as AI, VR, AR, and the metaverse. 'IEEE Transactions on Learning Technologies' closely aligns with its focus on advancements in educational

technology. This journal comprehensively covers the latest developments in learning technologies and their applications, providing researchers and educators with a crucial platform for exploring the integration of innovative technologies into educational practices (*IEEE Transactions on Learning Technologies*, 2024). On the other hand, the journal 'Sustainability' (Switzerland) aimed to promote innovative technologies for sustainable development. Within the educational context, this journal particularly concentrates on how emerging technologies can foster sustainable educational practices, including enhancing accessibility to educational resources, reducing environmental impact, and cultivating students' awareness of sustainable development (*Sustainability*, 2024). Although these two journals have slightly different foci, they both offer significant research platforms for the application of metaverse technologies in education with 'IEEE Transactions on Learning Technologies' emphasizing on the technologies and their educational applications, whilst 'Sustainability (Switzerland)' focuses on how these technologies can promote sustainable development and education.

In addition, the article's analysis showed 17 articles with a minimum of 50 citations each. From this corpus of highly cited works, examining the top 3 articles is essential to further establish its influence on the field of the metaverse in education. The article with the highest number of citations from Dwivedi et al. (2022)explores the development of the metaverse from multidisciplinary perspectives. This is a highly influential article as it has provided the preliminary input on how the metaverse can be implemented in various different industries and disciplines. Secondly, Hwang and Chien (2022) investigate the application of the metaverse in education from the perspective of artificial intelligence, clearly defining the metaverse's definition, framework, features, potential applications, challenges, and future research topics, highlighting how the onset of AI could contribute to the metaverse. Finally, Akour et al. (2022) proposed a conception framework for the implementation of the metaverse in education, potentially sparking the actual adoption of the metaverse in an educational setting. Overall, these three articles focused on the role and importance of the metaverse in educational environments, contributing to the increased attention into the application of the metaverse in education. Furthermore, these articles discuss the application of advanced technologies such as artificial intelligence (AI), virtual reality (VR), and augmented reality (AR), underscoring the significance of these technologies in educational settings. These highly cited articles collectively further demonstrated that the definition of the metaverse in education is becoming increasingly clear, and the scope and prevalence of its application in educational contexts are expanding, forecasting its growing significance. Furthermore, these works affirm that metaverse technology holds broad application prospects and substantial importance in the field of education.

Most Prominent Topics in Metaverse in Education Research, and the Areas for Future Exploration

Research findings indicate that, apart from the keywords of "metaverse" and "education," the prominent themes in the context of the metaverse in education primarily revolve around "virtual reality," "augmented reality," and "artificial intelligence." The metaverse enhances the real world by integrating augmented reality (AR) and virtual reality (VR) technologies, significantly improving teaching effectiveness and student motivation in fields such as medicine, engineering, and primary education. Furthermore, the clusters of frequent keywords further suggest that future research may involve studying the potential application of metaverse in the field of "extended reality," "blockchain," "sustainability," and "gamification".

In addition, by collectively analysing these findings with the influential articles indicated earlier, it was possible to categorize the prominent topics in the research on metaverse in education into two broad areas: Firstly, the utilisation of the metaverse as a technology to develop virtual environments for educational purposes. And secondly, the investigation of students' and teachers' perceptions and attitudes towards the application of metaverse in education.

Metaverse as a Technology for Creating Virtual Educational Environments

The integration of augmented reality (AR) and virtual reality (VR) technologies within the metaverse is revolutionising the field of education. Thomason (2021) discovered that in medical education and training, VR technology enables students to explore the human body in detail, providing an in-depth understanding of anatomical structures. This technology offers comprehensive, 360-degree perspectives that traditional textbooks and 2D images cannot. By immersing students in a virtual environment, they can interact with and manipulate organs, tissues, and systems, enhancing their spatial awareness and retention of complex information. Additionally, VR simulations allow students to practice real-life procedures in a safe and controlled setting, improving their skills and confidence before they perform these tasks in clinical settings. This approach not only reinforces theoretical knowledge but also bridges the gap between classroom learning and practical application, ultimately contributing to more effective and engaging medical education. Conversely, AR facilitates practical learning by enabling medical students to visualise and practise new techniques through patient simulations and surgical procedures, even replicating real surgical experiences. This immersive experience allows students to participate in operations as if they were surgeons, thereby enhancing their learning outcomes. Similarly, Estudante and Dietrich (2020) developed an AR application used in educational escape game activities. In these activities, students engage in virtual game scenarios adapted to AR experiences through the open application Metaverse. Feedback from students who participated in these activities confirmed that the use of AR technology and metaverse applications in education significantly increased their motivation. Furthermore, Díaz et al. (2020) utilised the Scrum methodology to develop a metaverse designed to resemble real university institutions, functioning as a digital tool to assist education for students and staff in the School of Systems Engineering. This metaverse employs various information and communication technology (ICT) tools to facilitate both self-directed and collaborative learning. Through the use of virtual avatars, students and teachers can flexibly access information both inside and outside the classroom, transforming traditional methods of knowledge transmission and acquisition. Park and Kim (2022) identified various world types within the metaverse that provide users with gaming experiences. Their findings suggest that survival, maze, multiple-choice, racing/jumping, and escape room worlds can be leveraged to create innovative educational environments, thereby offering equal educational opportunities to learners.

Hence, the metaverse integrates Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) to create an immersive and flexible interactive learning environment, enhancing educational outcomes and increasing learner engagement (Thomason, 2021). Furthermore, the metaverse has the potential to integrate various technologies, breaking down geographic barriers through simulations and virtual laboratories. This fosters

a more connected and diverse educational community, establishing a sustainable and continuous educational framework (Prakash et al., 2023). In the future, the metaverse could become a sustainable educational medium that transcends the limitations of time and space.

Perceptions and Attitudes towards the Metaverse in Education

Innovative technologies are a crucial component of educational practices. Supported by these technologies, the metaverse offers numerous advantages for teaching. Akour et al. (2022) investigated Gulf region university students' perceptions of the metaverse, revealing that students' views on using the metaverse were significantly linked to its innovativeness, which in turn was influenced by perceived ease of use and perceived usefulness. Dwivedi et al.(2022) found that in the educational sector, the metaverse enhances teaching effectiveness through immersive learning and interactive platforms, making learning engaging and motivational. Students can engage in practical learning and simulation training within virtual environments, thereby improving learning outcomes and motivation. Lee and Hwang (2022) documented the experiences of pre-service English teachers in designing VR content for K-12 English digital textbooks and explored the alignment of VR works with adaptive learning and sustainable education on metaverse platforms. Suh and Ahn (2022) conducted a survey with 336 Korean elementary school students to explore their experiences and attitudes towards learner-centred education. The findings revealed that, on average, 97.9% of the students had interacted with the metaverse, and 95.5% perceived it as closely related to their daily lives. These results demonstrate the widespread application of the metaverse in primary education.

To further clarify the main factors influencing the students' behavioural intentions of adopting metaverse technology, Al-Adwan et al.(2023) proposed an extended Technology Acceptance Model (TAM) and found that that perceived usefulness, personal innovativeness in IT, and perceived enjoyment are key facilitators of students' intentions to adopt metaverse technology. Similarly, research by Salloum et al. (2023) found that innovativeness plays a crucial role in determining the effectiveness of metaverse systems.

Overall, while the introduction of new technology in the education space can be daunting, the perceptions and attitudes of both teachers and students towards metaverse in the field of education are mainly positive. This can be due to how the metaverse offers immersive, interactive, and engaging learning experiences, which in turn enhance students' interest and motivation. Moreover, data collected from interactions within the metaverse can provide educators with valuable insights into students' behaviours and learning preferences, allowing for more effective adjustments to teaching strategies. By understanding and leveraging the potential of metadata systems, higher education institutions can create more dynamic, adaptable, and student-centred learning environments, ultimately fostering a more inclusive and effective educational process.

Conclusion

The current study utilising data retrieved from the Scopus database, employing the PRISMA method and applying inclusion and exclusion criteria, to identify a total of 270 articles, which were then analysed and visualised using

VOSviewer. The results indicated a steady increase in research on the metaverse in education starting from 2020, with a significant surge in publications in 2022 and a peak in 2023. The analysis further highlighted the countries (South Korea, China, the United States and United Kingdom) at the forefront of metaverse in education research and identified its most influential journal which are IEEE Transactions on Learning Technologies and Sustainability (Switzerland).

Despite the increasing number of studies, gaps remain in the current literature. For instance, there is a lack of longitudinal studies to assess the long-term impact of metaverse technologies on educational outcomes, including their effectiveness and scalability in diverse learning environments. Additionally, current research is predominantly concentrated in East Asia and the United States. Comparative studies across different cultural and educational systems are needed to better understand the global adaptability of metaverse-based education. Future research should prioritise longitudinal studies to evaluate the long-term effects of metaverse technologies on educational outcomes. This includes assessing their sustained effectiveness, scalability, and adaptability across various learning environments, such as traditional classrooms, online education, and hybrid models. Such studies would provide deeper insights into how metaverse technologies influence learning processes and outcomes over time. Furthermore, future research could explore the adoption and effectiveness of metaverse technologies from the perspectives of diverse cultural contexts, pedagogical practices, and institutional infrastructures, aiming to identify best practices for global implementation.

In conclusion, metaverse technology has already brought revolutionary changes to the field of education. The development of future technologies will further promote the application of the metaverse in education, making it a sustainable educational medium that is not constrained by time and space.

Notes

This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. The authors declare that there is no conflict of interest.

References

Akour, I. A., Al-Maroof, R. S., Alfaisal, R., & Salloum, S. A. (2022). A conceptual framework for determining metaverse adoption in higher institutions of gulf area: An empirical study using hybrid SEM-ANN approach. *Computers and Education: Artificial Intelligence*, *3*, 100052. https://doi.org/10.1016/j.caeai.2022.100052

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), 15381–15413. https://doi.org/10.1007/s10639-023-11816-3

Bizel, G. (2023). A bibliometric analysis: Metaverse in education concept. *Journal of Metaverse*, *3*(2), 133–143. https://doi.org/10.57019/jmv.1310768

Chamorro-Atalaya, O., Durán-Herrera, V., Suarez-Bazalar, R., Nieves-Barreto, C., Tarazona-Padilla, J., Rojas-Carbajal, M., Cruz-Telada, Y., Caller-Luna, J., Alarcón-Anco, R., & Arévalo-Tuesta, J. A. (2023). Inclusion of metaverses in the development of the flipped classroom in the university environment: Bibliometric analysis of iIndexed scientific production in SCOPUS. *International Journal of Learning, Teaching and Educational Research*, *22*(10), 247–270. https://doi.org/10.26803/ijlter.22.10.14

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*(3), 319–340. JSTOR. https://doi.org/10.2307/249008

Díaz, J. (2020). Virtual world as a complement to hybrid and mobile learning. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(22), 267–274.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to Conduct a Bibliometric Analysis: An Overview and Guidelines. *Journal of Business Research*, *133*, 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Duvvuru, A., Kamarthi, S., & Sultornsanee, S. (2012). Undercovering research trends: Network analysis of keywords in scholarly articles. *2012 Ninth International Conference on Computer Science and Software Engineering (JCSSE)*, 265–270. https://doi.org/10.1109/JCSSE.2012.6261963

Dwivedi, Y. K., Hughes, L., Baabdullah, A. M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M. M., Dennehy, D., Metri, B., Buhalis, D., Cheung, C. M. K., Conboy, K., Doyle, R., Dubey, R., Dutot, V., Felix, R., Goyal, D. P., Gustafsson, A., Hinsch, C., Jebabli, I., … Wamba, S. F. (2022). Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management*, *66*, 102542. https://doi.org/10.1016/j.ijinfomgt.2022.102542

Effendi, D. N., Irwandani, Anggraini, W., Jatmiko, A., Rahmayanti, H., Ichsan, I. Z., & Mehadi Rahman, Md. (2021). Bibliometric analysis of scientific literacy using VOS viewer: Analysis of science education. *Journal of Physics: Conference Series*, *1796*(1), 012096. https://doi.org/10.1088/1742-6596/1796/1/012096

Estudante, A., & Dietrich, N. (2020). Using augmented reality to stimulate students and diffuse escape game activities to larger audiences. *Journal of Chemical Education*, *97*(5), 1368–1374. https://doi.org/10.1021/acs.jchemed.9b00933

Fan, L., & Chiang, J. (2023). A systematic review of the application of metaverse in language education: Prominent themes, research methods, impacts, and future challenges. *Journal of Language Teaching*, *3*(10), 1–14. https://doi.org/10.54475/jlt.2023.026

Go, S. Y., Jeong, H. G., Kim, J. I., & Sin, Y. T. (2021). Concept and developmental direction of metaverse. *Korea Inf Process Soc Rev*, *28*, 7–16.

Han, J., Liu, G., & Gao, Y. (2023). Learners in the metaverse: A systematic review on the use of roblox in learning. *Education Sciences*, *13*(3), 296. https://doi.org/10.3390/educsci13030296

Howkins, D. T. (1981). Unvocational used of online information retrieval systems: Online bibliometric study. *Journal of American Society for Information Science*, *28*(1), 13–18.

Huang, H.-M., Rauch, U., & Liaw, S.-S. (2010). Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach. *Computers & Education*, *55*(3), 1171–1182. https://doi.org/10.1016/j.compedu.2010.05.014

Hwang, G.-J., & Chien, S.-Y. (2022). Definition, roles, and potential research issues of the metaverse in education: An artificial intelligence perspective. *Computers and Education: Artificial Intelligence*, *3*, 100082. https://doi.org/10.1016/j.caeai.2022.100082

IEEE Transactions on Learning Technologies. (2024, July 25). https://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=4620076

Ji, M., Xi, X., Kim, H., Zhou, Y., Kim, S., & Park, C. (2022). A comparative analysis of english language learning trends in Korea and China using the metaverse. *Asia-Pacific Journal of Convergent Research Interchange*, *8*(7), 127–136. https://doi.org/10.47116/apjcri.2022.07.12

Kaspar, W., Borgerding, J., Hodge, M., & Marino, B. (2017). PRIMO: Peer-reviewed instructional materials online. *College & Research Libraries*, *78*(1), 2–7. https://doi.org/10.5860/crl.78.1.2

Kelly, J., Sadeghieh, T., & Adeli, K. (2014). Peer review in scientific publications: Benefits, critiques, & a survival guide. *Ejifcc*, *25*(3), 227.

Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2022). Augmented reality and gamification in education: A systematic literature review of research, applications, and empirical studies. *Applied Sciences*, *12*(13), 6809. https://doi.org/10.3390/app12136809

Lee, H., & Hwang, Y. (2022). Technology-Enhanced education through VR-making and metaverse-linking to foster teacher readiness and sustainable learning. *Sustainability*, *14*(8), 4786. https://doi.org/10.3390/su14084786

Liu, C., Zou, D., Chen, X., Xie, H., & Chan, W. H. (2021). A bibliometric review on latent topics and trends of the empirical MOOC literature (2008–2019). *Asia Pacific Education Review*, *22*(3), 515–534. https://doi.org/10.1007/s12564-021-09692-y

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*, *70*, 29–40. https://doi.org/10.1016/j.compedu.2013.07.033

Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: A comparative analysis. *Scientometrics*, *106*(1), 213–228. https://doi.org/10.1007/s11192-015-1765-5

Nasir, N. B., Moon, J., & Kim, S. B. (2023). *Metaverse in education: Insights from South Korea and potentials for Malaysia*. 84–88. https://doi.org/DOI: 10.1109/ICSECS58457.2023.10256325

Okumuş Dağdeler, K. (2023). A systematic review of Mobile-Assisted Vocabulary Learning research. *Smart Learning Environments*, *10*(1), 19. https://doi.org/10.1186/s40561-023-00235-z

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *International Journal of Surgery*, *88*, 105906. https://doi.org/10.1016/j.ijsu.2021.105906

Pallavicini, F., Chicchi Giglioli, I. A., Kim, G. J., Alcañiz, M., & Rizzo, A. (2021). Editorial: Virtual reality, augmented reality and video games for addressing the impact of COVID-19 on mental health. *Frontiers in Virtual Reality*, *2*, 719358. https://doi.org/10.3389/frvir.2021.719358

Park, S., & Kim, S. (2022). Identifying world types to deliver gameful experiences for sustainable learning in the metaverse. *Sustainability*, *14*(3), 1361. https://doi.org/10.3390/su14031361

Pradana, M., Elisa, H. P., & Syarifuddin, S. (2023). Discussing ChatGPT in education: A literature review and bibliometric analysis. *Cogent Education*, *10*(2), 2243134. https://doi.org/10.1080/2331186X.2023.2243134

Prakash, A., Haque, A., Islam, F., & Sonal, D. (2023). Exploring the potential of metaverse for higher education: Opportunities, challenges, and implications. *Metaverse Basic and Applied Research*, 40. https://doi.org/10.56294/mr202340

Pritchard, A. (1969). Statistical bibliography or bibliometrics. *Journal of Documentation*, *25*, 348.

Rizvi, S. (2023). Unveiling the potential of artificial intelligence and machine learning in the 5G network landscape: A comprehensive review. *Asian Journal of Research in Computer Science*, *16*(4), 23–31. https://doi.org/10.9734/ajrcos/2023/v16i4367

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

Salloum, S., Al Marzouqi, A., Alderbashi, K. Y., Shwedeh, F., Aburayya, A., Al Saidat, M. R., & Al-Maroof, R. S. (2023). Sustainability model for the continuous intention to use metaverse technology in higher education: A case study from Oman. *Sustainability*, *15*(6), 5257. https://doi.org/10.3390/su15065257

Shareefa, M., & Moosa, V. (2020). The Most-cited Educational Research Publications on Differentiated Instruction: A Bibliometric Analysis. *Başlık*, *volume–9–2020*(volume9-issue1.html), 331–349. https://doi.org/10.12973/eu-jer.9.1.331

Singh, V. K., Singh, P., Karmakar, M., Leta, J., & Mayr, P. (2021). The journal coverage of Web of Science, Scopus and Dimensions: A comparative analysis. *Scientometrics*, *126*(6), 5113–5142. https://doi.org/10.1007/s11192-021-03948-5

Suh, W., & Ahn, S. (2022). Utilizing the metaverse for learner-centered constructivist education in the post-pandemic era: An analysis of elementary school students. *Journal of Intelligence*, *10*(1), 17. https://doi.org/10.3390/jintelligence10010017

Sustainability. (2024, July 25). https://www.mdpi.com/journal/sustainability

Suzuki, S., Kanematsu, H., Barry, D. M., Ogawa, N., Yajima, K., Nakahira, K. T., Shirai, T., Kawaguchi, M., Kobayashi, T., & Yoshitake, M. (2020). Virtual experiments in metaverse and their applications to collaborative projects: The framework and its significance. *Knowledge-Based and Intelligent Information & Engineering Systems: Proceedings of the 24th International Conference KES2020*, *176*, 2125–2132. https://doi.org/10.1016/j.procs.2020.09.249

Tamala, J. K., Maramag, E. I., Simeon, K. A., & Ignacio, J. J. (2022). A bibliometric analysis of sustainable oil and gas production research using VOSviewer. *Cleaner Engineering and Technology*, *7*, 100437. https://doi.org/10.1016/j.clet.2022.100437

Thomason, J. (2021). MetaHealth—How will the metaverse change health care? *Journal of Metaverse*, *1*(1), 13–16.

Turner, M., Kitchenham, B., Brereton, P., Charters, S., & Budgen, D. (2010). Does the technology acceptance model predict actual use? A systematic literature review. *Information and Software Technology*, *52*(5), 463–479. https://doi.org/10.1016/j.infsof.2009.11.005

Tyagi, V., Singh, H., Puri, N., & Tyagi, P. (2023). Exploring the potential of the metaverse in higher education:

A bibliometric analysis. *Journal of Content, Community & Communication*, *18*.

Van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3

Wang, D., Huangfu, Y., Dong, Z., & Dong, Y. (2022). Research hotspots and evolution trends of carbon neutrality—Visual analysis of bibliometrics based on citeSpace. *Sustainability*, *14*(3), 1078. https://doi.org/10.3390/su14031078

Zawish, M., Dharejo, F. A., Khowaja, S. A., Raza, S., Davy, S., Dev, K., & Bellavista, P. (2024). AI and 6G into the metaverse: Fundamentals, challenges and future research trends. *IEEE Open Journal of the Communications Society*, *5*, 730–778. https://doi.org/10.1109/OJCOMS.2024.3349465

Zhou, X., Yang, Q., Zheng, X., Liang, W., Wang, K. I.-K., Ma, J., Pan, Y., & Jin, Q. (2024). Personalized federated learning with model-contrastive learning for multi-modal user modeling in human-centric metaverse. *IEEE Journal on Selected Areas in Communications*, *42*(4), 817–831. https://doi.org/10.1109/JSAC.2023.3345431

Author Information

Jiaxin Ren

https://orcid.org/0000-0003-2208-2310

UCSI University Malaysia

Kuala Lumpur

Malaysia

Contact e-mail: *jiaxin0776@gmail.com*

Yee Hock Tan

https://orcid.org/0000-0003-4163-5267

UCSI University Malaysia

Kuala Lumpur

Malaysia

Juncheng Guo

https://orcid.org/0009-0000-0333-5226

UCSI University Malaysia

Kuala Lumpur

Malaysia