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PAPER

Benefits of Metaverse Application in Education: A Systematic Review

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ABSTRACT

The COVID-19 pandemic has brought about significant changes in people's lifestyles, with the educational sector being one of the most reliant on technology to facilitate the teaching and learning process. In this literature review, a search for articles related to the metaverse in education, published in 2022 and 2023, has been conducted across six databases: Scopus, EBSCO Host, ScienceDirect, Taylor & Francis Online, IEEE Xplore, and Springer. The PRISMA methodology was used to analyze and systematize the manuscripts found. The aim of this research was to examine how integrating the metaverse into education can enhance educational accessibility and equity by enabling students to utilize virtual learning resources and opportunities. In addition, they can engage in interactions with others to learn and create interactive content during the teaching and learning process. This requires a commitment from the student because a connection between the student and the machine will be established through the use of emerging technologies. These technologies offer unique opportunities to enhance teaching quality, broaden access to education, and prepare individuals for an increasingly digital and evolving world. The analysis identified 14 emerging technologies: artificial intelligence, cloud computing, big data, Internet of Things, blockchain, augmented reality, extended reality, virtual reality, 5G, EON-XR, digital twins, 3D virtual reality, and immersive virtual reality. These technologies offer immersion (simulation of a real world in a virtual world), interactivity (interaction with different people), improvement of the educational environment (innovative presentation of content), and motivation for learning (capturing attention). When it comes to the different types of learning, there are six categories: experiential (based on experience), collaborative (involving a guide to lead the process), cooperative (involving teamwork), significant (building on existing knowledge), explicit (self-directed learning), and emotional (involving the regulation of emotions).

KEYWORDS

metaverse, education, virtual reality, artificial intelligence, augmented reality

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1 INTRODUCTION

In [1], the aim was to analyze the relationship between the metaverse and education. The methodology involved a mixed-literature review combined with bibliometrics to identify articles. A total of 364 articles were found in Scopus and the Web of Science Core Collection, but after applying exclusion criteria (language, duplicates, editorial, and objective), only 35 research articles remained. As a result, it was found that the metaverse can offer greater direct and indirect opportunities in the students' English teaching and learning process. It was concluded that online scenarios encourage greater student participation, thus demonstrating the importance of the metaverse in education. This should be regulated for both teachers and students. In [2], the aim was to analyze metaverse literacy in education. The method employed was a mixed systematic review that included bibliometric analysis and content analysis. For this study, 77 research articles were considered. The results indicate that the metaverse has been evolving over time, gaining a stronger presence among the Z generation. Finally, it was concluded that the metaverse enables a connection between the real world and the virtual world. However, insufficient attention is being paid to emerging technologies such as blockchain for security issues or to the Internet of Things (IoT) technology for designing a more immersive learning scenario that integrates the real world with the virtual world through various technological devices. Similarly, in [3], the authors proposed analyzing the evolution of the metaverse in articles related to this topic. For this purpose, they considered the publications indexed in Scopus and Web of Science (WOS) from 2008 to 2022, totaling 162. After applying the inclusion and exclusion criteria, only 25 research studies were included in the study. The method used was PRISMA. The results indicate that the metaverse relies on specific conditions for optimal functioning, including augmented reality, virtual reality, and technological devices. It was concluded that several aspects of the metaverse still need to be investigated in detail, including user safety, energy consumption, and costs. Also, in [4], the authors analyzed the development of the metaverse from 1990 to 2022. The research focused on quantitative studies related to the metaverse. They found 491 publications in WOS and 2240 in Scopus. As a result, there has been a significant increase in research studies on the metaverse since 2022, with China leading in the number of research studies conducted, focusing on its uses and related technologies. It was concluded that very few studies on the metaverse have focused on sustainability (social, economic, and environmental). Similarly, in [5], the authors compiled, analyzed, and schematized the concepts of the metaverse. The methodology used was a systematic review. They analyzed 28 documents that define the metaverse. The findings revealed two prominent definitions. The first refers to a three-dimensional online framework where the user has an avatar, while the second is focused on its applicability in technological organizations. Finally, they concluded that the metaverse is still in an early stage of development, and undoubtedly, the interoperability between the components (hardware and software) must be analyzed. Similarly, in reference [6], the authors evaluated the potential application of the metaverse in education using a theoretical approach, as well as its relevance in information systems to understand the level of engagement among academics with the metaverse. The methodology applied was the systematic review, which involved searching multiple databases, including Wiley Online Library, Science Direct, Emerald, IEEE Xplore, Springer, Google Scholar, ACM Digital Library, and Taylor and Francis Online. This search yielded 177 articles, of which 41 were selected after applying the inclusion and exclusion

criteria. The selected articles were developed between 2021 and 2022 and were related to the use of the metaverse in education. As for the results, it was found that the most widely used tool to validate the various existing metaverse models is SmartPLS (PLS-SEM). The countries that have conducted the most research on the subject are China, Taiwan, and the United States. The researchers concluded that university students are the demographic most accepting of access to the metaverse. Also, in [7], the authors examined research related to the application of metaverse technology in education. The PRISMA method was applied, and 22 research studies were considered from ProQuest, WOS, ERIC, and Scopus. As a result, it was determined that the technical aspects of the connection should be analyzed to ensure a strong and reliable connection. Similarly, it is predominantly applied in higher education. As for the conclusion, the metaverse can be useful for enhancing learning in a coordinated or conflicting manner. Finally, in [8], the researchers aimed to identify the opportunities and threats of the metaverse. The PRISMA was applied, beginning with 1420 studies, of which only 30 were selected after applying the inclusion and exclusion criteria. In the results, the student is not the only beneficiary; the teacher also benefits, as does the teaching and learning process. The research concluded that, at present, the metaverse is more closely associated with education. To achieve beneficial results, it is necessary to evaluate both the hardware and the functionality of the software.

In 1992, the term "metaverse" first appeared in a novel called Snow Crash. However, it was in 2020 that it began to gain greater prominence, as Facebook modified its brand by incorporating the word "meta" [9]. According to [10], the metaverse is a new virtual reality that integrates the physical world with a digital world. It requires virtual reality, augmented reality, and mixed reality for its existence and development, allowing users to experience moments that are not possible in the real world through their avatars. Specifically, aspects of time and place, as well as socio-demographic variables, often limit people's interactions. These factors often restrict a student's motivation and participation, teamwork, access to learning resources, and the ability to create immersive learning experiences. With this, the use of the metaverse in education exposes students to emerging technologies and digital skills that will be increasingly relevant in the future of work. It prepares individuals to confront an increasingly digital and technological world [11]. In other words, the purpose of the metaverse is to create a parallel world to the real world, focusing on four important qualities: socialization, immersive interaction, imitation of the real world, and capacity for expansion [12]. Therefore, the metaverse can facilitate the convergence of various applications that, due to significant technological advancements, now require interconnectedness in the service, industrial, and commercial sectors [13]. This must also consider crucial factors such as human elements, social issues, and information security [14].

The COVID-19 pandemic marked a before and after in several aspects, with education being one of the sectors significantly impacted. This was particularly evident in the various forms of teaching and learning, as the use of technology was greatly enhanced [15]. Perhaps some students felt frustrated by the sudden change they had to adapt to in a short period of time. This was the only way to continue their studies, and they also had to quickly learn to interact with technology [16]. With the aim of facilitating distance learning, some teachers have developed various technological tools to ensure student learning and the diversity of educational settings in a rapidly changing world. Therefore, even as many have reverted to traditional methods, this material remains crucial as it positively impacts students' learning experiences and

contributes to improved academic performance [17]. Considering the metaverse in the elaboration and distribution of content in the teaching-learning process is undeniably beneficial as it maximizes opportunities for teacher and student access, time, and location [18]. Teachers must acquire digital skills to effectively utilize technological tools in the teaching process they deliver to students [19].

However, it is not sufficient for institutions or others to simply intend to provide quality hybrid education. It is necessary to carefully analyze crucial aspects to ensure the expected success: assignment design, established activities, relevant feedback, digital tools, and understanding of students and teachers [20]. Over time, the "smart classroom" has incorporated digital elements to meet the needs of users and adapt to the use of digital technologies. For this reason, it is essential for institutions to consider innovation in the teaching processes they provide. In this sense, smart classrooms reflect the integration of technology into educational settings, where classes are more dynamic and creative, with the aim of enabling students to learn in both face-to-face and remote settings [21]. It is also important to highlight those emerging technologies facilitate learning without geographical constraints [22].

Today, there are various challenges that hinder the success of the teaching-learning process due to factors such as: students facing economic, geographical, or cultural barriers to accessing educational resources and learning opportunities; lack of motivation to learn; limited participation; inadequate training and preparation of some teachers; and low quality of educational content. The objective of this literature review is to identify and explain the benefits of using metaverse applications in education. These applications can improve student participation, encourage teamwork, provide immersive experiences, facilitate experience-based learning, enhance accessibility and educational equity, and allow students to access global resources and virtual learning opportunities. Additionally, they can have a significant impact on the way education is conducted, opening up new possibilities and addressing challenges. This paper is organized as follows: Section II presents the methodology used for this research. Section III specifies the results obtained from tables and figures. Section IV discusses the findings, and Section V presents the conclusions of the research.

2 METHODS

The methodology used consisted of three steps. In the first step, we used PRISMA 20 [23] to select the research articles relevant to the present study. In the second step, bibliometric analysis was used to identify the common terms that influence the implementation of the metaverse in education. Finally, the chosen research was analyzed to extract the most pertinent statistical factors and methods related to the implementation of the metaverse in education and to correlate them with the results of the bibliometric analysis. Following the PRISMA 20 methodology [23], we obtained the following results.

2.1 Type of study

A systematic review of the literature was conducted to prepare the research article, which aids readers in understanding the approach used to gather and analyze relevant research articles.

2.2 Research questions

The following are the research questions posed for this study:

RQ1: What digital technologies shape the metaverse in education?
RQ2: What are the benefits of the metaverse in education?
RQ3: What is the type of learning that is achieved by students when the metaverse is linked to education?
RQ4: What is the focus of the studies conducted?

2.3 Search strategies

The search string utilized in the manuscript search is depicted in Figure 1.

Fig. 1. Search chain of documents related to the research topic

The search string has been used in major databases such as Scopus, EBSCO Host, ScienceDirect, Taylor & Francis Online, IEEE Xplore, and Springer. A total of 662 scientific articles were included.

2.4 Inclusion and exclusion criteria

Table 1 outlines the inclusion and exclusion criteria that were considered in this study.

Table 1. Inclusion, exclusion, and justification criteria

Inclusion Criteria	Justification
Articles related to the metaverse applied in education	Meets the objective of the research
Articles mentioning the benefits of the metaverse in education	To analyze what are the positive aspects of the metaverse in education.
Articles no more than 2 years old	To include recent studies because they are up to date
Full text articles	To be able to analyze the document in its entirety
Articles in English	Is a language in which articles are published more frequently and are reliable
Articles in high impact databases	Blind peer review and reliability that guarantees the veracity of the research.
Exclusion Criteria	**Justification**
Documents other than articles	Manuals, theses, books, or similar research
Studies unrelated to the metaverse applied to education	Do not contribute to the research
Articles older than 2 years	Updated information is required to contribute to the research.
Articles in Spanish	English manuscripts are mostly found in high impact databases.

The procedure is then applied, as illustrated in Figure 2, depicting the three phases of the selection process for scientific articles used in the development of this work. In phase 1, 63 duplicate manuscripts were excluded. In phase 2, 242 participants were excluded for not meeting the inclusion criteria, leaving 328 manuscripts. In Phase 3, 60 publications were selected after the eligibility analysis.

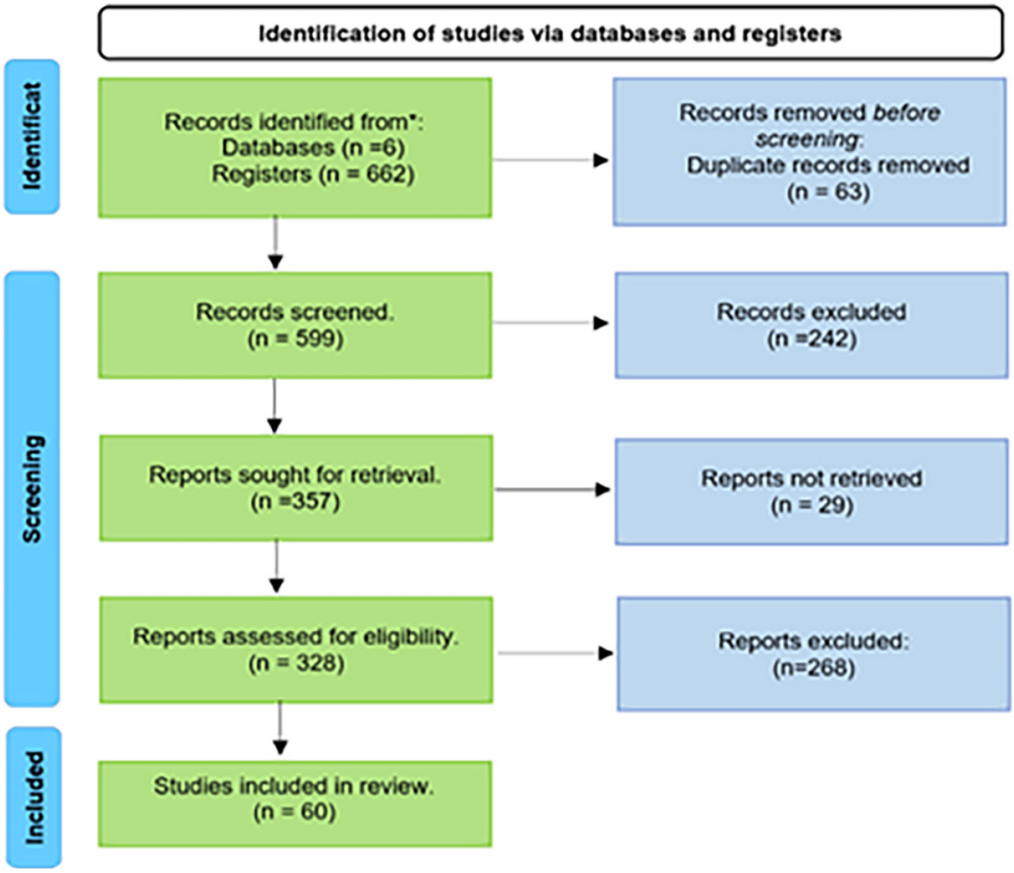

Fig. 2. Prism diagram method

3 RESULTS

This section presents the bibliometric analysis and a more comprehensive examination of the 60 manuscripts that met the inclusion criteria. Figure 3 depicts the visualization of the bibliometric map, illustrating the connections between words. The largest orange “metaverse” node represents the most frequently used term in the selected research, and its size corresponds to the frequency of appearance of these words in the selected research.

3.1 Bibliometric analysis

Bibliometric analysis is a quantitative technique that utilizes mathematics, statistics, and data mining to identify emerging trends in a specific topic.

VOSViewer was used to analyze the pertinent information related to the chosen research [24]. Additionally, VOS Viewer was utilized to generate networks based on the co-occurrences of significant fine print, from which visualization maps were created. This tool has helped visualize data by considering keywords related to the metaverse in education. Analysis was conducted on the title and abstract using a binary counting method with 115 keywords examined, applying a threshold of 1 occurrence. This resulted in 16 terminologies, as shown in Figure 3.

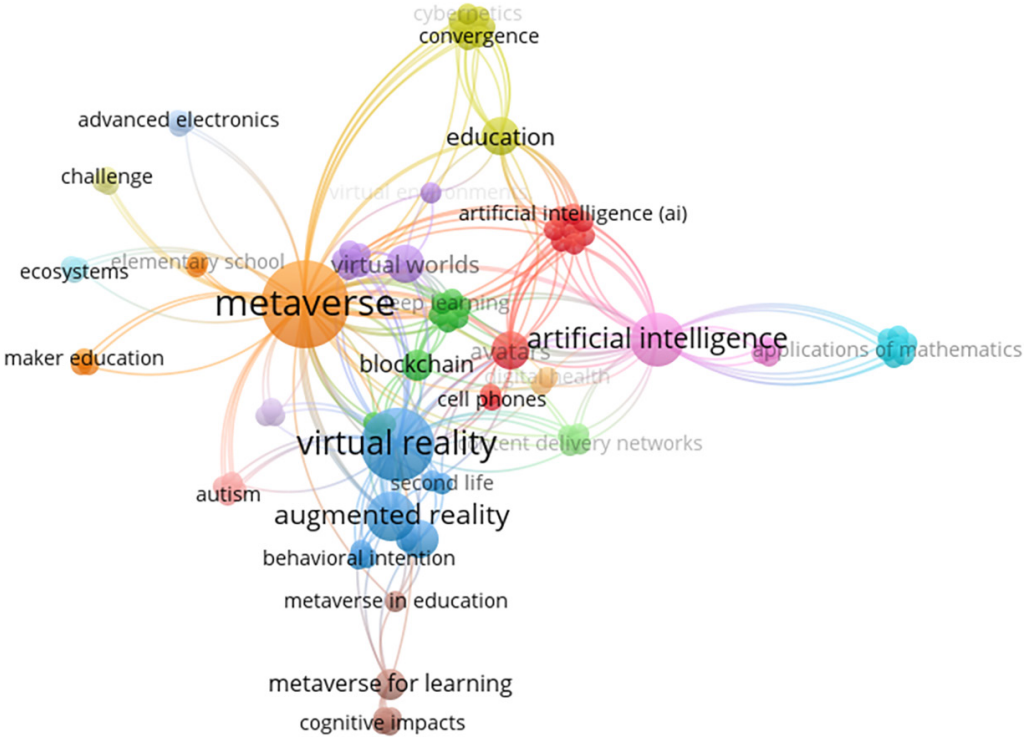

Fig. 3. Network visualization of bibliometric analysis

The largest nodes representing each cluster on the network map are as follows: the "metaverse" cluster (orange), the "virtual reality" and "augmented reality" clusters (light blue), the "artificial intelligence" cluster (lilac), the "blockchain" cluster (olive green), and the "education" cluster (green).

Looking at the network map in Figure 3, the 17 clusters are interconnected. For example, the term "metaverse" is linked to "virtual reality," "artificial intelligence," and "education." On the other hand, "education" is also associated with "convergence" and "artificial intelligence." In addition, the cluster "augmented reality" is related to the "metaverse in education" and the metaverse for learning. Finally, the "blockchain" cluster is related to "metaverse" and "virtual reality."

The "metaverse" cluster is at the center of the network and is connected to multiple clusters, including "virtual reality," "artificial intelligence," and "education." The metaverse is a central concept that encompasses several emerging technologies and has applications in various areas, including education. The connection between the "education" and "metaverse" clusters is notable due to the increasing interest and exploration of the use of the metaverse in the field of education. This could involve developing immersive learning environments, educational simulations, and innovative methods of teaching and collaboration. On the other hand,

the relationship between "education" and "artificial intelligence" implies that artificial intelligence is being investigated as a tool to enhance education. This can be seen through the development of intelligent tutoring systems, educational data analysis, and content adaptation based on student performance. The connection between "education" and "convergence" suggests a potential relationship between technological convergence and education. This could involve integrating various technologies to enhance the learning process and educational experience. The connection between the "augmented reality" cluster and the terms "metaverse in education" and "metaverse for learning" suggests that augmented reality is being explored within the context of the metaverse to enhance experiential learning, collaborative learning, cooperative learning, meaningful learning, explicit learning, and emotional learning. Finally, the connection between "blockchain," "metaverse," and "virtual reality" suggests that blockchain technology may be relevant for ensuring the security, authenticity, and ownership of assets and content in the metaverse and virtual reality.

Figure 4 depicts the analysis of the bibliometric data based on the publication year of the manuscripts, revealing a notable increase in research conducted in 2022.

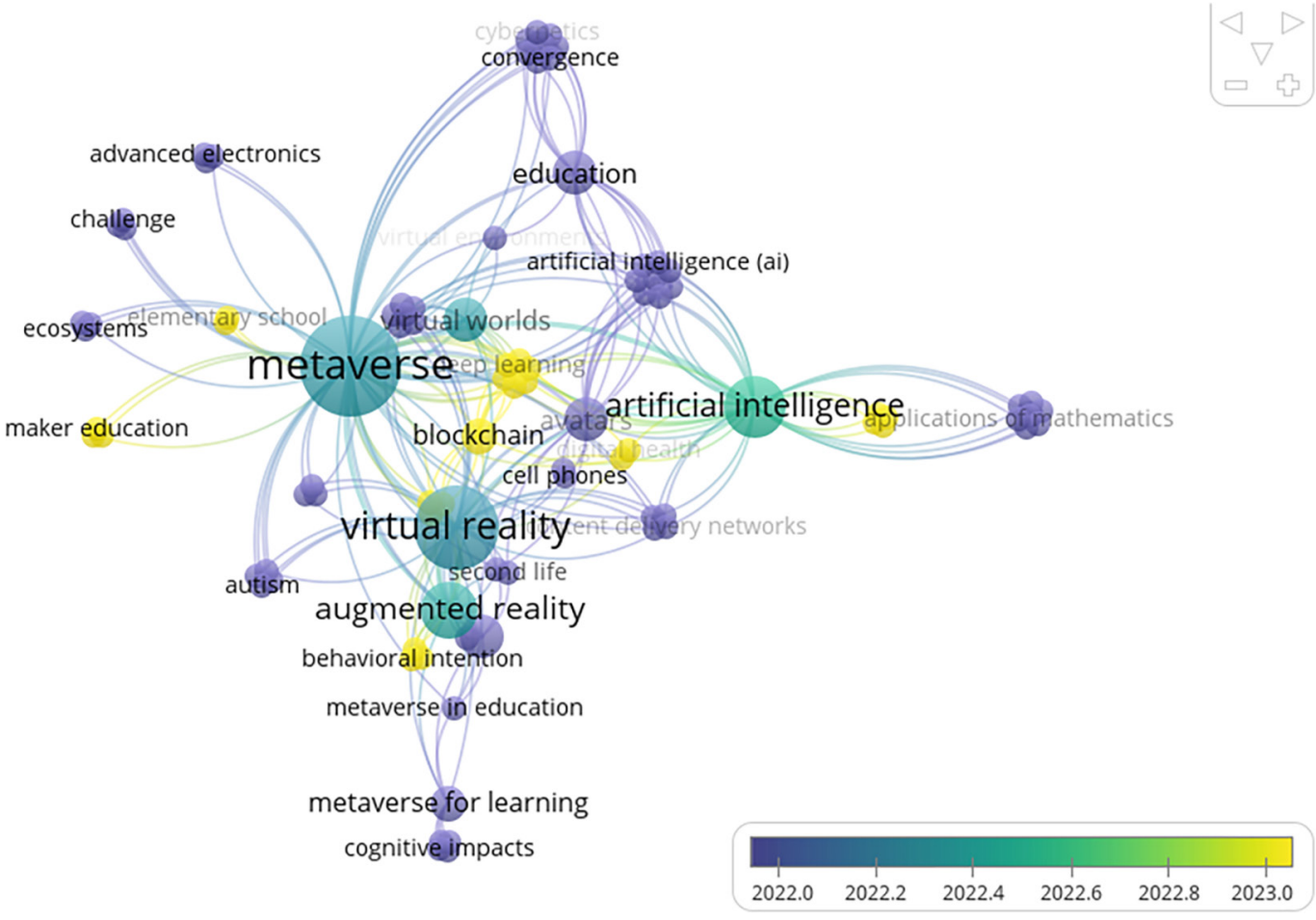

Fig. 4. Overlay visualization of bibliometric analysis

Figure 5 displays visualizations of manuscript density to identify recurring keywords found in online databases through bibliometric analysis.

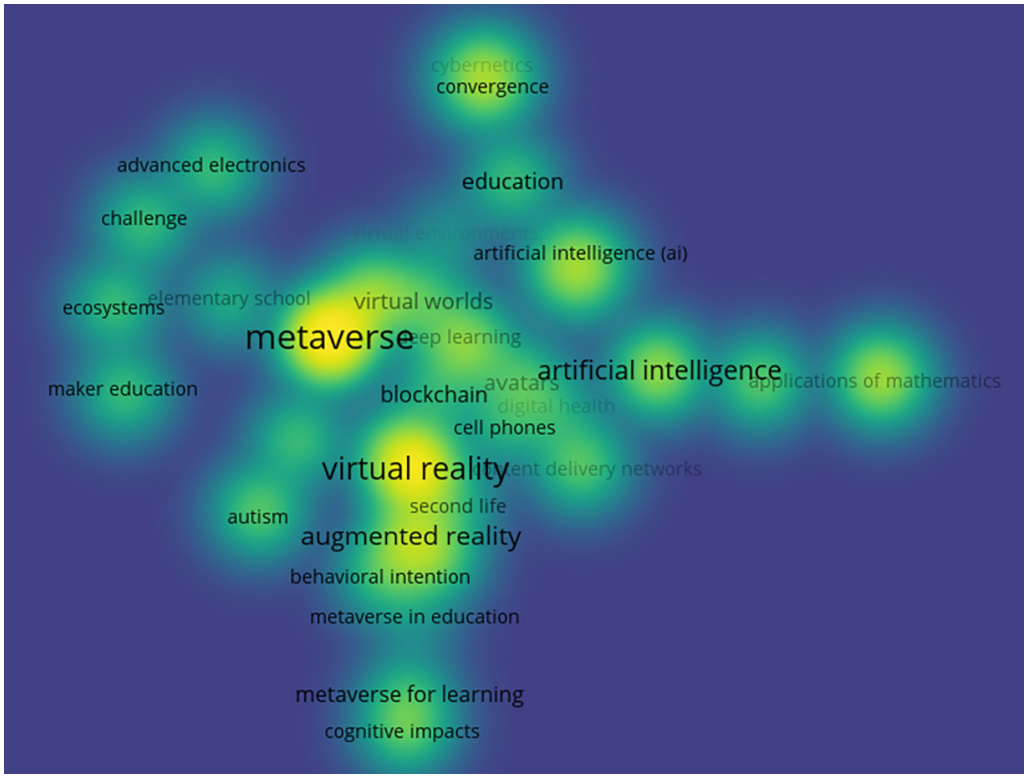

Fig. 5. Visualization of density of bibliometric analysis

Figures 3 and 5 identify the key terms of each cluster and their frequency levels. Figure 6 displays each of the terms based on this analysis.

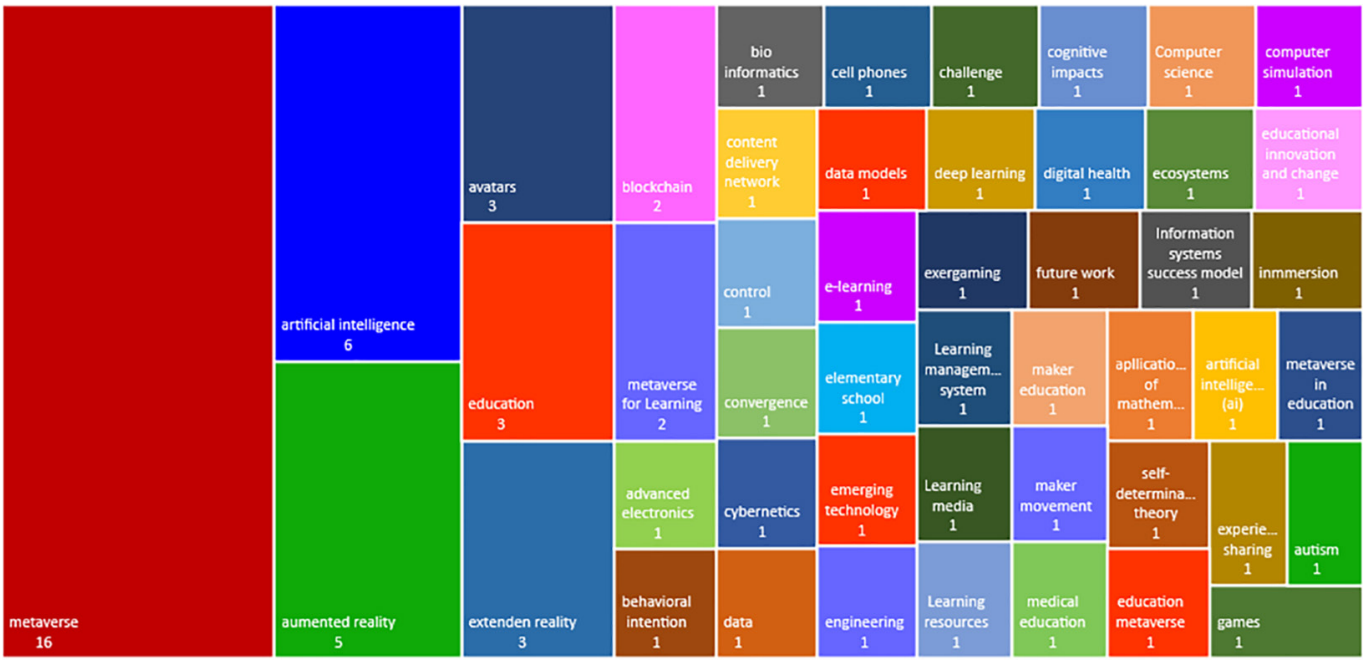

Fig. 6. Number of occurrences per keyword

3.2 Manuscript analysis

The number of articles found was 662, and after applying the exclusion criteria, 60 articles were found as shown in Figure 7.

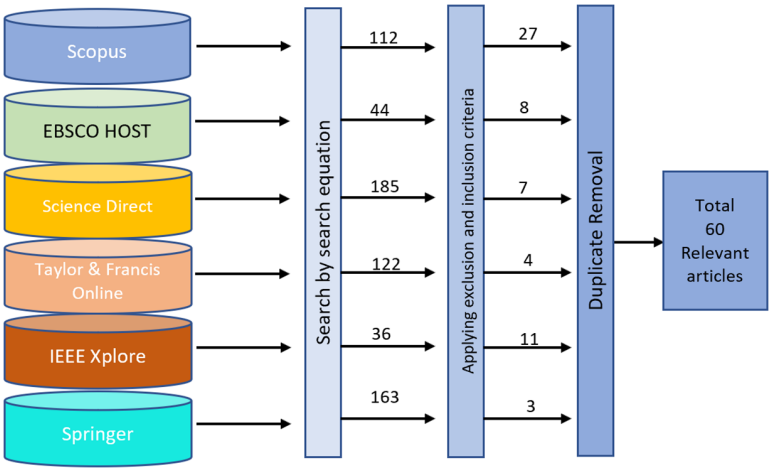

Fig. 7. Results obtained in the search

Figure 8 displays the percentage of information contributed by each of the databases. The three databases making the highest contributions are Scopus, IEEE Xplore, and Ebsco Host, accounting for 45%, 18%, and 13% of the total, respectively. They are followed by ScienceDirect, Taylor & Francis Online, and Springer, with 12%, 7%, and 7% market share, respectively.

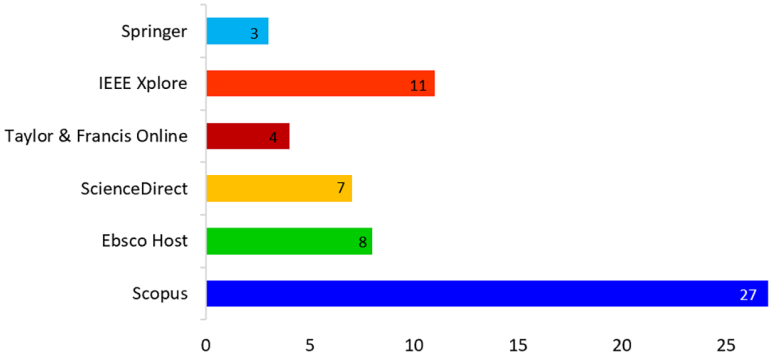

Fig. 8. Articles by database

Figure 9 displays the number of manuscripts published by year and database. The three databases with the highest number of publications in 2022 are Scopus, IEEE Xplore, and ScienceDirect, with 20, 9, and 5 manuscripts, respectively. They are followed by EBSCOhost, Taylor & Francis Online, and Springer with 4, 3, and 1 article, respectively. So far in 2023, Scopus has 7 publications, while EBSCOhost has 4. Finally, ScienceDirect, IEEE Xplore, and Springer each have 2 manuscripts, while Taylor & Francis Online has 1 manuscript.

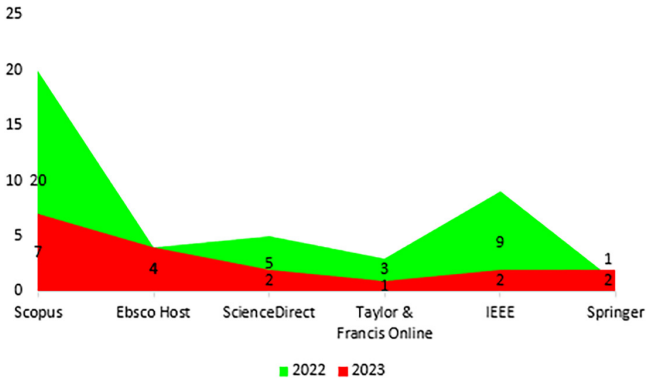

Fig. 9. Articles by year and database

Figure 10 displays the number of articles published by country. China has the highest research contribution with 14 articles, followed by the United States with 12 articles, South Korea with 5 articles, Taiwan with 4 articles, and India and Turkey with 3 articles each. Additionally, Vietnam, Australia, Indonesia, and Spain each have 2 articles, while the remaining countries have 1 article each.

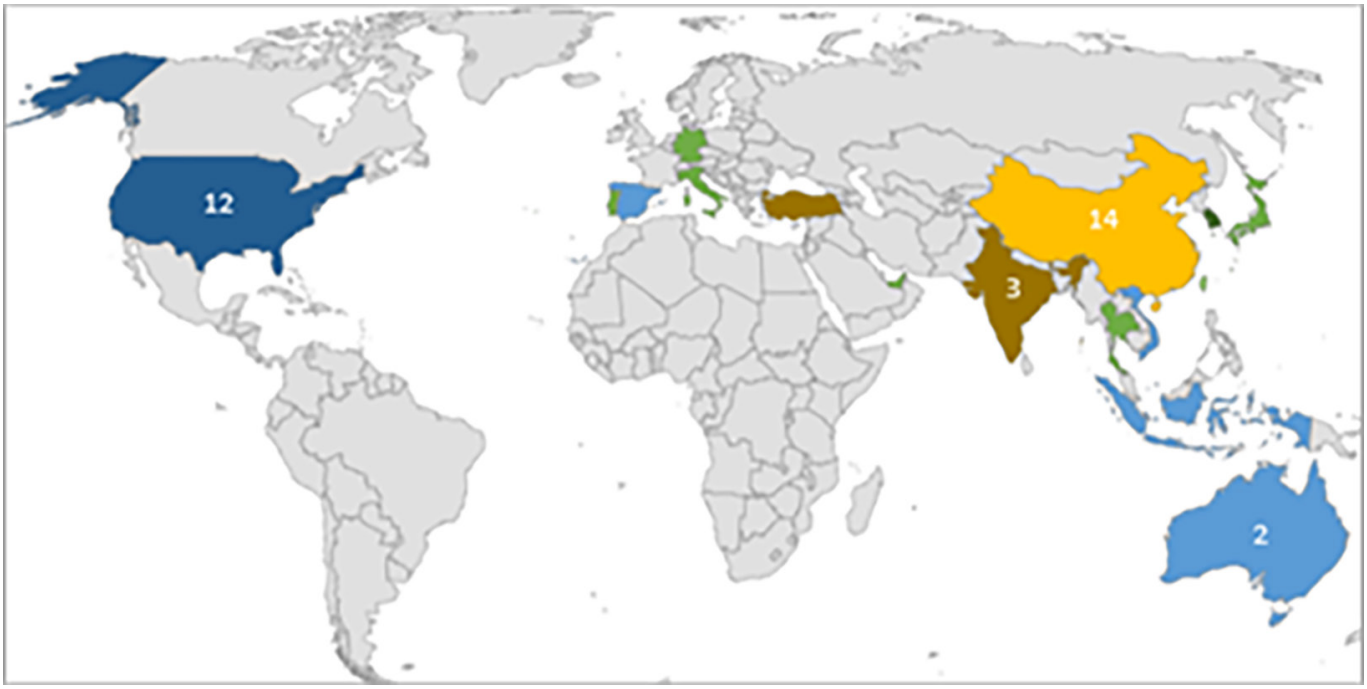

Fig. 10. Number of manuscripts published by country

4 DISCUSSION

RQ1. What digital technologies make up the metaverse?

According to Table 2, "emerging technologies" refer to digital technologies that are part of the metaverse, including big data, cloud computing, artificial intelligence, Internet of Things, augmented reality, extended reality, virtual reality, 5G, EON-XR, digital twins, 3D virtual reality, and immersive virtual reality, as mentioned in the study. The analysis of the 60 selected manuscripts led to the conclusion that "emerging technologies" enable the application of the metaverse in

education, facilitating new forms of interaction through avatars in a virtual world, as mentioned in their research [3]. The study indicates that the metaverse utilizes augmented reality, virtual reality (software), and technological devices such as sensors, smart glasses, headphones, and the Internet, among others (hardware). Augmented reality is important because it enhances the educational experience by providing support in the teaching-learning process, generating educational content, and offering a more personalized, effective, and inclusive education that better prepares students for the future [25]. In a rapidly changing world, especially after the global pandemic, current research indicates an increased need to utilize various emerging technologies and understand their evolution, change, and improvement. This aligns with the findings of a study [7], which highlighted the scarcity of information regarding the security of the participants, posing a significant threat [2]. Despite the widespread use of emerging technologies, the issue of security is still not receiving the necessary priority. Blockchain is a technology that can ensure users' trust when conducting network transactions through its blockchain technology. Hence, it is crucial for the relevant institutions to establish regulations for the use of the metaverse in education, aimed at upholding the rights of individuals in the virtual realm.

Table 2. Technologies that enable the application of the metaverse

#	Technology	Quantity	Reference
1	Big data	6	[26–31]
2	Blockchain	7	[26], [29], [32–36]
3	Cloud computing	1	[26]
4	Artificial intelligence	14	[15], [26], [27], [29], [36–45]
5	Internet of Things	4	[29], [32], [45], [46]
6	Augmented reality	17	[30], [36], [41], [44], [45], [47–58]
7	Extended reality	2	[26], [59]
8	Virtual reality	40	[31], [35], [37], [40], [43–48], [51]–[56], [59–81]
9	5G	1	[30]
10	EON-XR	1	[82]
11	Digital twins	2	[36], [45]
12	3D virtual reality	5	[28], [33], [49], [82], [83]
13	Immersive virtual reality	1	[84]
14	Second Life	1	[82]

RQ2. What are the benefits of the metaverse in education?

The potential of the metaverse in providing immersive learning experiences in 3D virtual environments has been demonstrated. The use of technology brings multiple benefits for people, specifically in the case of immersive learning, as it seeks to replicate the real world in a digital environment. Users can connect from anywhere in the world through their avatars [3] [4]. These authors indicate that the use of the metaverse in education promotes positive aspects that contribute to the teaching-learning process. However, it is important to consider both functional and non-functional aspects. That is, students need to have

hardware, software, and an Internet connection to access the educational spaces created by teachers, where they can interact and learn. These results are related to those obtained in [7], which argues that Generation Z (people born between 1990 and the early 2000s) have the characteristic of being more familiar with technology, enabling them to plan, organize, direct, and control their activities in a more optimal way. Similarly, the results of this study are consistent with those obtained in [2], where the authors argue that virtual scenarios are engaging and innovative enough to capture the attention of participants of different ages. This demonstrates that the metaverse in education offers various opportunities. The application of emerging technology (the Internet of Things) correlates with the results of the work [1] [2] because it enables the design of a more immersive learning environment that connects the real world with the virtual world through technological devices. Similarly, it is worth mentioning that there are still very few studies in the metaverse that focus on social sustainability, economic sustainability, and environmental sustainability. This is a topic that still needs to be investigated in order to have a complete understanding of the metaverse in education. Table 3 presents the manuscripts that examined the advantages of the metaverse in education.

Table 3. Benefits of the metaverse in education

#	Benefits	Brief Description	Quantity	References
1	Immersivity	Simulates the real world in a virtual one	14	[26], [30], [32], [36], [38], [41], [45], [47], [54], [59], [65], [71], [74], [84]
2	Interactivity	The ability to interact with different people	26	[15], [26], [27], [30], [35], [36], [38], [44], [45], [47], [49]–[53], [55], [59], [60], [63]–[65], [68], [69], [74], [80], [84]
3	Improves the educational environment	Innovative ways of presenting educational content	24	[15], [30], [34]–[42], [46]–[51], [54], [61], [63], [72], [77], [78], [82], [83]
4	Motivation learning	Captures students' attention motivating them to investigate and learn.	27	[28], [30], [31], [33], [36], [38], [43], [50]–[52], [55]–[58], [62], [63], [66]–[68], [70], [72], [73], [75], [76], [78], [79], [81]

RQ3: What is the type of learning that students achieve when the metaverse is linked to education?

Table 4. Type of learning when using the metaverse

#	Type of Apprenticeship	Brief Description	Quantity	Reference
1	Experiential learning	It is based on experience	12	[15], [26], [30], [32], [35], [36], [38], [45], [47], [54], [59], [65], [68], [69], [71], [74]
2	Collaborative learning	They have a guide who provides the topic to be researched	23	[15], [26], [27], [30], [35], [36], [38], [44], [45], [47], [49], [50], [52], [53], [59], [60], [63–65], [68], [74], [80], [84]
3	Cooperative learning	Involves working in teams	24	[15], [26], [27], [30], [35], [36], [38], [41], [44], [45], [47], [50–53], [59], [60], [63–65], [68], [74], [80], [84]
4	Significant learning	Uses the knowledge you have to learn more	27	[30], [31], [34–43], [46], [48–51], [54], [55], [61], [63], [72], [73], [77], [78], [82], [83]
5	Explicit learning	He wants to learn and selectively chooses what he considers relevant.	23	[28], [30], [31], [33], [38], [43], [51], [55–58], [62], [63], [66], [67], [70], [72], [73], [75], [76], [78], [79], [81]
6	Emotional learning	Proper management of emotions leads to good relationships with oneself and with others.	19	[28], [30], [33], [38], [51], [52], [55–58], [62], [63], [66], [70], [72], [75], [78], [79], [81]

Table 4 demonstrates the potential for experiential learning, collaborative learning, cooperative learning, meaningful learning, explicit learning, and emotional learning within the educational sector, benefiting both students and teachers [8]. This is consistent with the findings of this research. The metaverse in education can facilitate various types of learning for students, who can engage in virtual learning experiences, collaborate with other students in a connected world through their avatars, and work in teams without time or location restrictions. In addition, the level of digital literacy is a crucial factor in learning, considering the various limitations (economic, geographic, social, among others) faced by users. Therefore, it is important for educational institutions to offer engaging platforms and employ professionals who can provide support to students in their inquiries [1]. On the other hand, a point that has not yet been considered and investigated is the inclusion of users with disabilities, such as visual, auditory, physical, intellectual, or mental disabilities, who also have the right to education and to be included in the technological advances that have been taking place in the world, as clearly specified by [1] in his manuscript. For this purpose, it is important to monitor the behavior of the participants regarding the implementation of the metaverse in education to determine whether they adapt or not [6], i.e., to identify the positive and negative aspects of its use in real-life situations [7]. Students can access the metaverse, but it is important to consider that the content should be age-appropriate and aligned with the learning objectives of the class session. Table 4 presents the types of learning facilitated by the metaverse, as indicated by the findings.

RQ4. What is the focus of the studies conducted?

According to Figure 11, it can be observed that in the Scopus database, the qualitative approach is predominant in the articles related to the present research. This result indicates that currently, the focus is on describing the characteristics or qualities of the metaverse in education, as it is still in the process of development. It is likely that in the near future, there will be an increase in quantitative studies to test the hypotheses that have been proposed. In previous studies, such as the one in [6], researchers utilized instruments for data collection and identified university students as the target population. They concluded that immersive technologies, like the metaverse, make a significant contribution to the learning process. In the 60 studies analyzed, it was found that all of them utilized systematic review as a methodology to analyze the selected manuscripts. In some cases, a bibliometric analysis was also conducted, which is related in process and results to the present research. Only one study [13] specifies that it focused on quantitative research and utilized Scopus and WOS. Finally, it was found that China has the highest number of research studies among Asian countries, with 14 articles (12 in 2022 and 2 in 2023), coinciding with [4] [7]. This is because China is a country that has consistently shown its ongoing development in creating technology aimed at improving people's living conditions over the years.

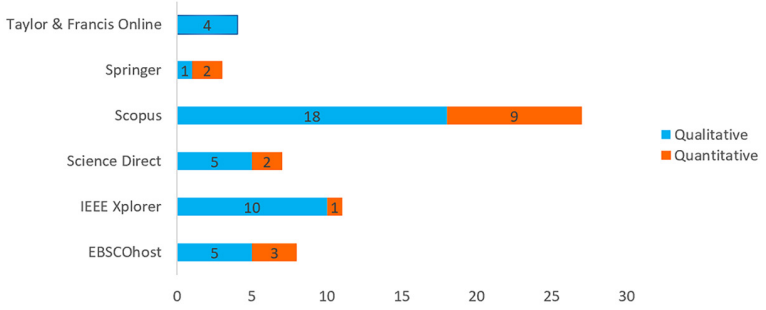

Fig. 11. Articles by research approach

5 CONCLUSIONS

For this study, manuscripts from 2022 and 2023 were selected. Initially, 662 manuscripts were identified, of which 60 remained after applying the inclusion and exclusion criteria using the PRISMA methodology. This review has identified the digital technologies that make up the applied metaverse. In education, we explore the benefits, types of learning, and focus of the studies. The research questions address four important points. First, the emerging technologies were identified as 14: artificial intelligence, cloud computing, big data, the Internet of Things, blockchain, augmented reality, extended reality, virtual reality, 5G, EON-XR, digital twins, 3D virtual reality, and immersive virtual reality. Second, they identified four benefits of the metaverse in education: immersion, interactivity, enhancement of the educational environment, and motivation for learning. Third, they identified several types of learning that are achieved: experiential, collaborative, cooperative, meaningful, explicit, and emotional. Finally, it was found that the qualitative approach predominates in the manuscripts, with a total of 43, while 17 employ a quantitative approach.

Finally, the results of this research will help future researchers understand that the metaverse is an extension of the real world. It offers the potential to enhance educational accessibility and equity by enabling students to access virtual learning resources and opportunities. Furthermore, they will have the opportunity to engage with others in order to acquire knowledge and generate interactive content. This commitment requires users to establish a link between humans and machines using emerging technologies, which have significantly impacted various sectors such as education, commerce, and productivity. The COVID-19 pandemic has led to a shift from face-to-face activities to virtual platforms, and the emergence of the metaverse has introduced new educational methods.

Regarding future research, it is important to analyze the individual impact and effectiveness of emerging technologies such as artificial intelligence, blockchain, and augmented reality in the teaching and learning process. Additionally, it is crucial to examine the technological barriers that may hinder the application of the metaverse in education and propose possible solutions to overcome these barriers. Finally, analyze a critical issue such as security. This analysis aims to explore methods for safeguarding students' data and privacy in virtual environments.

In discussing the limitations of using the metaverse in education, I will begin with teacher training. This is crucial because it is a key component for maximizing the potential of the metaverse. This involves understanding how it works, integrating the metaverse into curricular content, and promoting active learning among students. The second limitation is the economic investment (hardware and software) required for its implementation, which can be very expensive and not accessible to all students and teachers. This creates a digital divide and limits educational equity. Finally, there are no regulations on student and teacher access to a virtual world where they solely use avatars to interact. This should be regulated and made effective with emerging technology, such as blockchain.

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