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Review

How Does the Metaverse Shape Education? A Systematic Literature Review

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Abstract: In recent years, the potential of the metaverse as a tool to connect people has been increasingly recognized. The opportunities offered by the metaverse seem enormous in many sectors and fields of application. However, on the academic side, although a growing number of papers have been found to address the adoption of the metaverse, a clear overview of the solutions in place and their impact on education has been largely neglected so far. In the context of increasing challenges found with the metaverse, this review aims to investigate the role of the metaverse as tool in education. This contribution aims to address this research gap by offering a state-of-the-art analysis of the role the metaverse plays in education in relation to the future of work. The study is based on a systematic review approach performed by means of the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) protocol. The findings of this research help us to better understand the benefits, potential and risks of the metaverse as a tool for immersive and innovative learning experiences. Implications are discussed and streams for future investigation are identified.

Keywords: metaverse; education; virtual reality; blockchain; artificial intelligence; e-learning; horizon workrooms

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1. Introduction

1.1. The Historical Origins of the Metaverse

The origins of the metaverse go back to Neal Stephenson, who in his novel published in 1992 [1], described the metaverse as a sort of shared virtual reality [2]. The term "*metaverse*" is formed by the prefix meta, which means "*with, behind, beyond, after*", and the noun (uni)verse [3]. The notion of the metaverse has existed for decades [4]. However, only after thirty years does the term "metaverse" begin to have more defined contours. In fact, in 2021 Mark Zuckerberg, with the transition from Facebook to Meta, brought the term and the concept of "metaverse" back to the center of public discussion [5]. From a technological point of view, interest in the metaverse has been accelerated by the recent advancements in virtual and augmented reality technologies [6]. The metaverse is a digital universe resulting from multiple technological elements including video, virtual reality, and augmented reality [7]. In the metaverse, users access using 3D viewers and live virtual experiences. Users can create realistic avatars, meet other users, create virtual objects or properties, go to concerts, conferences, travel, and more [8]. There are several platforms to access the metaverse [9] (i.e., Second Life, Decentraland, Sandbox, Stageverse, etc.) [10]. Recent advances in virtual reality technology have made it more feasible to create the metaverse. Leading tech companies, including Facebook, Google, and Microsoft, have invested heavily in developing virtual reality and augmented reality technologies [11]. At present, the metaverse is considered to be a promising area for online technology, with capability to revolutionize interactions, education, employment, and recreation [12]. It is an all-encompassing, interactive, and collaborative environment that combines the features of augmented reality, virtual reality, and the Internet [13]. Figure 1 shows the evolution that led to the birth of the metaverse.

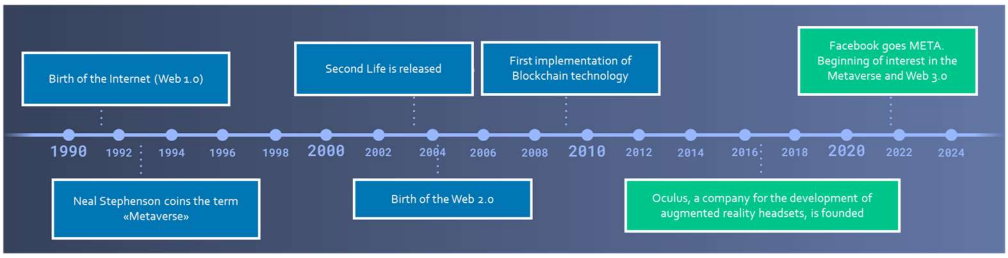

Figure 1. Evolution of the metaverse.

1.2. Technologies behind the Metaverse

Metaverse technologies are the essential tools utilized in constructing and managing virtual worlds. These encompass virtual reality (VR)/augmented reality (AR), blockchain, cloud computing, and artificial intelligence (AI) [14]. With these technologies, users can interact and experience virtual environments, generate digital assets, operate virtual worlds, and augment user experiences through intelligent, tactile feedback and motion tracking [15]. For example, virtual reality (VR) provides an immersive experience by simulating a complete digital environment, while augmented reality (AR) blends digital elements with the real world [16]. In addition, blockchain technology can secure and make transactions within the metaverse transparent. Cloud computing enables users to access metaverse experiences from anywhere with internet connectivity [17], and artificial intelligence (AI) can help to create more realistic and responsive virtual environments [18]. The metaverse is still under development; however, many companies are already exploring its potential. Big companies such as Microsoft, Nvidia, and Meta are making efforts in this direction, and with the technological advancement, we will see developments in these virtual worlds [19]. The continuous evolution of these technologies is critical as the metaverse continues to advance and expand [20]. As shown in Figure 2, the trend of "interest over time" is increasing. The development of the metaverse is connected with them. It is expected that the metaverse will use augmented and virtual reality (AR/VR) in combination with artificial intelligence and blockchain to create scalable and accurate virtual worlds.

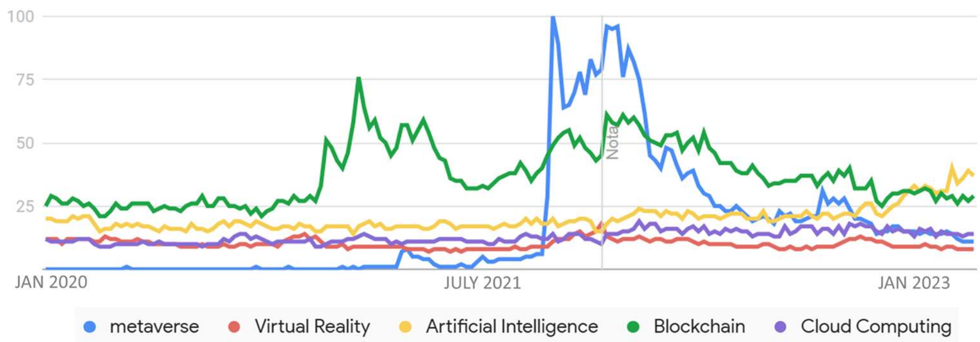

Figure 2. Trend of technologies related to the metaverse (source Google Trends—April 2023).

1.3. Exploring the Potential of the Metaverse

The metaverse has already become widely used in various technological fields. For example, it is being used in medicine to simulate surgical procedures and provide training for medical professionals [21]. Through artificial intelligence (AI), it is possible to improve medical diagnoses by connecting medical teams worldwide [22]. It is predicted that thanks to artificial intelligence, healthcare facilities will be able to quickly find timely and accurate information for the health of patients. It will be possible to make the most of resources, increasing efficiency and improving the flow performance of clinical and operational work. In finance, it is being used for virtual conferences and meetings, and even for conducting virtual trade shows and exhibitions. The metaverse has the potential to generate novel economic prospects by offering a platform for virtual commerce, advertising, and business transactions. Additionally, it could spawn new job openings in domains such as virtual reality development and design, contributing to the growth of the digital economy [23]. The metaverse holds promise in revolutionizing the work environment by providing new opportunities for remote teamwork, virtual conferencing, and skill development.

1.4. Motivation of the Study and Research Gap

Based on the previous reflections, it seems that the opportunities offered by the metaverse are enormous in many sectors and fields of application [24]. However, there are not many scientific studies that demonstrate the trend of the metaverse in the next few years. It is important to point out that at present, the systematic literature reviews on the metaverse are few. In detail, a search on Scopus (dated April 2023) showed that there are thirty-five reviews from between 2021 to 2023 (one in 2021; sixteen in 2022; eighteen in 2023 in progress). The publications are very heterogeneous, covering research sectors such as the blockchain, augmented reality, medicine, and digital technologies. Few of them are on training and education. Therefore, the present review intends to fill this gap. It is intended to be a pilot study used to analyze the main opportunities, challenges, and limitations related to education in the metaverse. In particular, in the context of the increasing challenges of the metaverse, this review aims to investigate the role of the metaverse as a tool in education. By exploring the opportunities and challenges of this innovative technology, the aim is to analyze the relationship between the metaverse and education. In fact, despite the increasing interest in the metaverse in education, there is still a research gap regarding its implementation and effectiveness [25]. Therefore, it is crucial to conduct rigorous research to understand the limitations and best practices for integrating metaverse technology in the context of education [26]. Definitely, this study aims to synthesize and analyze the current state of knowledge on the potential benefits and drawbacks of using metaverse technology in education. The analysis focused on the relationship between the metaverse education focused on the transmission/acquisition of knowledge and the development of specific and vertical skills in the industrial/work environment. This review article can provide valuable insights for educators, researchers, and policymakers interested in the potential of metaverse technology in education.

1.5. Research Structure

The topic analyzed in this research is new and complex. Thus, to develop a detailed analysis to define the research trajectory, an in-depth study was conducted. In detail, in Section 2, “Materials and methods” are presented. In particular, the core of the section revolves around research questions that are intended to be answered. Inclusion and exclusion criteria are then defined, and quality criteria were established to ensure that only relevant and high-quality studies were included in the review. Screening and data extraction criteria to carry out the research were defined, while the results of the analysis are presented in Section 3, which examines the publication trends by year, document types, country analysis, and subject areas, respectively. In addition, the current research trends on the metaverse were analyzed using Nvivo and VOSviewer software as argued in Section 4. In Section 5, the discussion is structured around the research questions. The main challenges of the metaverse in education are outlined in Section 6. Finally, Section 7 summarizes the main findings and limitations of the study.

2. Materials and Methods

In this manuscript a systematic literature review (SLR) approach is adopted to identify gaps in knowledge, leading to future research opportunities [27]. To ensure rigor and transparency, the SLR adheres to a specific protocol that outlines the research questions, selection of databases, exclusion criteria, and quality standards for analyzing only relevant documents. The SLR protocol reduces the risk of arbitrary decisions during the review process and minimizes duplication. SLRs are widely utilized in various fields, including healthcare, social sciences, and engineering, to identify, evaluate, and consolidate relevant evidence [28]. The SLR process typically involves five phases [29], as illustrated in Figure 1. Once these phases are completed, the results are classified and analyzed, followed by a discussion of the findings and an identification of the challenges and limitations. The classification and analysis, discussion, challenges, and limitations are discussed in Sections 4 and 5. Figure 3 shows the research methodology and the different steps involved in constructing the reference sample for the systematic review.

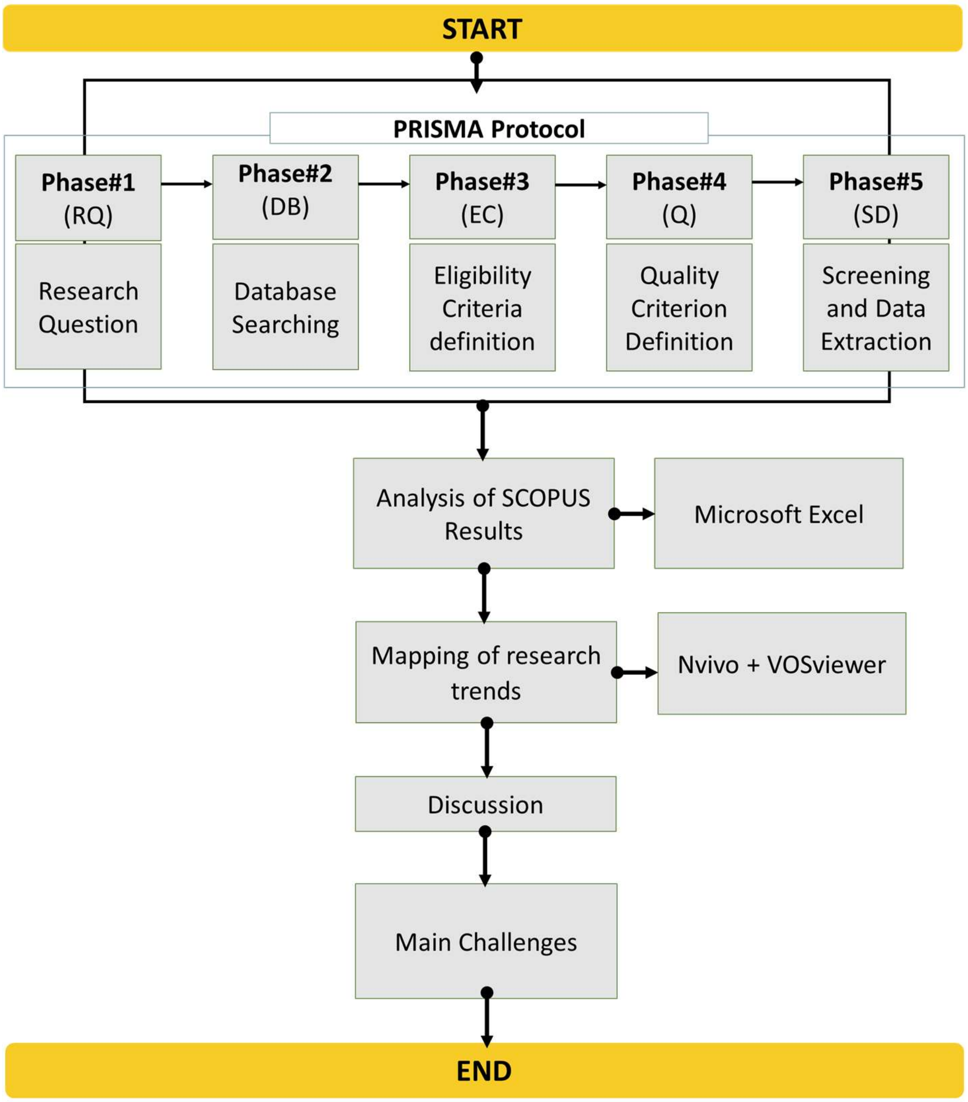

Figure 3. Stages of review protocol (author's elaboration).

Documenting each step of an SLR is essential for ensuring that the review is conducted rigorously, thereby increasing the credibility of the findings and the usefulness of the review for informing future research and practice. In the following sections the details of each phase are analyzed.

2.1. Phase#1: Research Question (RQ)

Research questions in a systematic literature review (SLR) utilize a clear and concise form of inquiry that guides the search for the relevant literature and the analysis of the data [30]. Questions should be well-defined, specific, and answerable, and should help to identify and evaluate the current state of knowledge on a particular topic. The main research questions identified in this review are summarized below:

RQ1: What platforms are used to access the metaverse?

RQ2: Who are the main users?

RQ3: What are the main technologies integrated into the Metaverse?

RQ4: What are the social and ethical implications of the Metaverse?

Answering these research questions can provide valuable insights into the use of metaverse technology in the field of education.

2.2. Phase#2: Database Searching Identification (DB)

Database Searching Identification is a crucial step in conducting an SLR. This step involves identifying and selecting relevant databases that are likely to contain articles related to the research questions. The selection of appropriate databases should be based on the scope of the research and the types of articles that are being targeted [31]. Common databases used in SLRs include Google Scholar, Web of Science, Scopus, and PubMed. In this regard, bibliometric data were collected from one of the largest academic citation databases recognized worldwide. It contains a vast collection of peer-reviewed academic journals, books, conference proceedings, and other scholarly publications from various disciplines.

To ensure comprehensive coverage, a search strategy is developed, which includes the use of specific keywords, Boolean operators, and search filters. The research investigation was started with the keywords “Metaverse AND Education*”, with Boolean operators “AND”, which were processed as: (TITLE-ABS-KEY (metaverse) AND TITLE-ABS-KEY (education*)) AND (LIMIT-TO (PUBSTAGE, “final”)) AND (LIMIT-TO (LANGUAGE, “English”)) AND (LIMIT-TO (DOCTYPE, “ar”)) AND (LIMIT-TO (SRCTYPE, “j”)). In this study, only papers published in international journals were analyzed. The motivation behind the choice was linked to the awareness that journal publications are more solid and rigorous from a scientific point of view.

Table 1 shows the search methodology and literature criteria selection.

Table 1. Search methodology and literature selection (initial setup).

Database Search Identification	
Keywords	Metaverse Education *
Boolean operator	AND
Time	2005 2023 (until February)

Initially, Scopus analysis identified 236 documents from 2005 to 2023. However, it was deemed appropriate not to include documents from years before to 2005 in the search, as it is only recently that the technology has spread beyond gaming and become more robust.

2.3. Phase#3: Eligibility Criteria Definition (EC)

Eligibility criteria refer to a predefined set of rules that determine the selection of studies to be included or excluded in an SLR [32]. Exclusion criteria are specific factors that would lead to the exclusion of a study from the review. Inclusion criteria, on the other hand, are specific factors that a study must possess to be included in the review. These criteria are developed based on the research questions and objectives, with the aim of ensuring that the studies included in the review are relevant and of high quality, minimizing the risks of bias.

After querying the search engine of the Scopus database and from the skillfully returned automatic results, sorting of articles was carried out. Specifically, the following exclusion criteria were identified:

E1. Documents not related to metaverse beyond science fiction.

E2. Duplicate documents.

While the inclusion criteria identified are:

I1. Only articles at the final state of publication.

I2. English language documents only.

The documents not related to research questions and duplicates were removed. Similarly, only documents in the final state of publication and in the English language were considered. However, applying these criteria does not rule out the possibility that documents that meet the requirements for ineligibility may have been overlooked and continue to be included in the work plan.

2.4. Phase#4: Quality Criteria

Systematic literature reviews (SLRs) typically employ several quality criteria to ensure that the included studies are of high quality and that their findings can be trusted [33]. This study established three criteria to ensure the quality and relevance of the selected documents:

Q1: Documents that include opportunities and challenge management in the context of education in the metaverse.

Q2: Documents that explore the fields of application of artificial intelligence categories and tools in education.

Q3: Documents with a significant impact factor, SCImago Journal Rank, or CiteScore, indicating their scholarly, academic excellence.

By employing these selection criteria, the study aimed to identify high-quality documents that provide valuable insights into the practical, experimental, and theoretical aspects of education in the metaverse.

2.5. Phase#5: Screening and Data Extraction (SD)

The screening and data extraction phase in an SLR is crucial for selecting relevant studies and extracting data to answer the research questions. In this SLR, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) protocol was used to ensure the transparency and accuracy of the screening and data extraction process. The PRISMA protocol involves several main steps [34]. The identification phase involved searching for relevant studies using specific keywords. The eligibility phase involved assessing the full text of the studies that passed the screening phase to determine whether they met the inclusion criteria. Finally, the inclusion phase involved searching for studies with open access, extracting data from the included studies, and synthesizing the results to answer the research questions. The use of the PRISMA protocol helped to ensure that the screening and data extraction process was conducted systematically and transparently, thereby enhancing the rigor and credibility of the SLR. Specifically, using a reference protocol to follow helps minimize bias. Search results captured using keywords provided accessibility to 236 documents. Researchers evaluated each document based on inclusion and exclusion criteria. It appears that 144 documents did not meet the criteria, and 92 articles were therefore incorporated into the evaluation procedure. Finally, eight documents that were not freely accessible were excluded. Therefore, the final sample obtained consisted of 84 documents. The PRISMA [35] has been used during the search and filtering of articles for this review document. Figure 4 shows the PRISMA flow diagram. The list of the selected papers identified using the PRISMA protocol is included in the references chronologically.

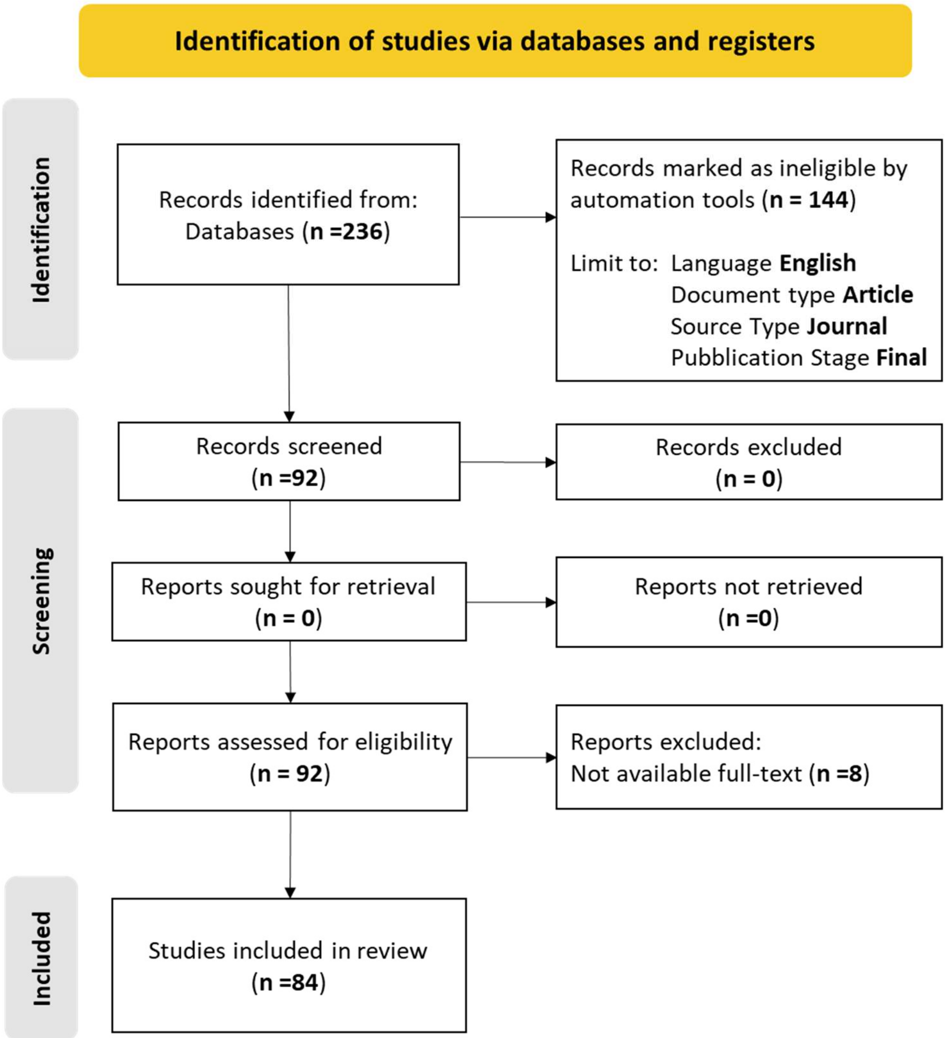

Figure 4. Flow chart for document selection based on Preferred Reporting Items for Systematic Review and Meta Analyses (PRISMA).

3. Results of Systematic Literature Review

This section presents and discusses the findings of the review. First of all, an overview of the selected 84 studies is presented. All papers have been classified. The full list of analyzed papers is shown in Supplementary Material. Quantitative evidence of the study is analyzed considering the following issues:

Publication by years and by source;
Country analysis;
Subject area;
Most collaborative authors;
Most cited documents.

3.1. Publication by Years and by Source

In recent years, the metaverse has become a hot topic, highlighting an increasing trend linearly until 2018, as shown in Figure 5. After 2020, an exponential growth in the number of publications is evident. Considering that the metaverse is an ever-evolving technology, it is expected that in the coming years, the trend in the number of publications will be confirmed.

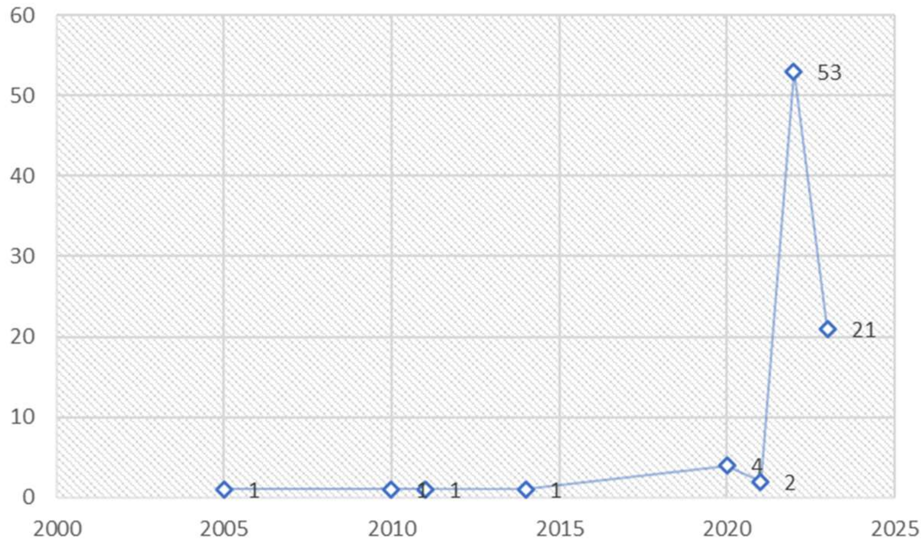

Figure 5. Publications by years (source: Scopus).

The analysis of documents pointed out that most of the manuscripts were published in the following journals: IEEE Access (7%), Sustainability Switzerland (6%), Electronics Switzerland (5%), Applied Sciences Switzerland (4%), and Heliyon (4%). Table 2 summarizes the five top journals.

Table 2. Journal ranking (source: Scopus).

Journal	Publisher	CiteScore 2021 [1]	SJR 2021 [2]	Percentile
IEEE Access	IEEE	6.7	0.927	90th
Sustainability	MDPI	5.0	0.664	86th
Electronics	MDPI	3.7	0.590	60th
Applied Sciences	MDPI	3.7	0.507	73rd
Heliyon	Elsevier	4.0	0.550	82nd

[1] CiteScore measures average citations received per document published in the serial. [2] SCImago Journal Rank measures weighted citations received by the serial.

3.2. Country Analysis

Analyzing the trend of publications based on the territory/country of affiliation of the authors, it emerges that the most productive country is South Korea (27.3%), followed by China (22.6%) and the United States (13%). The details are shown in Figure 6. This result is not surprising given that the aforementioned countries are the most innovative from a technological and cutting-edge point of view. This means that the academic and research world is showing interest in this issue.

3.3. Subject Area

The 84 selected documents refer to various subject areas. Figure 7 shows that the most significant areas are: Computer Science (53%), followed by Engineering (20%) and Social Sciences (15%). However, it is noteworthy to observe the interdisciplinary nature of the publications. Additionally, it is equally important to note that the potential impact of metaverse technology provides innovative solutions in the field of medicine, materials sciences, physics, and astronomy.

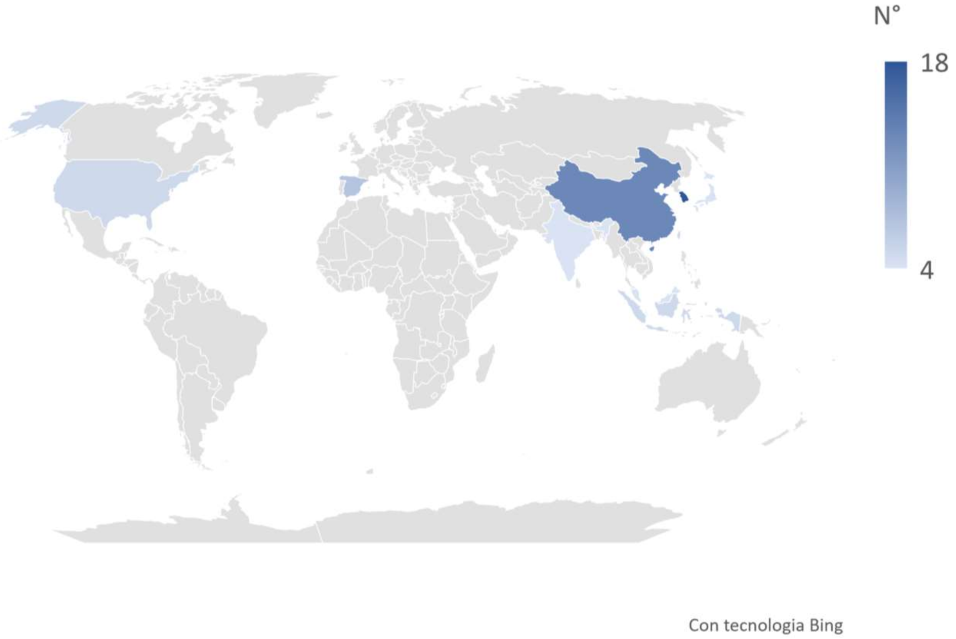

Figure 6. Country analysis (source: Scopus).

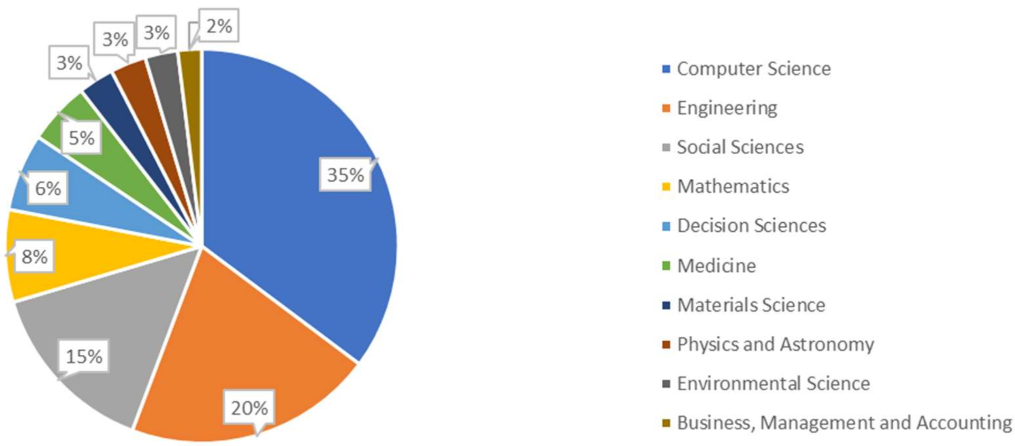

Figure 7. Documents by subject area.

3.4. Most Collaborative Authors

Another aspect that is evident from the analysis is the scientific collaboration characterizing the publications. Figure 8 shows that most papers have four authors (22 papers; 26%). Then, there are the papers with two authors (21 papers; 25%) and one author (11 papers; 13%).

3.5. Most Cited Documents

From a scientific point of view, the impact of publications is measured by the number of citations. Therefore, we analyzed the most cited papers among the 84 selected papers, as shown in Table 3.

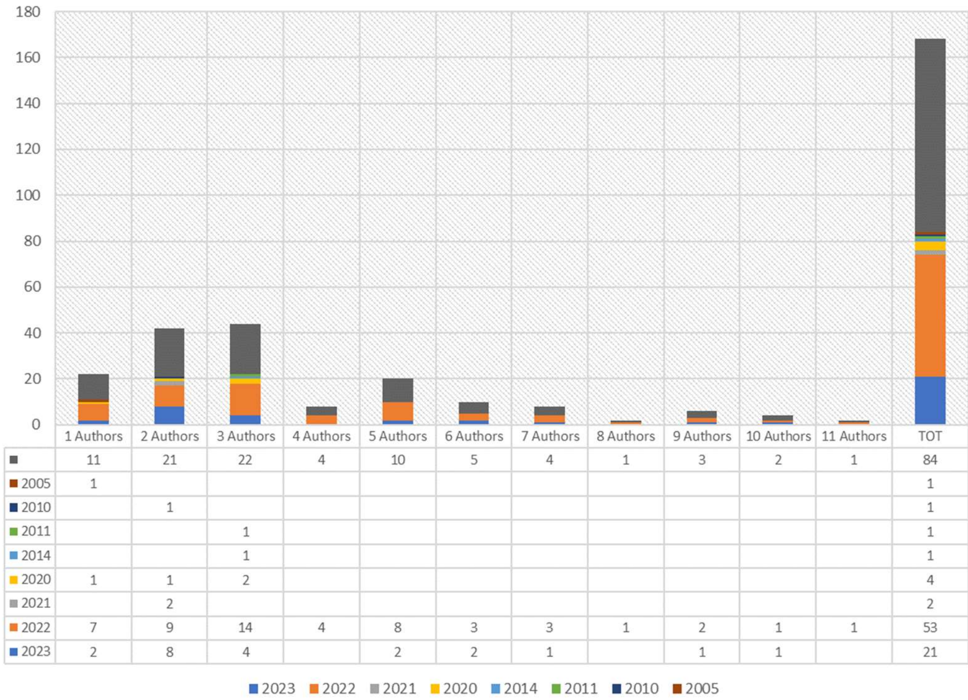

Figure 8. Most collaborative authors (source: Scopus).

Table 3. Journal ranking (source Scopus).

Title	Year	Authors	Journal	N° of Citations
Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy	2022	Dwivedi et al.	International Journal of Information Management	95
Definition, roles, and potential research issues of the metaverse in education: An artificial intelligence perspective	2022	Hwang and Chien	Computers and Education: Artificial Intelligence	51
Virtual world as a resource for hybrid education	2020	Díaz et al.	International Journal of Emerging Technologies in Learning	40
Using Augmented Reality to Stimulate Students and Diffuse Escape Game Activities to Larger Audiences	2020	Estudante and Dietrich	Journal of Chemical Education	39
Towards aircraft maintenance metaverse using speech interactions with virtual objects in mixed reality	2021	Siyaev and Jo	Sensors	38

An interesting observation emerged when analyzing the keywords most used in the most cited documents. As shown in Table 4, the most used keywords (excluding metaverse and education/learning) are: (1) AR/VR, (2) AI, and (3) I4.0.

Table 4. Journal ranking (source: Scopus).

Title	Keywords		
	AR/VR	AI	I4.0
Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy	X	X	X
Definition, roles, and potential research issues of the metaverse in education: An artificial intelligence perspective	X	X	
Virtual world as a resource for hybrid education		X	
Using Augmented Reality to Stimulate Students and Diffuse Escape Game Activities to Larger Audiences	X		X
Towards aircraft maintenance metaverse using speech interactions with virtual objects in mixed reality		X	X

4. Mapping of Research Trends through Nvivo and VOSviewer Analysis

To collect the factors enabling the transition to education in the metaverse from the literature, the articles were analyzed through VOSviewer and Nvivo. Nvivo is a powerful qualitative data analysis software that is widely used in various fields such as social sciences, market research, and more [36]. Figure 9, obtained with Nvivo, shows the most used keywords in the selected manuscripts. As shown the word "Metaverse" is the focal point, while the words connected to "virtual" and the various branches of words connected to "education" surround it.

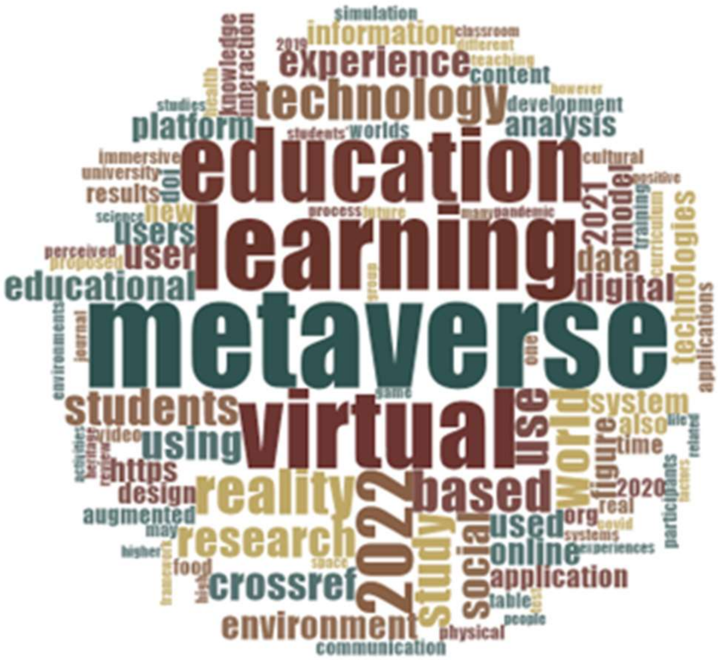

Figure 9. Word cloud of keywords.

While VOSviewer is a free software tool that utilizes bibliometric networks to generate co-citation and co-authorship maps. These maps help identify the most influential papers, authors, and research topics in a given field [37]. Additionally, it allows us to carry out a visualization of co-occurring networks of important terms extracted from scientific literature. In the context of education research in the metaverse, Vosviewer can be used to identify valuable insights into the structure and dynamics of education research in the metaverse and identify opportunities for future research. Therefore, a keyword analysis was carried out. The total number of keywords identified was approximately 903. The maximum co-occurrence value calculated using VOSviewer is 66. A minimum of three keyword occurrences was chosen, returning five clusters. Figure 10 shows the network of links between the main keywords.

The colors of each circle are determined by its weight/meaning, as explained in the following paragraphs. In addition, the size of each circle corresponds to the frequency of occurrence for the respective keyword. [38]. The total link strength indicates the number of publications in which two keywords occur together [39]. As shown in Figure 4, the metaverse is the keyword with the highest occurrence in the blue cluster. It has an occurrence equal to 72, a total link strength of 50, and 245 links with other keywords. This means that the metaverse is a strong driver in this cluster. Table 5 shows the identified clusters, items, and authors belonging to each cluster.

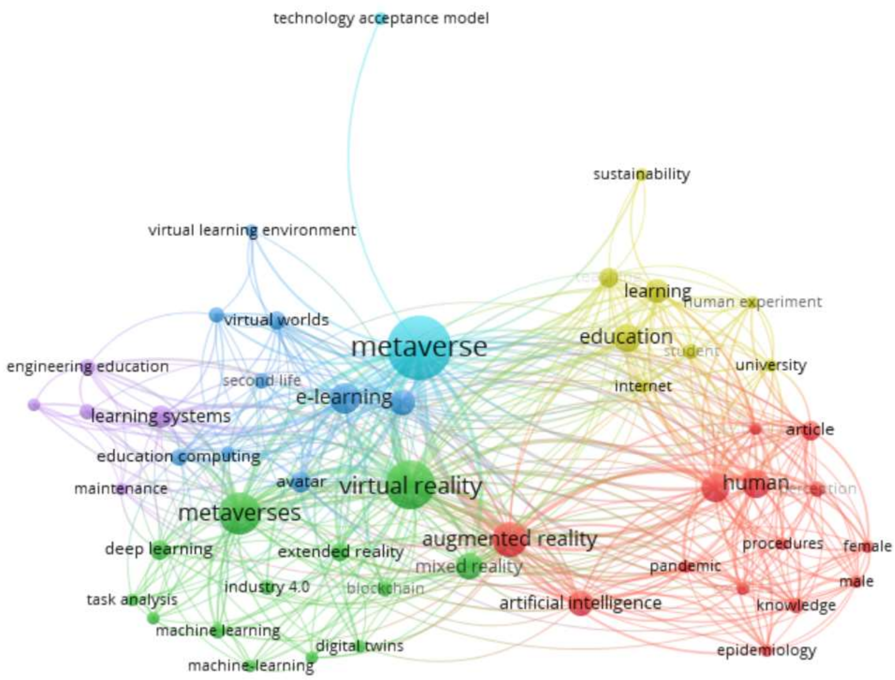

Figure 10. Co-occurrence analysis (VOSviewer).

Table 5. Clusters, items, and authors (VOSviewer and author's elaboration).

Cluster	Color	No. of Items	Cluster Label	Details Items (VOSviewer)	Main Authors (Author's Own Elaboration)
Cluster 1	Red	14	Knowledge	Artificial intelligence, augmented reality, knowledge, pandemic/COVID-19, human, procedures.	A2, A3, A4, A8, A13, A23, A25, A26, A37, A39, A48, A54, A59, A66, A70, A72, A74, A75, A76, A82
Cluster 2	Green	13	Technologies	Blockchain, deep learning, digital twins, extended reality, I4.0, IoT, machine learning.	A9, A11, A12, A15, A20, A27, A29, A33, A38, A44, A55, A62, A78, A79
Cluster 3	Blue	9	Platform	Avatar, e-learning, educations, training, platforms, virtual worlds, virtual learning environment.	A10, A16, A19,A24, A32, A34, A35, A43, A51, A57, A58, A63, A65, A69
Cluster 4	Yellow	8	Academic	Human experiment, university, sustainability, teaching, internet, student.	A14, A17, A18, A21, A22, A30, A31, A49, A52, A53, A61, A68, A73, A77, A80
Cluster 5	Purple	7	Ecosystems	Ecosystems, learning systems, technology acceptance.	A1, A5, A6, A7, A28, A36, A40, A41, A42, A45, A46, A47, A50, A56, A60, A64, A67, A71, A81, A83, A84

4.1. Red Cluster "Knowledge"

The Red Cluster is associated with a high importance score. The red cluster contains keywords related to the concepts: artificial intelligence, augmented reality, knowledge, pandemic/COVID-19. Traditionally, learning takes place in a physical classroom setting, whereas with metaverse technology, learning activities are conducted within a 3D virtual world [40]. As discussed by several authors, leveraging metaverse technology for learning has the potential to transform the way people acquire and process information [41]. This allows them to adapt and refine their knowledge as needed [42]. The analysis of the documents has highlighted that the need to imagine different ways and worlds to socialize [43], to study, and to work emerged essentially in the period of the pandemic/COVID-19 [44,45]. In fact, due to this catastrophe, companies have begun to understand the need to develop new technologies (i.e., the metaverse) [46,47]. In this way, new knowledge and skills can be developed [48]. Innovation makes it possible to implement effective and efficient processes to support the process of changing society worldwide [49]. Thanks to artificial intelligence in the metaverse, it will be possible to create increasingly similar users with a realistic appearance [50]. It will allow them to interact with others and share experiences and knowledge [51]. Furthermore, for the metaverse, as in other fields, artificial intelligence makes it possible to automate software development processes, reducing the time to create new applications and solutions in the metaverse [52]. Therefore, after years in which cloud computing, virtual reality, and artificial intelligence have dominated media interest and attention from organizations, a new trend is now making its way to innovate how people and companies will work, communicate, and have fun [53].

The studies analyzed highlight that realizing the metaverse as the next immersive internet requires overcoming several unprecedented technological challenges [54]. The metaverse has the potential to transform education by creating immersive, interactive, and collaborative learning environments that can enhance employee/student engagement and facilitate active learning [55]. In the era of Industry 4.0 and virtual reality, the industrial metaverse takes shape [56]. Enabled by artificial intelligence, it promotes digital twin technology to help decision-makers make timely informed decisions [57]. However, the success of the metaverse will greatly depend on the integration of technologies and the data that are transmitted by sensors installed in the real world [58]. Figure 11 shows an example of training through the metaverse.

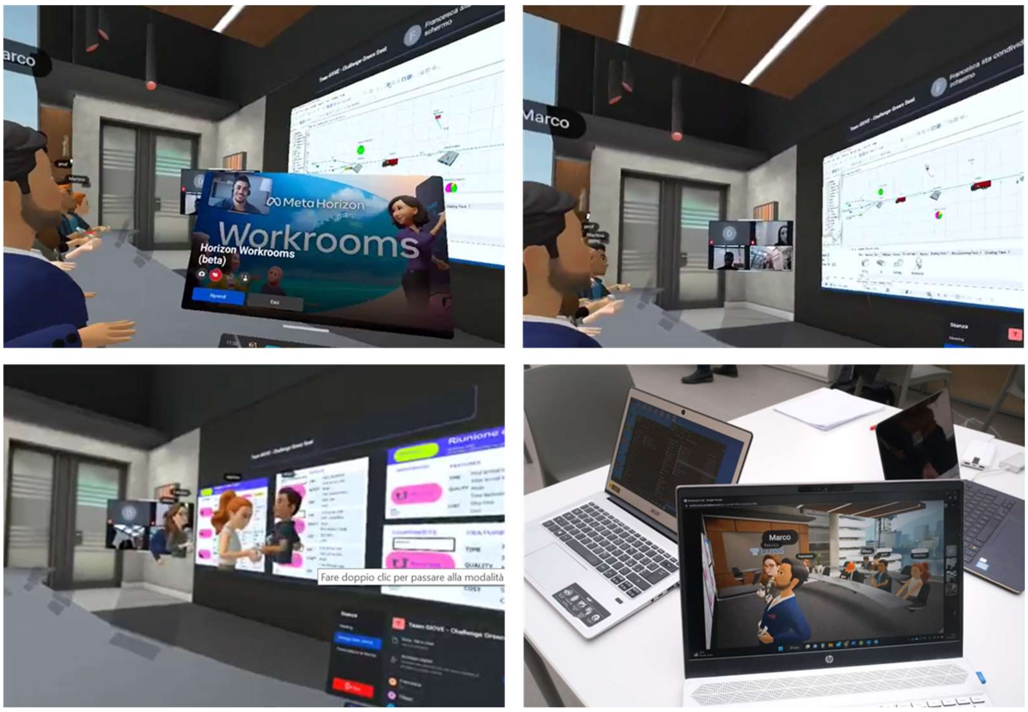

Figure 11. Metaverse experience integrated with a digital twin (elaboration by the authors).

In the experience, a photo-realistic digital twin is integrated into the industrial metaverse, offering a potential to transform a real supply chain into a virtual world in which people can interact and collaborate. A svupply chain of a manufacturing company is simulated.

4.2. Green Cluster "Technologies"

The Green Cluster is characterized by a medium importance score. The keywords are: blockchain, deep learning, digital twins, extended reality, I4.0, IoT, and machine learning. As highlighted by several authors, from a technological point of view, there are several technologies that today contribute to the creation of metaverses [59,60]. These technologies include virtual reality, mixed reality, artificial intelligence, blockchain, and finally the internet infrastructure and device processors [61,62]. In this regard, it emerges that the various industrial sectors have long been looking for new ways to increase productivity, efficiency, and resilience [63,64]. Thus, digitization has become one of the main methods to achieve this goal [65,66]. COVID-19 has required and enabled companies to accelerate their digital transformation journey, opening up multiple opportunities that many did not think possible before [67]. As a result, the need for digital skills of the future will become ever more critical [68]. Emerging technologies that enable Web3, the cloud, and perhaps one of the greatest ICT innovations of all, the metaverse, will be essential [69,70]. A lot of research shows that the biggest and most impactful opportunities will come from other forms of this virtual and augmented environment, such as the industrial and corporate metaverse [71]. These applications will allow organizations to blur the lines between physical and digital environments and to reshape the world, defined as "digital twins" [72]. In practice, it means that projects can be built virtually before being replicated in the real world [73]. For example, using augmented reality and virtual reality (AR/VR), factory employees will be able to design and test equipment before implementing it in a real production line, thereby limiting risk and more accurately predicting production volumes [74]. Figure 12 shows an example of training through the metaverse for interactive learning using VR and AR.

Figure 12. Industrial metaverse for interactive learning (elaboration by the authors).

4.3. Blue Cluster "Platform"

The Blue Cluster contains keywords related to the concepts: avatar, e-learning, education, training, platforms, virtual worlds, and virtual learning environment. Analysis of the documents highlights that the metaverse is seen as the next big evolution in online interaction, moving from today's text-based websites and often closed ecosystems to shared, interconnected spaces where users interact via avatars [75,76]. However, many authors point out that today the technology of the metaverse is only in its infancy [77,78]. Despite the existence of various virtual worlds, many of them are still in fact far from becoming truly interconnected with each other [79,80]. However, studies show that there is no doubt about its potential. The metaverse at the moment is like the internet of the 1990s; it needs several leaps of development before it gains widespread use [81]. The metaverse represents a new means of communication [82]. It radically evolves social interactions between users, overcoming the limits of 2D technology, and therefore offers the possibility of relating in an innovative and immersive way, as pointed out by several authors [83]. It is reasonable to think that the metaverse is not only a virtual universe, but also an innovative means of communication [84]. Probably it is the most inclusive space currently existing, both online and offline [85]. This undoubtedly represents a strong point of the metaverse, which characterizes it and distinguishes it from all the rest, fully demonstrating its innovative character that everyone is talking about [86,87].

4.4. Yellow Cluster "Academic"

The Yellow Cluster contains keywords related to the concepts: human experiment, university, sustainability, teaching, internet, and student. From this point of view, many authors agree in stating that the metaverse and training is a winning combination because AR, VR, and MR experiences increase student involvement, promoting memory and understanding [88,89]. Associating the words metaverse and formation may seem precocious [90]. However, the academic and training world is witnessing an unstoppable evolution. In fact, on the one hand, traditional teaching methods make it possible to achieve the desired learning objectives [91]. On the other hand, however, the younger generations (digital natives) require the adoption of tools and methodologies beyond the traditional frontal lesson [92]. Therefore, from the analysis it emerges that especially in academies (places of excellence of knowledge) it is worth exploring what technology offers today for education, because Web3, even more than Web2, presents great opportunities for those who want to learn [93,94]. In fact, students can follow the lesson wherever they are, but without losing the perception of being in the place assigned to learning [95]. The metaverse makes travel not only in space, but also in time. This means that the study of history can take place by visiting the still intact ancient Rome, or that of astronomy by traveling to the moon, and so on [96]. Many authors point out that, for example, another typical activity of the metaverse and training (above all corporate) is the simulation of risky or difficult actions to try firsthand in reality [97]—an activity from which technical-scientific professions can especially benefit, making up for the possible scarcity of physical means with digital technology and avoiding the risk of accidents [98,99]. In addition, it should be noted that virtual worlds can also support intellectual learning (for example, languages can be learned by dialoguing and interacting with chatbot avatars, guided by artificial intelligence) [100,101]. Finally, the metaverse can support the implementation of teamwork activities in the classroom or in the company. In fact, students in the virtual space can work more easily on a common project by sharing a desktop without limitations [102,103].

4.5. Purple Cluster "Ecosystems"

The Purple Cluster is associated with the following keywords: ecosystems, learning systems, and technology acceptance. From this point of view, most of the authors agree in stating that the world is heading towards a "great reversal" [104–106]. It means a new ecosystem composed of 5G and related key technologies such as edge cloud infrastructure, software, augmented intelligence/machine learning, advanced sensors, and robotics [107–110]. Thanks to the combination of these capabilities the technologies operating in the physical and digital industries will find the necessary solutions to address the much-needed digital transformation in the next ten years [111,112]. In other words, the metaverse is a complex ecosystem made up of different tools and digital tools [113–118]. The digital transition in the health system is revolutionizing medicine. For example, many researchers predict that it will be possible to amplify the curative efficacy of rehabilitation treatments (both at home and post-operative in specialized centers) [119–122]. Without doubt, many researchers believe that metaverse-related opportunities will grow as long as they are balanced by long-term plans to support economic needs and social and environmental transformations [123–126].

5. Discussion

The main considerations that emerged from the systematic analysis of the literature are reported below.

5.1. RQ1: What Platforms Are Used to Access the Metaverse?

Currently, the metaverse is the most popular place due to its ability to offer immersive experiences. Several platforms offer access to the metaverse, each with its features and functionality. The choice of platform depends on the preferences and needs of the user, who should choose the one that best suits their interests. Table 6 shows a list of the most used platforms for accessing the metaverse.

Table 6. Main platforms used in the metaverse.

Platform	Year of Release	Type of Metaverse	Type of Experience			
			Gaming	Cultural	Real Estate Market	Fashion
Second Life	2003	Desktop-based metaverse (non-blockchain)	X			
VRCha	2017	Metaverse in virtual reality	X			
Roblox	2006	Desktop-based metaverse (non-blockchain)	X			
Decentralan	2020	Metaverse on blockchain, desktop-based			X	
Horizon Worlds	2021	Metaverse in virtual reality	X	X		
Minecraft	2009	Desktop-based metaverse (non-blockchain)	X			X

The choice of platforms depends on the purpose of the user. In addition, it is important to specify that in each case, the main devices for diving into the metaverse are the visors, i.e., helmets with an integrated audio system that incorporate two displays that observe the movement of the head and eyes, allowing our avatar to show expressions.

5.2. RQ2: Who Are the Main Users?

The use of the metaverse in work and study environments is still a relatively new concept. However, based on current trends, it appears that the use of the metaverse is spreading globally in different working environments. The metaverse can be used to create collaborative learning environments where employees and/or students can work together on projects and assignments. The metaverse can also be used to create simulations that allow the exploration of complex work environments (i.e., reengineering of the layout, industrial risks, eco-efficiency of the equipment, etc.)

5.3. RQ3: What Are the Main Technologies Integrated into the Metaverse?

We can conclude that the virtual worlds of the metaverse are built based on of the interconnection between technologies of different kinds, among which the most important are: blockchain, digital twin, artificial intelligence, virtual and augmented reality, and the Internet of Things (IoT). However, it is clear that the future metaverse will be composed of a network infrastructure that will be unlike the current one, since it has multiple limitations, such as the reliability, bandwidth, and latency of data transmissions. The 5G and 6G networks will improve the situation, allowing the use of complex three-dimensional worlds and interactive and immersive experiences in real-time. In particular, the present research has highlighted that the most enabling technology of the metaverse is artificial intelligence. Indeed, the adoption of the metaverse by an increasing number of people will lead to the generation of a large amount of data, due to the three-dimensionality of the shared virtual space. The powerful technologies available today make it possible to "explore" these immense amounts of data by revealing behavior dynamics, patterns, and information that the human brain would not be able to identify. However, *how to "exploit" the data of the Metaverse through Artificial Intelligence*? The data obtained through the metaverse can be used mainly through the use of machine and deep learning algorithms, to be used to analyze the speech, behavior, and interaction mechanics that take place in a meta-environment. Artificial intelligence, through the collection of ever more detailed data, can lead to obtaining an increasingly large and elaborate number of information, which can thus be developed. In this way it will be possible to have more and more information available to one's visitors and to have increasingly interesting and advanced automated interactions with users. The potential of artificial intelligence in the educational field is almost boundless considering that it meets a segment of the population in full development of the creative, problem solving, and team building faculties.

5.4. RQ4: What Are the Social and Ethical Implications of the Metaverse?

There is great potential for productivity or entertainment offered by metaverse scenarios, but there are also many questions that arise from an ethical point of view. The highly immersive nature of the metaverse can result in individuals spending too much time in virtual reality, which can lead to social isolation and disconnection from the real world. The use of the metaverse can result in personal data privacy breaches and security risks, as users are required to share sensitive information to access the virtual world. There is potential for the metaverse to be addictive and have negative effects on mental health, especially for younger users who spend a significant amount of time in virtual worlds. The metaverse has the potential to be exploited for illegal activities, including cybercrime, fraud, and cyberbullying. It is important to consider these potential problems and ensure appropriate measures are in place to address them while exploring the potential of the metaverse. Essential is an understanding of the different types of metaverses that exist, including the gaming metaverse, civic metaverse, social metaverse, business or work metaverse, and educational metaverse. Each type of metaverse offers unique experiences and features catering to different user needs. In the metaverse, individuals can generate digital representations (avatars), communicate with other users in real-time, and engage in a variety of activities and events, such as virtual concerts, sports, interactive gaming experiences, and socializing. The metaverse has the potential to transform the landscape of entertainment by offering an immersive platform that could enable people to participate in events from any location, enhancing accessibility and promoting inclusivity in entertainment. Through avatars, individuals could partake in socializing by attending events and participate in activities within a virtual environment, ushering in a new phase of social interaction.

6. Main Challenges of Metaverse to Empower Work Environment

The studies pointed out that the use of the metaverse involves several aspects, as shown in Figure 13.

Another important aspect that has emerged is that artificial intelligence in the metaverse will represent an essential enabling factor. It is expected that the metaverse will use augmented and virtual reality (AR/VR) in combination with artificial intelligence and blockchain to create scalable and accurate virtual worlds. There are currently at least three possible use cases for AI in the metaverse: the creation of metahumans, intuitive interfaces, and multilingual virtual worlds. The metaverse is a very complex and articulated concept that is still being defined. However, it should be noted that the metaverse can represent a real opportunity; however, it must possess some specific characteristics. In particular, these must be that it is:

· *interoperable*, thus ensuring the interconnection of data, objects, digital resources, and identities;
· *able to guarantee the ownership of the assets*, i.e., that the user will be the owner of his/her digital assets;
· *modular*, with the user being able to create assets and/or customize the space;
· *freely accessible*, with users being able to join the metaverse by participating in specific events, places, and activities at the same time;
· *representative*, with the possibility for users to be represented through the creation of customizable avatars;
· *persistent*, i.e., continuing to exist indefinitely and independently of the presence or absence of a subject;
· *immersive*, i.e., able to provide an experience that combines the real world and the virtual world, providing creative and customization tools.

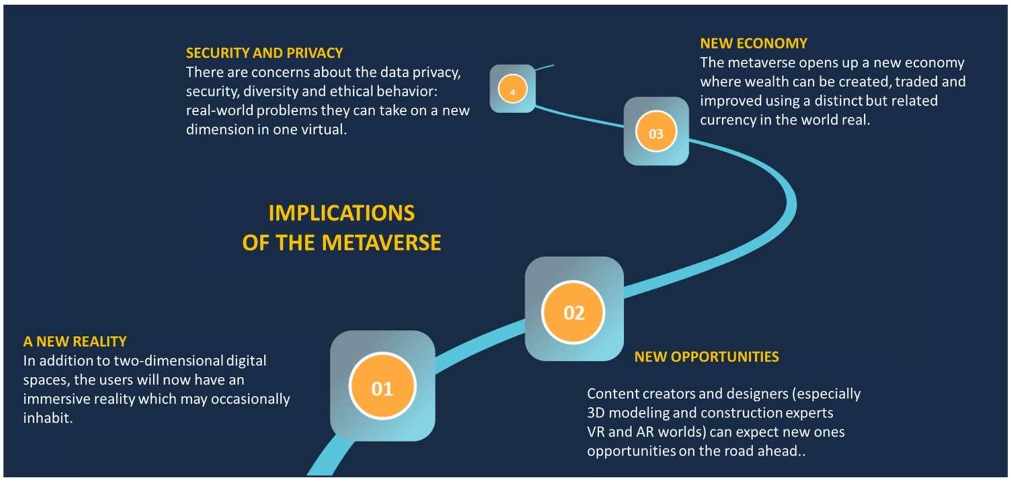

Figure 13. Implications of the metaverse.

The "heart" of the metaverse is the encounter and interaction between users. A virtual environment is first of all a moment of meeting and exchange capable of overcoming any type of barrier, be it geographical, physical, emotional, or whatever. This aspect could already give a great boost and improvement to phases of training such as interviews and preliminary assessments. The almost total immersion, typical of the metaverse, can improve concentration, understanding, and retention. Additionally, obviously one of the benefits of the metaverse is its impact on education. There are other benefits too, such as:

· Enhancement of creativity, enhanced by the use of new technologies, their interaction, and the shared context.
· Greater customization and simulations tailored to the individual user.
· Faster learning, four times higher than traditional training and two times higher than a "simple" e-learning course.
· Strengthening of continuous training, which becomes more flexible and engaging thanks to the possibility of lowering the various modules into tangible and recognizable situations.

Today, technology primarily interacts with two senses: sight and sound. Our vision is that thanks to artificial intelligence algorithms, a connection of the senses and the ability to digitally communicate thoughts will be possible in the coming years (see Figure 14).

Currently, there is also a big challenge in terms of the metaverse. There is no super-moderator or regulator for the metaverse.

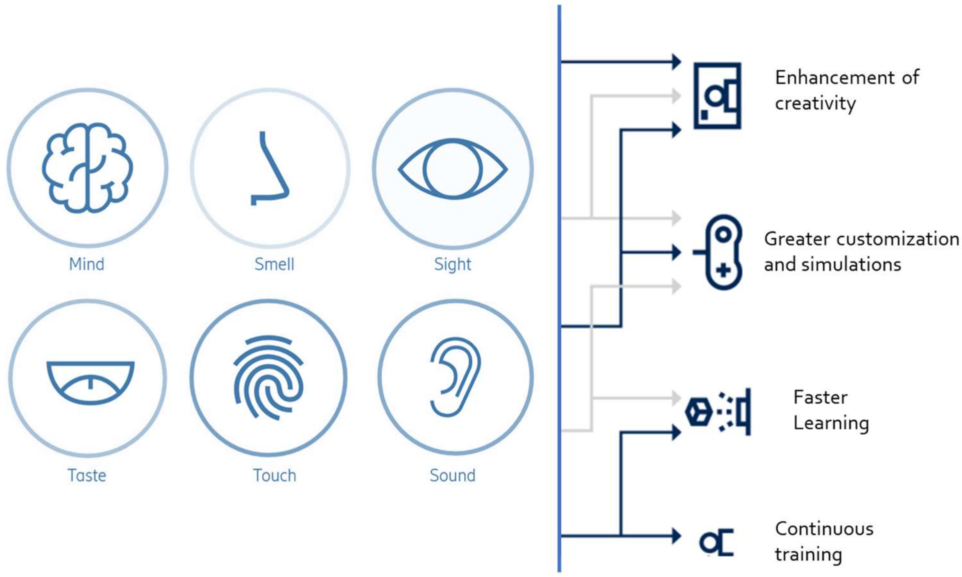

Figure 14. Metaverse, artificial intelligence, and education—opportunities and challenges.

7. Conclusions

7.1. Concluding Remarks

The metaverse is a concept that has been in development for several years. This study aimed to explore the potential of the metaverse in education and other fields. The metaverse presents a promising opportunity for educational innovation, particularly in fields that require hands on experience and practical training. In fact, the economy of the metaverse is predicted to reach over $824 billion by 2030. Organizations investing in this technology now are the ones that will win the innovation race. However, the metaverse can only reach its full potential if organizations themselves work together to create an open, safe, environmentally sustainable, and all-encompassing environment that encourages innovation and translates into value for all involved. This will require huge technological investments and adaptations, sophisticated content creation tools, and large servers to maintain system stability and create a truly immersive experience.

7.2. Limitations and Future Research Developments

As the field of metaverse education continues to evolve, it is important to acknowledge its current limitations and areas for future research development. One major limitation is the lack of standardized assessment tools and metrics to evaluate the effectiveness of metaverse education compared to traditional methods. Another limitation is the limited access to high-speed internet and powerful hardware required to fully experience the metaverse, which may exclude certain populations from participation. Moving forward, it will be important for researchers to continue to explore the potential benefits and challenges of metaverse education, while also identifying ways to address these limitations. Additionally, given the rapid pace of technological advancement in the metaverse, it may be necessary to conduct an annual review of the latest developments and research to ensure that educators are aware of the most up-to-date information and resources available.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app13095682/s1. Full list of analyzed papers (84 documents).

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