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Imbricación del Metaverso en la complejidad de la educación 4.0: Aproximación desde un análisis de la literatura

Imbrication of the Metaverse in the complexity of education 4.0: Approach from an analysis of the literature

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RESUMEN

El Metaverso como objeto de estudio se ha incrementado debido a su potencial para crear entornos inmersivos para acercar a las personas a realidades alternas. Aunque las investigaciones realizadas permiten conocer aspectos conceptuales y de aplicación, existe un conocimiento limitado sobre cómo se imbrica con la complejidad de la educación 4.0. En este estudio se realizó una revisión sistemática de la literatura (SLR) con 231 investigaciones recopiladas de Scopus y Web of Science en las que se imbricó el Metaverso con los componentes de la educación 4.0. Los resultados evidenciaron: (a) un amplio crecimiento de las publicaciones desde el año 2022, (b) el predominio del uso del Metaverso en la industria del diseño de algoritmos y las ventas al detalle, (c) una fuerte colaboración para desarrollar infraestructura 4.0 entre investigadores de Estados Unidos de Norteamérica, Corea del Sur, China, Reino Unido y Japón, (d) la aplicación del Metaverso utilizando tecnologías inmersivas, aumentadas y el diseño de avatares, así como su aplicación como estrategia de elearning. Se concluye que el tema ha despertado interés en la academia, no solo por su incidencia en el conocimiento de las tecnologías emergentes, sino también por su trascendencia en la evolución de ecosistemas digitales.

ABSTRACT

The Metaverse as an object of study has increased due to its potential to create immersive environments to bring people closer to alternate realities. Although the research carried out allows us to know conceptual and application aspects, there is limited knowledge about how it is intertwined with the complexity of education 4.0. In this study, a systematic review of the literature (SLR) was carried out with 231 investigations compiled from Scopus and Web of Science in which the Metaverse was interwoven with the components of education 4.0. The results evidenced: (a) a large growth in publications since 2022, (b) the predominance of the use of the Metaverse in the industry of algorithm design and retail sales, (c) a strong collaboration to develop infrastructure 4.0 among researchers from the United States of America, South Korea, China, the United Kingdom and Japan, (d) the application of the Metaverse using immersive, augmented technologies and the design of avatars, as well as its application as an e-learning strategy. It is concluded that the subject has aroused interest in the academy, not only because of its impact on the knowledge of emerging technologies, but also because of its importance in the evolution of digital ecosystems.

PALABRAS CLAVES · KEYWORDS

educación 4.0, educación superior, innovación educativa, metaverso, pensamiento complejo, realidad extendida.
education 4.0, higher education, educational innovation, metaverse, complex thinking, extended reality.

Imbrication of the Metaverse in the complexity of education 4.0: Approach from an analysis of the literature

1. Introduction

The use of digital technologies to improve the quality of education and bring professional teaching closer to more students has been a topic of study in recent decades (Cabero & Martínez, 2019; Cabero, 2020; UNESCO, 2019). However, the appearance of Covid19 in the American continent forced the migration of teaching to virtual settings using videoconference tools, learning platforms, and digital content (García et al., 2020; Sepulveda & Morrison, 2020). This move required strengthening the use of these technologies and generating teaching strategies that break the paradigm that education must take place permanently in physical classrooms (Means & Neisler, 2021).

The learning processes must respond to the challenges of emerging educational scenarios, which can change and not necessarily be conducive to face-to-face formats. Taking advantage of the opportunities offered by technological trends in our day-to-day classes is imperative. This can achieve a transformation that makes using technology in education essential for disruptive learning. In particular, educational environments bring new requirements for digital education, specifically those regarding inclusion, diversity, and the use of state-of-the-art technologies to integrate into complex environments seamlessly (Ramírez-Montoya et al., 2022a). During the change from presential to non-face-to-face teaching, millions of students used digital skills to participate in learning processes (Darling & Hyler, 2020). They will likely continue to do so continuously due to the evolution and integration of disruptive technologies, skills, and infrastructures that support teaching in digital ecosystems. In this sense, using virtual tools to deal with emergent teaching situations has been considered a successful alternative to expanding learning scenarios in the short and medium term (Arnove, 2020; Maier et al., 2020).

Virtual worlds offer immersive experiences that streamline and make access to knowledge more flexible, thereby causing more participatory and sustainable interactions (Díaz, 2020; Lee & Hwang, 2022). In particular, the Metaverse, understood as a virtual world based on the maturity of various digital technologies such as virtual reality (VR), augmented reality (AR), Big Data, and blockchain, represents the next step in the future of education (Gu & Gao, 2022), especially in those formative processes in which teaching strategies based on collaboration in alternate worlds are present through the design of avatars that interact with other people and with the environment. Thus, the Metaverse is becoming an alternative teaching-learning space for the new generations (Lee et al., 2022).

2. The imbrication of the Metaverse in Education 4.0

The Metaverse is a topic of debate in education, in part due to the excitement generated by Facebook's announcement regarding its transition to Meta, a unified ecosystem of virtual environments that allows users to not only socialize, collaborate, and have fun but also be part of learning by developing extended realities and financing high-quality immersive experiences (Meta, 2022).

However, Stephenson outlined the concept decades before in his novel *Snow Crash* (1992), where characters coexist in the real world and cyberspace through avatars that interact and develop alternative histories. Thus, the Metaverse represents the evolution of an internet of hyperlinks to another based on virtual reality environments. The term *metaverse* received a substantial boost in 2003 when the Second Life (SL) platform came onto the market, which can be considered the first virtual world where a person uses an avatar to enter a parallel universe and experience simulated situations in an alternate world.

At that time, SL became an immersive space where teachers could simulate workplaces such as laboratories and classrooms without walls (Brenen & de la Cerna, 2010; Beaumont et al., 2014) and develop demonstrations, problem-based learning, role-playing, practical exercises, and curricular learning activities (Anacona et al., 2019). The rise of the Metaverse as an option to participate in alternate realities became another convergence between virtually-enhanced physical reality and physically persistent virtual space. That is, digital mirrors of the natural world coexist alongside digital worlds in which interactions, communication, and exchange of information are generated in the internet environment (Collins, 2008). The Metaverse is also described as a set of internet iterations in persistent and shared three-dimensional spaces (Hackl, 2021).

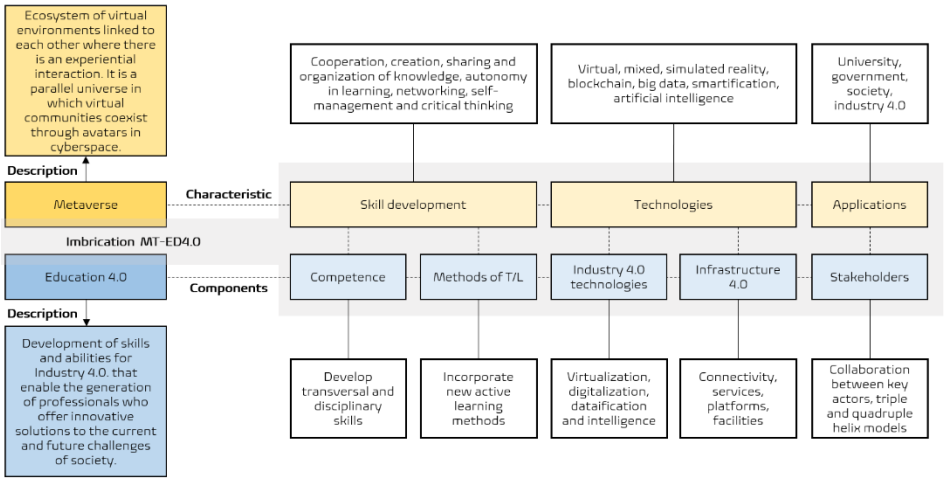
In Education 4.0, the concept of the Metaverse is much broader than using virtual reality glasses and interacting with avatars because it is linked to the needs of Industry 4.0, requiring cooperation, creation, dissemination, knowledge management, and strengthening of complex thinking (García-González & Ramírez-Montoya, 2019; Kipper et al., 2021; Miranda et al., 2021). It is related to learning experiences that use a wide variety of digital tools such as HoloLens, where anatomical models of diseases can be explored with augmented and virtual realities (Stromberga et al., 2021), virtual and augmented reality platforms to build molecular models (Cortés et al., 2022), and gamification experiences in simulated spaces that motivate learning (Park & Kim, 2022).

In the web-based virtual reality (WebVR) environment, the Virtual Campus of Tecnologico de Monterrey stands out as an example; it is an environment specially designed for students to attend classes with their personalized avatars (TecReview, 2021). Thematic sessions and complete courses in the Metaverse have been held in this space (CONECTA, 2021). Additionally, researchers from this university designed and implemented an instrument to assess the acceptance of this tool among teachers and students. This demonstrated that the Metaverse could generate interactive and dynamic learning experiences that strengthen competencies in digital transformation, the reasoning for complexity, social intelligence, and communication (Rocha et al., 2022).

Due to the above, the Metaverse and Education 4.0 overlap to offer added value to the learning processes, thus generating new experiences of digital pedagogy (Abdul Bujang et al., 2020) and dissemination of knowledge in active and hybrid learning ecologies (Vodovozov et al., 2021; Wasilah et al., 2021). In this regard, Ramírez-Montoya et al. (2022b) developed a reference framework to understand the contribution of Education 4.0 in the design of innovative pedagogical strategies. Figure 1 illustrates a first approximation to the already mentioned imbrication.

Figure 1

A first approach to the Metaverse-Education 4.0 imbrication



The arrival of the Metaverse in education means participating in a more disruptive learning environment due to the paradigm change. This implies moving from traditional teaching dynamics such as face-to-face, hybrid or digital modalities mediated by digital content, videoconferences, and educational platforms to a fully immersive 4.0 educational process that requires a change in content delivery formats and improvement in knowledge formation.

Thus, this article aims to present the results of bibliometric research that identifies studies that consider the relationship between the infrastructure, skills, and technologies of Industry 4.0 with stakeholders (interest groups) and teaching methods within the Metaverse. For this, a systematic review of the literature (SRL) was prepared using the SCOPUS and Web of Science (WoS) databases to provide a broad vision and set a horizon for future research.

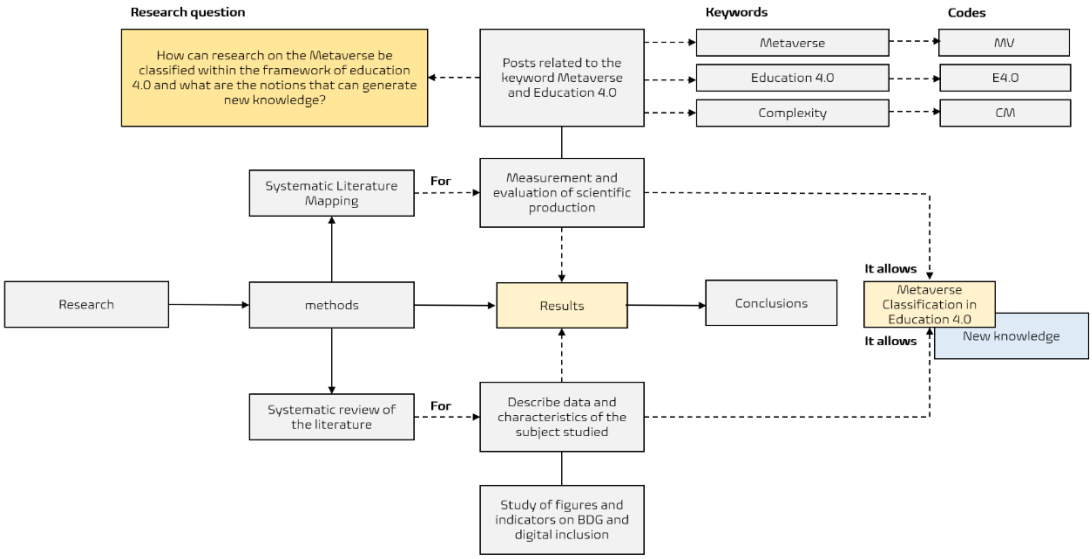
3. Methodology

In this section, the stages and techniques for carrying out SRL are defined to answer the research question: How can research on the Metaverse be classified within the framework of Education 4.0, and what are the notions that can generate new knowledge? The search and selection of literature were carried out in the Scopus and WoS databases to know the contributions of research related to the Metaverse and the components of Education 4.0, its evolution over time, and in this way, analyze the topic from a comprehensive vision of the phenomenon studied (Donthu et al., 2021; Baena et al., 2022). The research is descriptive since it collects information to analyze the social phenomenon of the Metaverse and how it overlaps with Education 4.0 (Shields, 2020). To search for scientific production, we used the term *metaverse* (MV) as a keyword, and Education 4.0 (E4.0) and complexity (CM) were used as contextual terms. They were also searched for in English to guarantee their appearance in the databases. The period covered by the analysis was 2000-2022; the PRISMA method (*Preferred Reporting Items for Systematic Reviews*

and Meta-Analyses) (Page et al., 2021) was used, which consists of two stages: planning and action (Vázquez et al., 2022). Figure 2 shows the strategy used in detail.

Figure 2

The strategy applied to search for information



31. Objective of the SRL

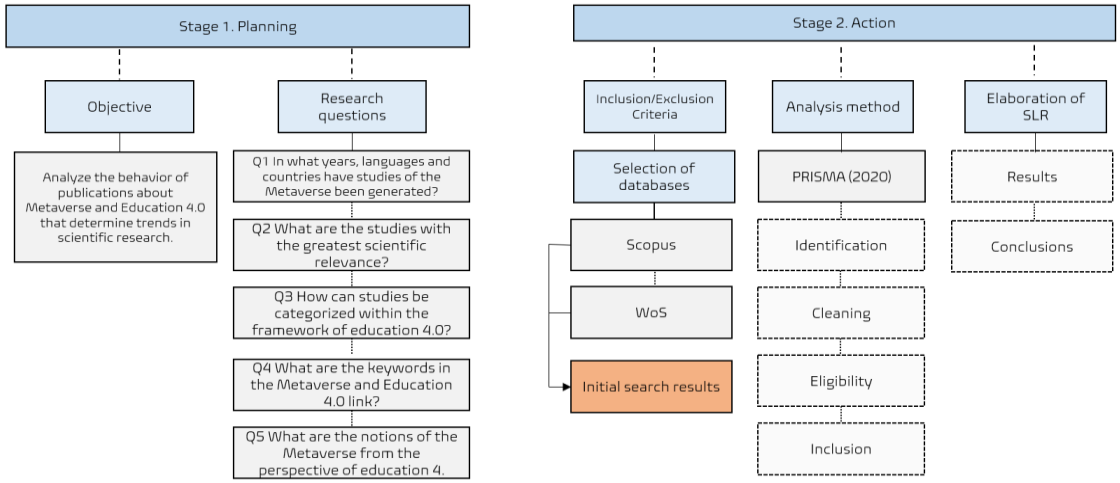
The objective of the SRL was to analyze the behavior of publications focusing on the Metaverse in the reference framework of Education 4.0 to identify their contributions to generating new knowledge.

3.2 Research questions

The research questions were guided by the sense of complexity that the transformation of digital ecosystems implies (García-González & Ramírez-Montoya, 2019; Ramírez-Montoya et al., 2022a). Figure 4 shows the wording of the questions, which guided the analysis, and the planning and action stages of the PRISMA method used.

Figure 3

Steps to carry out the study



3.3 Inclusion criteria and selection of databases

Two databases were chosen to search for and select information: Scopus as the main one and Web of Science (WoS) as its complement. Emphasis was placed on using Scopus because it is considered one of the largest and most prestigious peer-reviewed literature and citation databases (Ball, 2021). The first step in this stage was to search for the selected keywords (MV-E4.0-CM); Table 1 shows the descriptors.

Table 1

Descriptors for the search in databases

Database	Descriptor
Scopus	(TITLE-ABS-KEY ("Metaverse") AND TITLE-ABS-KEY ("Education 4.0") AND TITLE-ABS-KEY ("Complexity"))
Web of Science	("Metaverse") AND ("Education 4.0") AND Complexity

The result was the identification of 390 articles; subsequently, the filtering of the documents was carried out by applying the following inclusion and exclusion criteria:

- Research, scientific dissemination, systematic review of literature, and methodological and meta-analysis documents were included - as well as publications with titles, abstracts, or keywords that contained the keywords MV-E4.0-CM.
- Editorials, errata, and documents not closely related to the subject of study were excluded, as well as publications without a title, abstract, or keywords.

The quality criteria were that they were articles published in the period 2010-2022, with access to the full text, written in English or Spanish, and whose focus was on the study of the Metaverse and whose topics touched on any of the components of Education 4.0.

3.4 Analysis method

The selected analysis method was PRISMA (Page et al., 2021). It consists of identifying and selecting scientific documents, curating by eliminating duplicates, and applying the inclusion, exclusion, and quality criteria. Finally, the abstract was read to include those that were relevant to carry out the quantitative and qualitative analyses. The result was the classification of the documents in one of the categories related to the components of Education 4.0: skills, teaching-learning methods, stakeholders, Industry 4.0, and Infrastructure 4.0.

This generated a total of 232 documents (see Figure 4), which were assigned a sequential numbering and placed in a bibliographic database using Excel software with the following fields: a) author(s), b) title of work, c) year, d) type of document, e) journal or publisher, f) country of the authors, g) institutions or organizations, h) DOI, i) bibliographic data in APA style, j) abstracts, k) keywords, l) language and m) type of access.

Figure 4

Application of the PRISMA method for the preparation of the study.

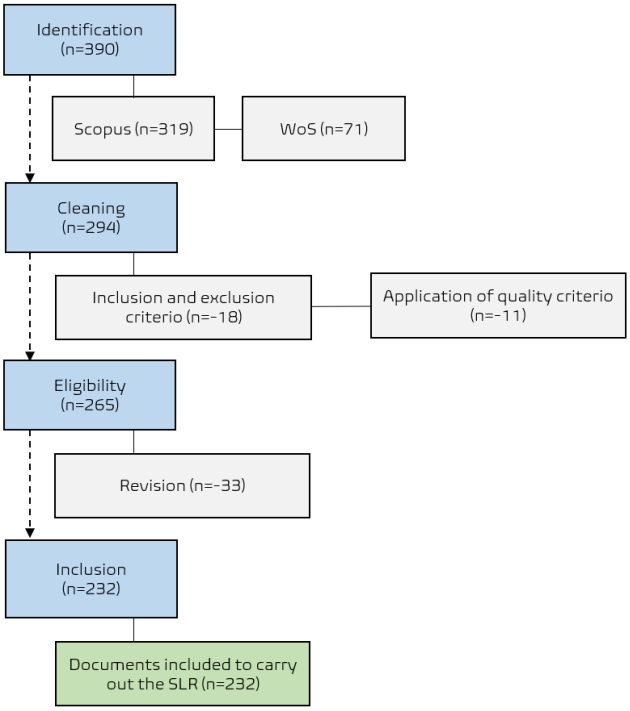
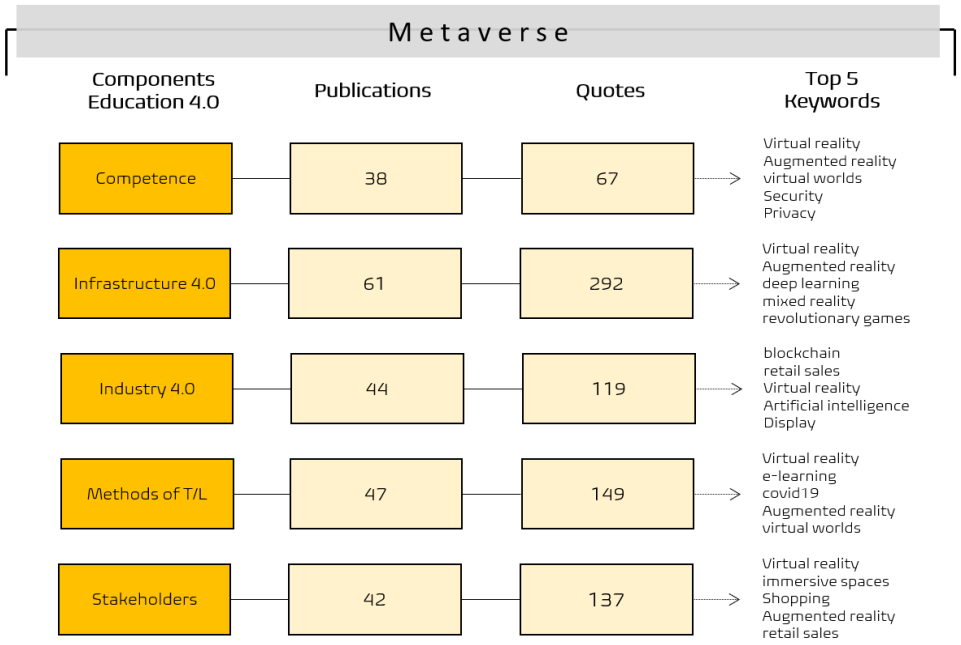


Figure 5

Classification of MV in the environment of E4.0



3. Analysis and results

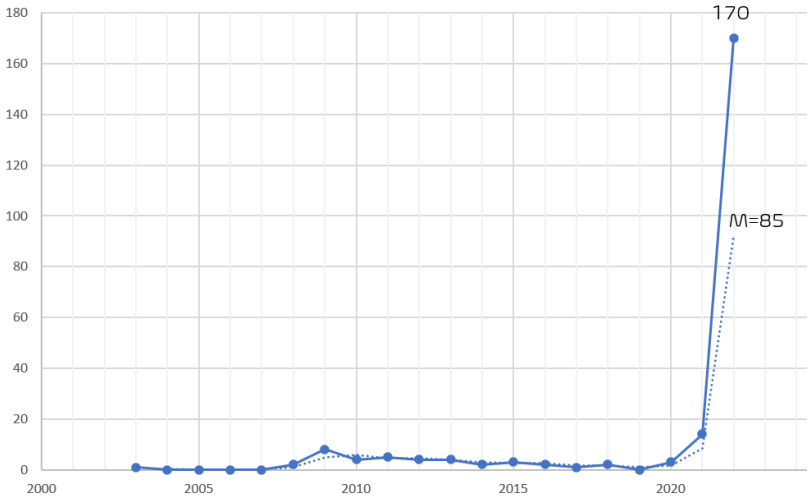
Below is a panoramic analysis of the publications found and how they were classified according to their content related to Education 4.0, the number of citations, and the keywords that appear most frequently. Figure 5 shows that the Metaverse has had more impact on the scientific production related to Infrastructure 4.0, with 61 publications and 292 citations. The keywords *virtual reality*, *augmented reality*, *deep learning*, *mixed reality*, and *innovative games* are associated with these publications, which shows that knowledge about the Metaverse is focused on exploring technological trends that have managed to be incorporated into education and industry. The most frequent words were *virtual* and *augmented reality*, *digital security*, and *retail sales*.

3.1. Q1 In what years, what languages, and which countries have researched the Metaverse?

Figure 6 shows that scientific production increased in 2022 with 170 publications, representing 156 more than the previous year (14 documents). Two factors can explain this: the first is related to the increase in strategies to use disruptive tools to give continuity to school and work activities in digital environments due to the transition from face-to-face to distance attendance caused by the Covid19 pandemic. (Rocha et al., 2022). The second one is due to the media coverage that the creation of Meta by Mark Zuckerberg garnered (Fernandez, 2022), which implies the use and dissemination of virtual reality environments to position products and services in social networks (Kraus et al., 2022), and education (Akgül & Uymaz, 2022).

Figure 6

Scientific production by year of publication



Regarding languages, most of the publications were in English (215), followed by Chinese (6), Korean and Spanish (2), and finally, Japanese and Portuguese (1). Regarding the contribution by country, Figure 7 shows that 59 countries contributed to scientific production, highlighting the United States of America as the largest producer (66), followed by China (53), South Korea (41), Great Britain (36), and Japan (23). The Ibero-American country with the highest production was Spain (1).

Figure 7

Scientific production by country

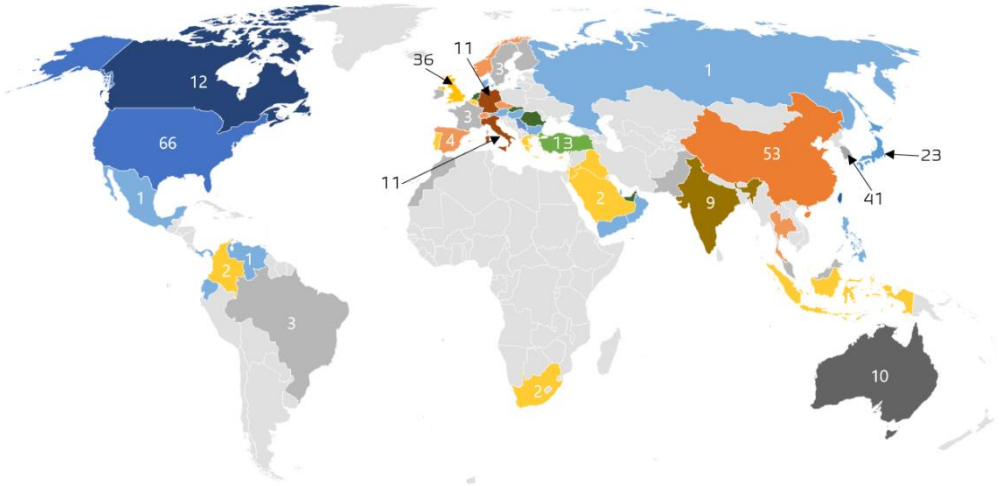
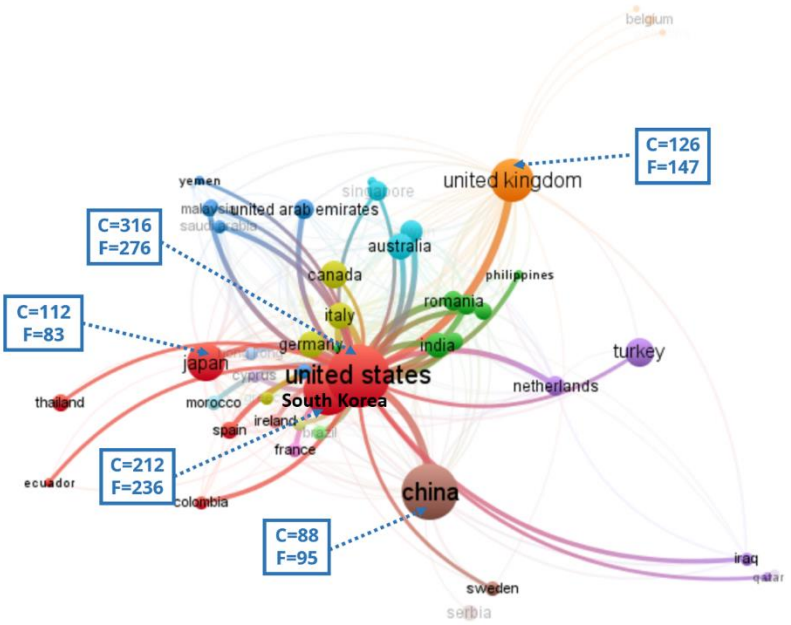


Figure 8 shows the collaboration structure of the papers; as can be seen, the closest relationship is between researchers from the United States of America (316 citations and a

link strength of 276) and Korea (212 citations and a link strength of 236). Japan is in the same collaboration cluster (112 citations and link strength of 83). Similarly, it can be seen that the works from the United Kingdom (126 citations and a link strength of 147) have fewer ties with the countries mentioned above since their production is more closely related to Belgium, Iraq, Yemen, Malaysia, and Saudi Arabia, among others.

Figure 8

Scientific collaboration by country



3.2. Q2 What are the most scientifically relevant studies?

The documents with the highest frequency of publication were articles (138), followed by conference papers (86), and finally, book chapters (6). Regarding relevance, Table 2 shows that the journals and conferences had the highest citations. The information was classified according to the components of Education 4.0 (E4.0): Infrastructure 4.0 (IFR), Industry 4.0 (IND), Stakeholders (ST), Competencies (CT), and Teaching and learning methods (MTE).

The best-positioned article on the list is called *3D Virtual Worlds and the Metaverse: Current Status and Future Possibilities*; it has been cited 62 times in 2022, that is, more than twice as many as cited from its publication in 2013 (53), which indicates that it has become a benchmark for various researchers. It explores four dimensions attributable to the Metaverse: immersive realism, ubiquity of access and identity, interoperability and scalability, and the link with E4.0 from the digital infrastructure and industry.

Table 2

Documents with greater scientific relevance

Title	E4.0	Year	Magazine / Conference	Citations	Type
3D virtual worlds and the Metaverse: Current status and future possibilities	IFR	2013	ACM Computing Surveys	115	Article
A content service deployment plan for metaverse museum exhibitions - Centering on the combination of beacons and HMDs	ST	2017	International Journal of Information Management	51	Article
A Metaverse: Taxonomy, Components, Applications, and Open Challenges	IFR	2022	IEEE Access	55	Conference Paper
Metaverse for Social Good: A University Campus Prototype	IFR	2021	MM 2021 - Proceedings of the 29th ACM International Conference on Multimedia	45	Conference Paper
Retail spatial evolution: Paving the way from traditional to Metaverse retailing	IND	2009	Electronic Commerce Research	43	Article
The Metaverse - A networked collection of inexpensive, self-configuring, immersive environments	IFR	2003	Proceedings of the Workshop on Virtual Environments, EGVE'03	27	Conference Paper
The challenges of entering the Metaverse: An experiment on the effect of extended reality on workload	IND	2022	Information Systems Frontiers	20	Article
The Social Metaverse: Battle for Privacy	CT	2018	IEEE Technology and Society Magazine	16	Article
Toward an aircraft maintenance metaverse using speech interactions with virtual objects in mixed reality	IND	2021	Sensors	16	Article
Evaluation of students' learning style using an eye-blinking system in Metaverse	MTE	2015	Procedia Computer Science	15	Conference Paper

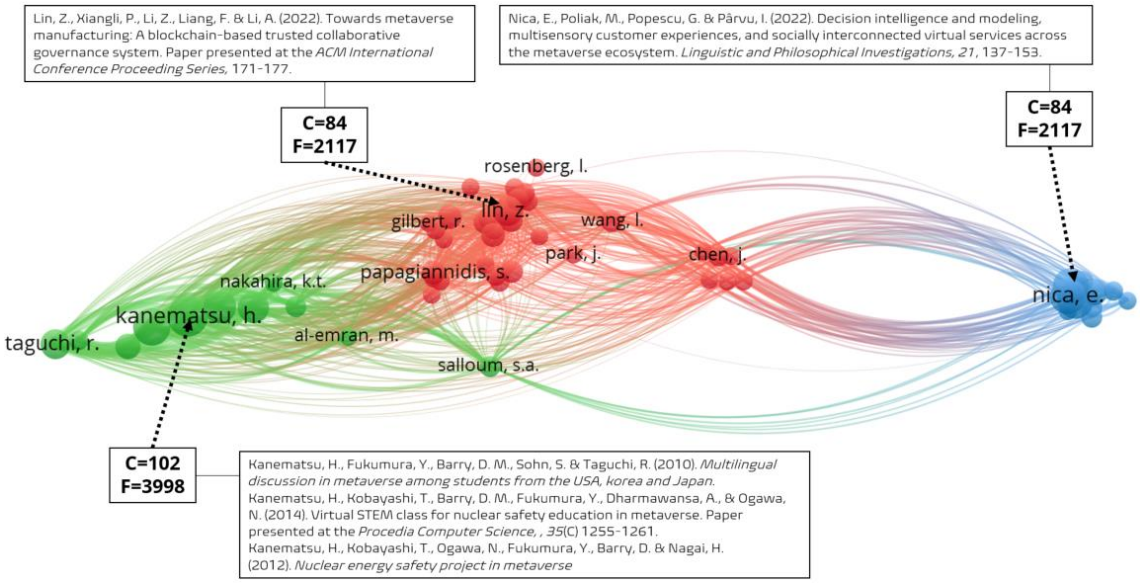
On the other hand, the conference document *A Metaverse: Taxonomy, Components, Applications, and Open Challenges,* has been cited 55 times in the same year of its publication (2022). This indicates that it has high relevance in the scientific field, in particular, because of the subject it addresses. It redefines the Metaverse based on hardware, software, and content evolution. It also touches upon the interaction with the user, implementation, and application.

Regarding the author's relevance, Figure 8 shows a co-citation analysis of the leading researchers. The results show that at least three authors have collaborated in developing the theoretical foundations on the topic of study. It can be seen that the work *Decision Intelligence and Modeling, Multisensory Customer Experiences, and Socially Interconnected Virtual Services across the Metaverse Ecosystem* by Elvira Nica (Nica et al., 2022) has

served as a bridge for collaboration in works such as *Multimedia Research towards the Metaverse* (Cheng. 2022) and *A survey on Metaverse: Fundamentals, Security, and Privacy* (Wang et al., 2022).

Figure 9

Scientific collaboration by author



3.3 Q3 How can studies be categorized within the framework of Education 4.0?

Classification focused on the components of Education 4.0 was elaborated (see Table 3). Regarding the skills, it is stated that one of the challenges of the Metaverse is to enable students to cultivate cybersecurity strategies that allow healthy interaction in virtual settings. On the other hand, the term *immersive netnography* was constructed to study augmented and virtual reality experiences from the qualitative-phenomenological approach.

Industry 4.0 is related to the Metaverse from the perspective of the evolution of retail sales spaces, which are beginning to move from exhibition spaces in physical environments to virtual worlds in which it is possible to have a realistic vision of the products and services offered by different types of distributors. It is also stated that the Metaverse increasingly facilitates work, education, health, consumption, and entertainment.

Regarding Infrastructure 4.0, the most important studies focus on the design and development of virtual campuses and the challenges and possibilities of incorporating extended realities in educational spaces. The previous component is closely related to the teaching-learning methodologies that investigate delivery and evaluation formats related to STEM (Science, Technology, Engineering, and Mathematics) strategies and the use of biometric systems to measure student attention.

Finally, regarding the stakeholders, studies including the Metaverse consider implementing content for different types of display of services based on virtual, mixed, and augmented reality, as well as evaluating the quality of the service offered by retailers. While research done in 2022 emphasizes consumer experience analysis, it also explores incorporating society and government into metaverse experiences.

Table 3

Categorization of metaverse studies in the components of Education 4.0

E4.0	Authors	Title	Journal	Citations	Universities
	Falchuk, Loeb & Neff (2018)	The Social Metaverse: Battle for Privacy	IEEE Technology and Society Magazine	16	Vencore Labs NJ, Open Ventures LLC.NJ, InterDigital Inc.
CT	Kozinets (2022)	Immersive netnography: a novel method for service experience research in virtual reality, augmented reality, and metaverse contexts	Journal of Service Management	11	University of Southern California
	Zyda (2022)	Let's Rename Everything 'the Metaverse!'	Computer	8	University of Southern California
	Bourlakis & Papagiannidis (2009)	Retail spatial evolution: Paving the way from traditional to Metaverse retailing	Electronic Commerce Research	43	Brunel University, Newcastle University.
IND	Xi et al. (2022)	The challenges of entering the Metaverse: An experiment on the effect of extended reality on workload	Information Systems Frontiers	20	Tampere University, University of Vaasa, Anhui University of Finance and Economics, Technical University of Berlin
	Siyaev & Jo (2021)	Towards aircraft maintenance metaverse using speech interactions with virtual objects in mixed reality	Sensors	16	Inha University
	Dionisio, Burns & Gilbert (2013)	3D virtual worlds and the Metaverse: Current status and future possibilities	ACM Computing Surveys	108	Loyola Marymount University.
IFR	Park & Kim (2022)	A Metaverse: Taxonomy, Components, Applications, and Open Challenges	IEEE Access	48	Korea University, Sejong University.
	Duan, Li, Fan, Lin, Wu & Cai (2021)	Metaverse for Social Good: A University Campus Prototype	MM 2021 - Proceedings of the 29th ACM International Conference on Multimedia	45	The Chinese University of Hong Kong.
	Barry et al. (2015)	Evaluation of students' learning manner using the eye blinking system in Metaverse	Procedia Computer Science	15	Clarkson University, Gifu College, Nagaoka University of Technology, National Institute of Technology, Nagaoka University of Technology, Sendai College, Tsuyama College, Japan
MTE	Kanematsu et al. (2014)	Virtual STEM class for nuclear safety education in Metaverse	Procedia Computer Science	15	Suzuka National College of Technology, Nagaoka University of Technology, Gifu National College of Technology.
	Kanematsu et al. (2012).	Nuclear Energy Safety Project in Metaverse	Smart Innovation, Systems, and Technologies	15	Suzuka National College of Technology, Tsuyama National College of Technology, Gifu National College of Technology, Nagaoka University of Technology, Clarkson University.
ST	Choi & Kim (2017)	A content service deployment plan for metaverse museum exhibitions—Centering on the combination of beacons and HMDs	International Journal of Information Management	51	Sangmyung University.

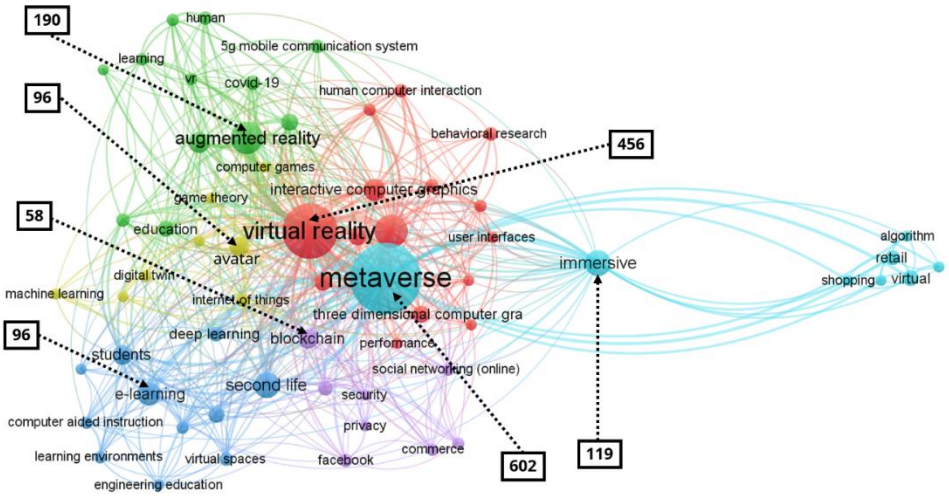
Gadalla, Keeling & Abosag (2013)	Metaverse-retail service quality: A future framework for retail service quality in the 3D internet	Journal of Marketing Management	14	University of Manchester
Han, Bergs & Moorhouse (2022)	Virtual reality consumer experience escapes: preparing for the Metaverse	Virtual Reality	14	Breda University of Applied Sciences, Zuyd University of Applied Sciences, Manchester Metropolitan University.

3.4 Q4 What are the keywords in the Metaverse and Education 4.0 link?

The analysis carried out identified the keywords, which are shown in Figure 11. Four terms with correlation stand out: metaverse (frequency=602), virtual reality (frequency=456), augmented reality (frequency=190), and immersion (frequency =119). There is a remarkable dispersion between immersive spaces and the application of the Metaverse with the design of algorithms, purchases, and retail sales in virtual environments.

Figure 10

Scientific collaboration by country



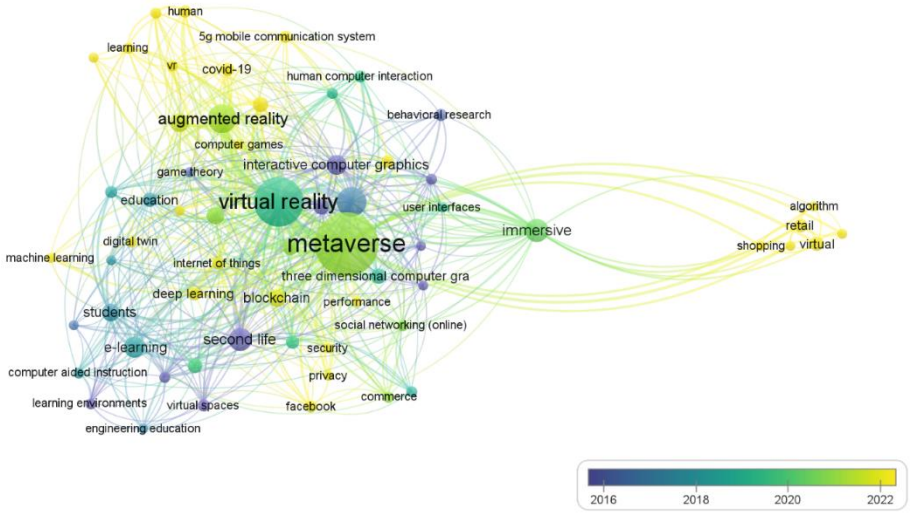
Regarding virtual reality, most research focuses on behavioral research and the human-computer relationship. Augmented reality is linked to the evolution of 5G communication systems and learning in the environment of the Covid19 pandemic. An emerging correlation between the blockchain and privacy and security issues on the internet can be found.

Finally, Figure 12 shows the frequency of the keywords over time. It is observed that the Metaverse evolved from the first practices carried out in the *Second Life* environment, the design of the first accessible virtual spaces, and the creation of digital learning environments. As of 2020, the study of the Metaverse begins to correlate with Education 4.0 technologies such as virtual reality, augmented reality, immersive environments, and e-learning. Figure 9 also shows that research generated in 2022 explores topics related to COVID-19, 5G technologies, deep learning, blockchain, machine learning, security, and

privacy in media such as Facebook, and the correlation with stakeholders dedicated to developing algorithms to direct purchase offers and retail sales in immersive ecosystems.

Figure 11

Keywords temporal frequency



3.5 Q5 What are the notions of the Metaverse from the perspective of Education 4.0?

The Metaverse and its involvement with Education 4.0 focus on formulating proposals that address complex schemes of interaction, collaboration, management, and critical thinking based on the development of active and hybrid methodologies, competencies, and infrastructures to support learning. The MV-E4.0 imbrication finds its space in environments mediated by extended environments such as virtual, augmented, and mixed reality, where people interact in a simulated but realistic way, both among themselves and with objects and three-dimensional spaces.

The notion arising from the MV-E4.0 imbrication provokes more than definitions that explain how the Metaverse is being incorporated into each component of Education 4.0. It creates questions that can guide future studies as complex as the evolution of digital transformations that cause the emergence of new industrial revolutions.

To conclude with the results of this study, Table 4 includes questions that intend to guide future and independent studies related to skills, industries, and Infrastructure 4.0, as well as teaching-learning methodologies and the contributions of groups interested in strengthening the implications of the Metaverse in society.

Table 4

Notions of nesting MV-E4.0

4.0 Focus	Notions
CT	What learning, academic, and digital literacy 4.0 competencies enable people to safely and successfully participate in the Metaverse?
IND	How can new forms of telepresence be built from Industry 4.0 to streamline work, education, health, consumption, and entertainment by reducing the operating costs of virtual and augmented reality?
IFR	What 4.0 technologies must be developed to move from a set of independent virtual worlds to an integrated network of virtual worlds or metaverses that generate immersive realism, the ubiquity of access and identity, interoperability, and scalability?
MTE	What educational purposes should the Metaverse pursue to develop teaching and learning methodologies that provoke an understanding on the part of teachers and students that allows building active pedagogies?
ST	How, through governance, academia, industry, and society, can immersive experiences that provide multidirectional information and content delivery services in virtual worlds be designed, developed, implemented, and evaluated?

4. Discussion

The scenarios analyzed to understand the interest in studying metaverses are increasingly frequent and have significantly risen in the last two years. Figure 6 shows a clear interest in the subject from 2022, which coincides with the transformations of leading companies in developing social technology, such as Facebook. Unlike other studies regarding the use of technologies in general (Cabero & Martínez, 2019), the Metaverse is made up of disruptive technologies that, when they mature, allow the creation of suitable scenarios that meet the demands of Education 4.0.

This research recognizes no geographical area in which scientific production regarding the Metaverse predominates. Figure 7 shows close collaboration between geographically dispersed countries such as the United States of America and South Korea. This denotes a topic of interest transcending borders and is not explicitly concentrated in any geographic region.

On the other hand, studies about the Metaverse allude to the transition from face-to-face to virtual scenarios due to the expansion of COVID-19 and the importance of formulating appropriate strategies to face the challenges that the pandemic established (Darling & Hyler, 2020). In response to this, tools and experiences were created worldwide that facilitated the distance learning process, marking the acceleration of the use of digital tools of Education 4.0 that shaped a more complex scenario, such as the Metaverse.

During the development of the article, an overview was established that clarifies the Metaverse-Education 4.0 imbrication in its current path. It found that the different disruptive tools typical of Education 4.0 allow iteration and necessary conditions for the Metaverse to be possible, such as the development of indispensable technologies like augmented reality and the concept of immersion. In this sense, it was possible to identify that an immersive virtual environment is an adequate definition for understanding the Metaverse; however, terms such as algorithmic design also emerged.

5. Conclusions

Digitalization has created spaces for people's interactions. These new scenarios, unimaginable until recently, have allowed the construction of various types of relationships, forms of interaction, and the construction of imaginaries and social representations. This new parallel reality (which can become an opportunity for educational teaching) requires a unique perspective, where traditional educational limits are broken down, to learn the reality that provides alternative solutions to changing environments. In this sense, the Metaverse can bring technology closer to learning environments to reduce the digital gap between schools and society. This article's objective focused on analyzing the Metaverse literature as an alternative scenario of digital interaction.

The study started with the question regarding how to classify research studies about the Metaverse in the framework of Education 4.0 and the notions that could generate new knowledge. Like any new social phenomenon, it is necessary to document possible potentialities, the effects, and the impact on the various application environments to project alternatives that seek better benefits.

The results showed an overall growth in publications since 2022, demonstrating that digital environments are part of daily life in various political, social, cultural, and economic aspects. Specifically, in the financial aspect, there is a significant increase in marketing since the Metaverse has become an essential vehicle in new ways of offering products and their consequent consumption. The results highlight a predominance of the use of the Metaverse in algorithm design and retail sales.

The new spaces' imprint has increased communication among various communities, demonstrating strong collaboration on 4.0 infrastructure among researchers from the United States of America, South Korea, China, the United Kingdom, and Japan. The Metaverse has become another space for interactions among people beyond communications. This has transformed "artificial" digital spaces into "almost real" scenarios based on interaction characteristics, with immersive and augmented realities and the design of avatars and their application as an e-learning strategy.

The implications for educational practice are linked to interest in academia because of its impact on knowledge of emerging technologies and the evolution of digital ecosystems. In particular, 4.0 education environments promote the development of skills based on new strategies and infrastructures, which lead to the configuration of digital learning spaces, both at school and in work environments, and the interaction of families. The implications for innovative educational research include the ability to analyze a phenomenon from diverse perspectives, mega, macro, and micro, according to the focus of the study.

The limitations of this research could be subjecting the literature analysis to only two indexing systems (Scopus and Web of Science), which, although they are considered to have the most bibliometric breadth, other sources with valuable literature might have been omitted. Future studies should expand the search chain in these other systems and address the analysis from various questions that broaden the knowledge of the Metaverse and its potential. With this writing, an invitation goes out to continue analyzing the possibilities to improve diversity in learning and educational environments, enriching the options that open new ways of more democratic digital constructions.

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