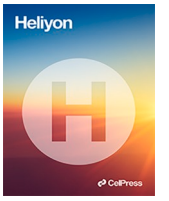
Heliyon 10 (2024) e31271

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Review article

Understanding the knowledge structure and the value creation process of the metaverse

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ARTICLE INFO

Keywords:
Metaverse
Pioneering research
Co-word analysis
Value-creation
Smartization

ABSTRACT

The metaverse is a digital space that empowers users to interact socially, using new and specific technologies, to generate value and co-create experiences. This paper provides a framework for organising the themes discussed in pioneering literature. An adaptation of the PRISMA process was used to explain the methodology applied. The results showed that more than 84 % of studies on the metaverse have been published since 2020. Technologies such as augmented reality and artificial intelligence are positioned as the basic themes, and decision-making and human-machine interface are emerging themes. This paper constitutes an original contribution as it also presents the highlights and structure of the main themes on metaverse. Additionally, it develops an analytical framework for understanding the metaverse value creation. Therefore, this paper represents a starting point for a reflection on the applications of the metaverse that can contribute to the achievement of productive and valuable progress in various fields of research.

1. Introduction

The metaverse is an attractive topic that in recent years has been a revolution [1]. The metaverse adds a virtual environment to the real world that has important social, cultural and economic effects [1–3]. In this virtual environment, many of the activities of our daily lives can be carried out in parallel [4]. However, the metaverse also has many faces that are being revealed as its utilities and applications evolve with the use of new technologies such as artificial intelligence, Big Data and mixed reality [5]. Technologies related to the metaverse lead to a redefinition of its concept [6,7]. This leads to a paradox as the more information we have, the more confusion there is about this parallel world [8].

Both lay people and academics are wondering whether there is a new social paradigm with the metaverse or whether it is a fad, and there are positions for and against it [8]. In the academic context, in recent years there has been a great growth in the literature on this topic. The literature on metaverse is very current. It can be observed that pioneers in this topic have conducted studies to mainly define and delimit the concept [3], explore its technologies [5] and its applications in topics such as education [e.g., [9–11]], business management [12,13] marketing [14,15], journalism [16], the fashion industry [17] or sustainable development [18].

The technological basis of the metaverse has led to the evolution of its delimitation [3] and the first published papers are key to understanding this phenomenon. This is evidenced by the literature reviews that have been published in recent years, especially in

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https://doi.org/10.1016/j.heliyon.2024.e31271
Received 5 April 2023; Received in revised form 9 May 2024; Accepted 14 May 2024
Available online 14 May 2024

2023 and 2024. Most of these works analyse the literature prior to 2023, i.e. the origins of the metaverse research.

Literature reviews have analysed topics such as the metaverse concept [e.g., [3,7]], its technologies [e.g., [1,5]], its applications [e.g., [19]] or the key factors for its adoption [4].

Among them, we highlight the work of Wider et al. [19] that use a co-citation analysis to look at past and current trends in the metaverse and a co-word analysis to look at emerging trends. From these analyses they identify several clusters but do not make a comprehensive analysis to propose a logical and ordered structure of the themes studied in the previous literature. Shen et al. [7], using Scopus in previous studies published up to 2021, analyse the keywords and group them into three clusters, but they do not go beyond the point of leaving them open without connecting them or giving them a structure for their understanding. On the other hand, Dhingra [4] proposes a "Technology Acceptance Model" (TAM), based on a review of the metaverse literature, with four dimensions: Theories, Contexts, Methods and Characteristics, but they do not consider the effects that their adoption may have such as value creation.

Wider et al. [19] state as limitations of their work that only the Web of Science -WoS- database has been used and that other databases such as Scopus may produce different results. Wider et al. [19] propose as future lines of research the use of other databases and complementary methodologies to carry out qualitative studies that help to delve deeper into the specific aspects of metaverse. Wider et al. [19] also propose the need for a holistic understanding of the implications of the metaverse and to guide its development.

The metaverse is a revolution not only because of its vertiginous advance, but also because with it the delimitation of the concept is changing. For this reason, the pioneering studies are fundamental to understand the surprising growth of studies on this subject. Faced with such a novel and complex subject to understand, it is important to give order to the revolution that the metaverse represents and it can be of great help to offer a logical framework of analysis.

The main objective is to provide a framework for organising the main themes discussed in pioneering literature. The primary research question addressed is What is the knowledge structure of pioneering metaverse research?

To answer this question, the next section presents the background. In the third section, the PRISMA process is adapted to explain the methodology applied. The fourth section presents the results, and the fifth section develops a discussion. The final section shows the conclusions.

This study fills some of these gaps by complementing the results obtained in the works of Dhingra [4], Shen et al. [7] and Wider et al. [19]. The Scopus database was used, a review of the pioneering literature on the metaverse was conducted and a combination of qualitative techniques was employed. A reflexive process has been undertaken which has allowed us to go beyond the past, present and emerging themes found from the co-word analysis. A comprehensive analysis has been carried out which has allowed us to propose a logical relationship of the themes, giving structure to the original literature on the metaverse. This paper takes another step further than previous papers, that is, to include the effects of the metaverse. To this end, a five-step process for value creation is proposed, which is a useful tool in academic, practical, professional and social contexts.

This paper constitutes an original contribution as it also presents the highlights and structure of the main themes developed in the pioneering literature on metaverse. On the other hand, it develops an analytical framework for understanding the metaverse value creation. All in all, this work represents a starting point for a reflection on the applications of the metaverse that can contribute to the achievement of productive and valuable progress in various fields of research.

2. Background

The metaverse is a digital space that empowers users to interact socially, using digital avatars that blend the physical and virtual worlds, to generate value and co-create experiences [20–22]. It opens up the possibility to create and share digital assets with economic value [1]. Users can acquire virtual goods, ranging from virtual land to virtual clothing. The value of products and services in the metaverse is acquired through economic transactions, just as we exchange goods and services in the real world [3].

There are different definitions of metaverse [3]. The vision of a real and a virtual space – a hypothetical "parallel virtual world" that incarnates ways of living and working in virtual cities as an alternative to the smart cities of the future [16]. Human reality has shifted in two parallel paths, the real dimension, and the digital dimension that has evolved into the virtual experience. In physical reality, nature provides, in the digital reality, the return is the information [19]. On the internet of things (IoT), human presence is what provides the required data that empowers social network empires. In this specific data-driven order, the metaverse creates a virtual reality (VR) extension of the digital world [5,19]. The metaverse is often considered an embodied Internet that can create an amplified sense of presence and make online interaction closer to the real world [17].

The goal of the metaverse is to allow users to interact with people worldwide through a virtual environment using 3D avatars while simultaneously providing seamless transactions [5,19,23]. The first appearance of the metaverse as a concept is in Neal Stephenson's science fiction novel, *Snow Crash* (1997), in which humans interact as avatars [4]. The presence of avatars as humans in this unreal world meant a relevant innovation such as the metaverse itself. Nowadays users interact in the virtual environment via their 3D avatar [7]. Unlike pre-existing digital worlds, where individuals are identified by their ID, username and picture, metaverse platforms offer 3D avatars that represent the user and are perceived by other users [1,24]. Given the importance of avatars in the metaverse experience, the function of this profile has been a subject of study in terms of the psychological functioning underlying virtual interactivity and relatedness.

The economic model of the metaverse developed from the previous IoT ecosystem implies an exchange of information and data where the user gains content while the online platforms receive a data and economic return. Every online transaction means data collection for the business that supports the platform [13]. The metaverse replicates this data process, although there are specific issues to be discussed to navigate in a secure environment. When a user navigates in a virtual ecosystem [19], the metaverse empowers an unlimited offer of goods and services, from digital asset creation, trading or experiencing 3D real time music concerts. The user is

expected to spend time and money in the platforms and experiences provided by the metaverse.

Metaverse worlds require the implementation of different laws, and the current laws and regulations need to make implementation adjustments for metaverse worlds [19]. Because the metaverse is controlled by companies, they have substantial power in terms of rules and governance, as well as the monetisation of the virtual economy [3]. Today there is a lack of agreement from the giant leading technology companies (e.g. Meta, Microsoft, NVIDIA, Apple, Roblox, Google, Intel) that have invested in metaverse technologies. Privacy and legislation in terms of user security are uncertain issues in the metaverse. Technological advances and new products push ethical boundaries for the greater good and tend to make things possible without valuing human responsibility. Due to the decentralised nature of the metaverse, each metaverse publisher can monetise and sell this collected data, which is an act that is also difficult to control [25]. Inequality and exploitation are issues to be considered regarding users, as it is expected they will never consolidate enough resources to invest in the metaverse or achieve the same opportunities as the companies in control. On the other hand, companies and investors are also at great risk, as is the economic environment, because the expected financial return is vanishing as there are not enough users for the disproportionate investment surrounding the metaverse.

The metaverse means a world in which the virtual and the real interact and develop together through the social, economic and

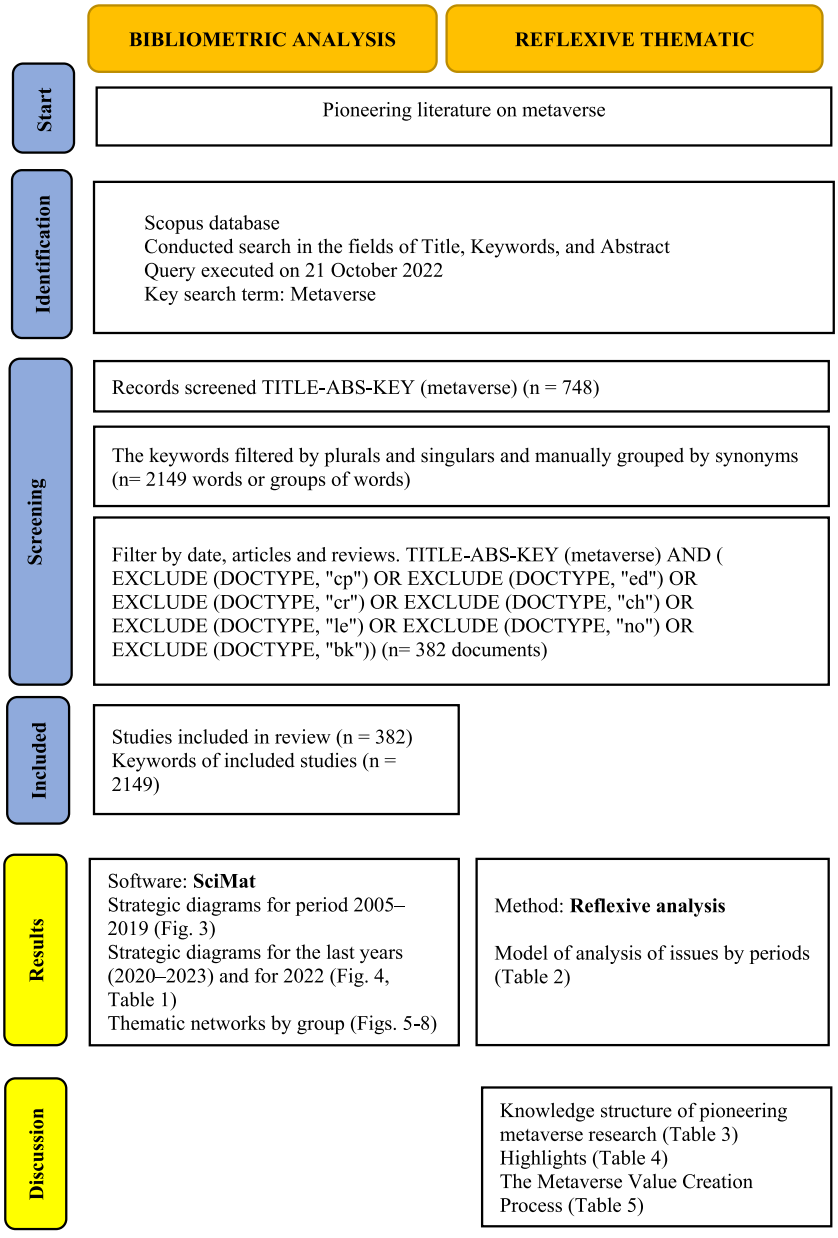

Fig. 1. Methodological process.
Source: own elaboration based on the PRISMA model

cultural activities that are carried out to create entities and value [1,26,27]. Every action within the global platforms that form the metaverse implies a transaction and a mandatory economic return for the investors and creators of this future phenomenon. Thus, while the metaverse has the potential to generate significant profits and growth for companies and investors, it cannot be forgotten that it requires constant investment and consideration of ethical and legal issues to sustain its growth [4].

The metaverse is a complex and evolving reality that is expanding its reach across different technological dimensions. The metaverse does not refer to a specific type of technology but is rather a shift in the way we interact with technology to create a new version of the worldwide web – Web 3.0. One way to understand the metaverse is as a combination of VR and augmented reality (AR) – that is, a combination of the digital and the physical world [5]. However, it is not only these tools that are used to participate in the metaverse. Other spaces in the virtual world, such as Fortnite, which can be accessed through PCs, game consoles or even phones, can be metaverses. Among the technologies being linked to the metaverse are web-based technologies, blockchain technologies, the application of artificial intelligence (AI), human-computer interaction tools and applications in simulation, multi-scale network and collaborative environments [23,28–30].

3. Methods

Fig. 1 illustrates the methodological process used to obtain the sample and the different phases of the study. This process is explained based on the adaptation of authors [31] under the PRISMA model [32]. Firstly, the search was conducted to provide an overview of the most important topics studied in the metaverse. For this purpose, a co-word analysis was carried out. Considering the results obtained in the strategic diagrams and thematic networks, the reflective analysis process presents a knowledge structure of pioneering metaverse research and the main highlights. Then, a reflection process was also carried out to present a five-step process for value creation through metaverse.

To identify the main themes covered in the literature on the metaverse, co-word analysis was used in conjunction with the SciMat program [33]. SciMAT is an open-source software that performs scientific mapping analysis in a longitudinal framework. SciMAT provides different modules that allow to identify the knowledge base from keywords, to analyse the scientific mapping and to visualise the results and maps generated [33]. It thus allows to understand the knowledge structure of a topic or line of research.

To carry out the co-word analysis, a co-occurrence matrix and an association index – namely the equivalence index – were calculated. From these indices, the simple centre clustering algorithm was applied to identify the words that are strongly associated with each other [34,35].

Calculation of centrality and density for each thematic network is suggested [34]. Centrality can be interpreted as a measure of the importance of a topic in the development of a field of knowledge, while density measures the strength of the internal relationships of the network and is a measure of the level of development of that topic. From the centrality and density measures, a strategic diagram can be made. Classification of each thematic network into four groups has been suggested [34]. In the upper right quadrant are represented the themes that are considered motor themes as they have strong centrality and high density. In the upper left quadrant are the themes with well-developed internal linkages but with low relevance externally, i.e., the well-developed and isolated themes. Themes in the lower left quadrant are underdeveloped representing, especially emerging themes. Themes in the lower right quadrant are important but underdeveloped and are considered basic themes.

Finally, for each identified topic, a thematic network can be represented in which the most significant keyword (the one with the highest centrality) is placed in the centre and the size of each node (keyword) represents the number of documents containing the word, while the thickness of the lines indicates the strength of the association between the keywords.

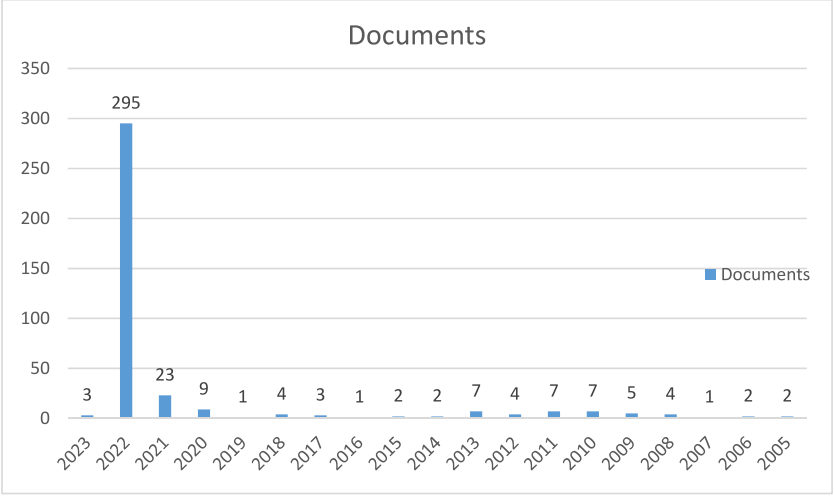

Fig. 2. Sample of documents by year.
Source: own elaboration based on Scopus search

Fig. 2 shows the papers in the sample by year. Metaverse literature is very recent, with 77.23 % of the papers being published in the year 2022, and 86.4 % of the papers published since 2020.

4. Results

This section presents the results of the bibliometric analysis carried out to answer the research question. To identify the knowledge structure of the studied topic, the results of the co-word analysis are presented. Fig. 3 presents the strategic diagram obtained from this analysis for the previous period (2005–2019, 13.61 % of the documents) and Fig. 4 for the most recent period 2020–2023 (86.39 % of the documents).

As shown in Fig. 3, the first papers published focused on VR as a motor theme and analysed issues such as virtual teams and second life. From 2020 onwards, the number of publications on the subject has increased significantly, and the topics have broadened (Fig. 4). The motor themes in recent years have been virtual worlds, 5G mobile communication systems, streaming media and computer games. Mental health, haptic interfaces and retail are also well-developed themes. Learning and technologies such as AR and AI are positioned among the basic themes. Finally, emerging themes include decision-making, three-dimensional computer graphics and human-machine interface (HMI) (Table 1). In 2022 (Fig. 3), when most of the papers were published, streaming media, 5G mobile communication systems and interactive computer-systems were the motor themes, and decision-making, three-dimensional computer graphics and digital twin were the emerging themes (Table 1).

Based on the themes identified in Fig. 4, a model of analysis can be proposed (Table 2). As can be seen, the aspects developed in the literature can be grouped into four blocks: the context (where it is framed), the technologies being used, the main sectors in which their application has been studied and the purposes (what for).

In terms of context, the recent literature has studied the metaverse associated with virtual worlds and considering haptic interfaces and HMI. Moreover, three-dimensional computer graphics, 5G mobile communication systems and streaming media are drawing more attention. It is important to highlight the virtual world network in all the studies (Fig. 5). The real world is combined with VR to shape the metaverse, and in this world the avatars and digital devices appear that are necessary to use interactive computer systems. The main application studied has been their role in learning, analysing aspects such as e-learning, teaching learning process, mobile learning and education computing.

Studies on the metaverse have also taken into account the application of the technologies necessary for its development. In particular, AI, AR, machine learning and digital twin have been analysed. Fig. 6 illustrates the network for AI, and its application in cyber world and IoT contexts together with big data are highlights, although it is also combined with machine learning, digital twin and blockchain. One of the fields in which it has been applied is telemedicine.

In Fig. 6, we can see the thematic network for AR in which the application to gender, consumer experience, education and training and social connection issues is striking. In addition, AR has been related to the other reality modalities, such as VR, extended and mixed reality.

The sectors that have been studied the most are retail and health. Fig. 7 shows the thematic network for the retail sector, in which aspects such as sales and customers are analysed, as well as the algorithms developed to apply the metaverse world to this sector and its

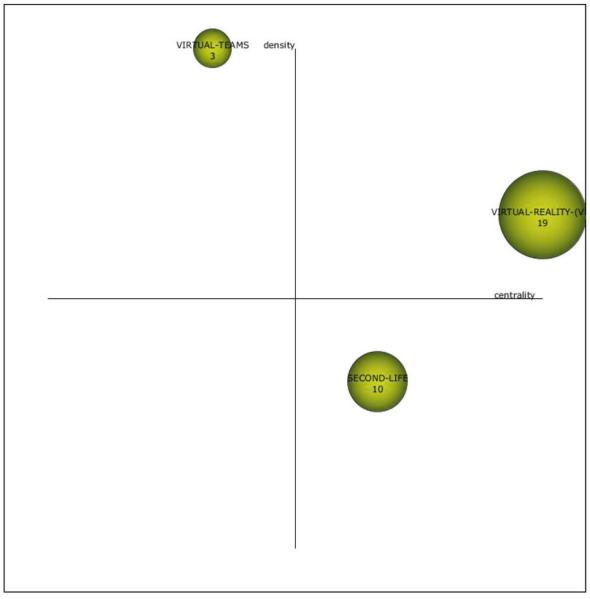

Fig. 3. Strategic diagram by number of documents, 2005–2019.
Source: results from SciMat

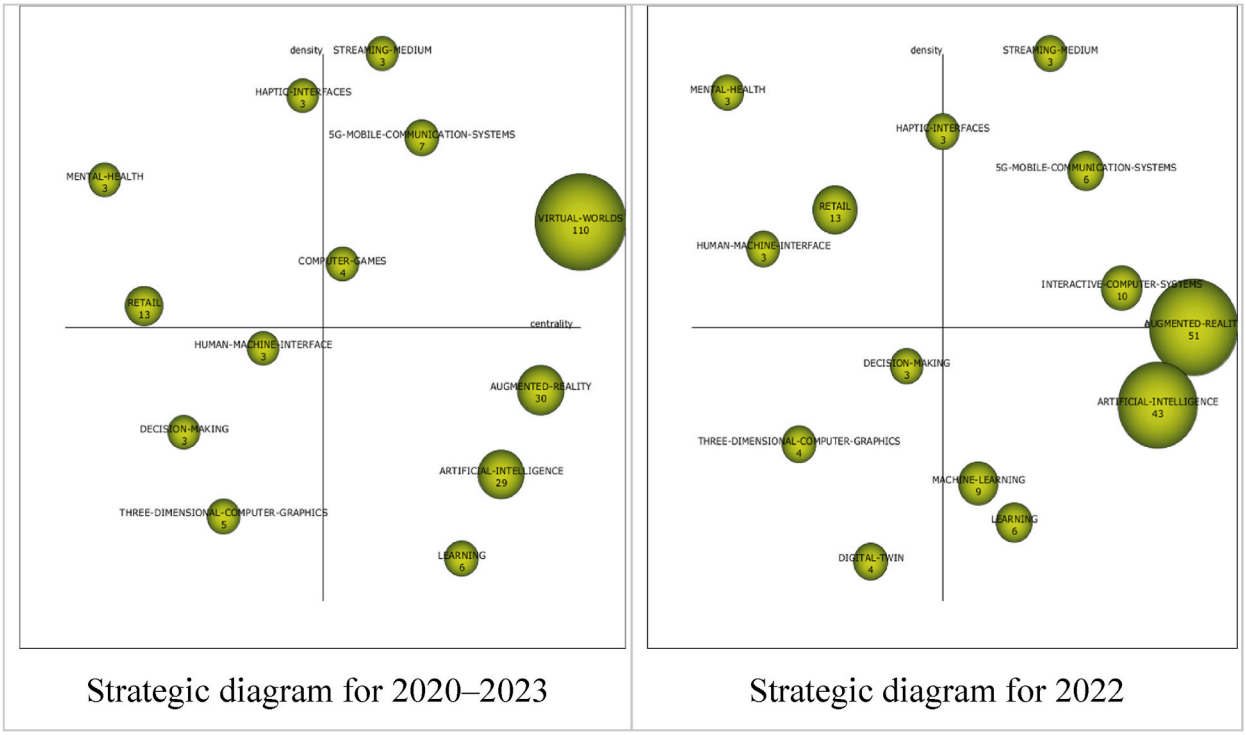

Fig. 4. Strategic diagrams by number of documents for recent years (2020–2023) and for 2022.
Source: results from SciMat

Table 1
Thematic group types for recent years (2020–2023) and for 2022.

Thematic group	Theme type (2020–2023)	Theme Type (2022)
Virtual worlds	Motor	–
5G mobile communication systems	Motor	Motor
Streaming media	Motor	Motor
Computer games	Motor	–
Interactive computer systems	–	Motor
Haptic interfaces	Well-developed	Motor to well-developed
Mental health	Well-developed	Well-developed
Retail	Well-developed	Well-developed
Augmented reality	Basic	Motor to basic
Artificial intelligence	Basic	Basic
Learning	Basic	Basic
Machine learning	–	Basic
Human-machine interface	Emerging	Well-developed
Decision-making	Emerging	Emerging
Three-dimensional computer graphics	Emerging	Emerging
Digital twin	–	Emerging

Source: own elaboration

visualisation.

For the health sector, the application of the metaverse has targeted the mental health sector, in which quantitative analyses and the application of the metaverse in exposure therapies through VR stand out (Fig. 7).

Regarding the utilities of the metaverse, we can highlight its role in decision-making and learning (Fig. 8). In decision-making processes, the metaverse can have applications for making multi-criteria decisions on sustainable development issues. It has also been applied to improve learning processes, especially during the pandemic, with the use of both developed and emerging technologies and a special focus on the field of education and the study of sustainability.

5. Discussion

A discussion based on the results obtained are presented. To facilitate this discussion, a process of reflection and analysis was first

Table 2
Model of analysis of issues by period.

	2020–2023	2022
Contexts	Virtual worlds	Interactive computer systems
	Haptic interfaces	Haptic interfaces
	Human-machine interface	Human-machine interface
	Three-dimensional computer graphics	Three-dimensional computer graphics
	5G mobile communication-systems	5G mobile communication systems
	Streaming media	Streaming media
Technologies	Artificial intelligence	Artificial intelligence
	Augmented reality	Augmented reality
	–	Machine learning
	–	Digital twin
Application sectors	Retail	Retail
	Mental health	Mental health
Purposes	Learning	Learning
	Decision-making	Decision-making
	Computer games	–

Source: own elaboration

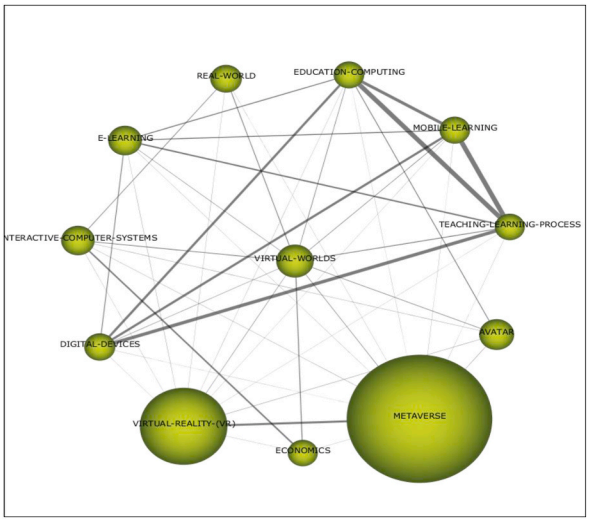

Fig. 5. Thematic network for virtual worlds.
Source: results from SciMat

carried out to logically group the identified themes. Table 3 shows the grouping discussed below to establish a knowledge structure of pioneering metaverse research. In addition, from this discussion, two further steps have been taken. One to present the highlights from pioneering metaverse research (Table 4) and the other to propose a five-step process for value creation through metaverse (Table 5).

These analyses, which are set out in Tables 3–5, complement the results obtained in previous literature review studies. Wider et al. [19] identify several thematic clusters. From co-citation analysis they propose four clusters: Metaverse Development, opportunities and challenges; Role of technology in shaping contemporary business practices; User experience and interaction design in immersive technologies; and Metaverse-enhanced education and its applications. From a word analysis they present five more: Technology-driven Education Transformation; The Future of Smart Cities; Digital Revolution in the COVID-19 Era; Metaverse Ecosystem and Extended Reality (XR) Technologies. However, this paper does not make a logical and structured proposal of the identified themes and does not consider the value creation of the metaverse among them.

Shen et al. [7] review the literature included in Scopus until 2021 and analyse the keywords, which are grouped into three clusters, but they do not connect them nor is a logical structure provided for their understanding. Additionally, Dhingra [4] conducts a systematic literature review in WoS and Scopus to study metaverse adoption and proposes a Technology Acceptance Model (TAM) with four dimensions: Theories, Contexts, Methods and Features, but does not consider the effects or value creation that adoption may entail.

Table 3 summarises the topics studied by type and level of development. In terms of the context in which the metaverse has been applied, haptic interfaces stand out as a theme already well-developed in the literature, while the motor themes are its application in virtual worlds and streaming and the use of 5G mobile communication systems and interactive computer systems [36,37]. However, we cannot fail to consider the rapidly evolving concept of the metaverse [38], which has led to the emerging use of three-dimensional

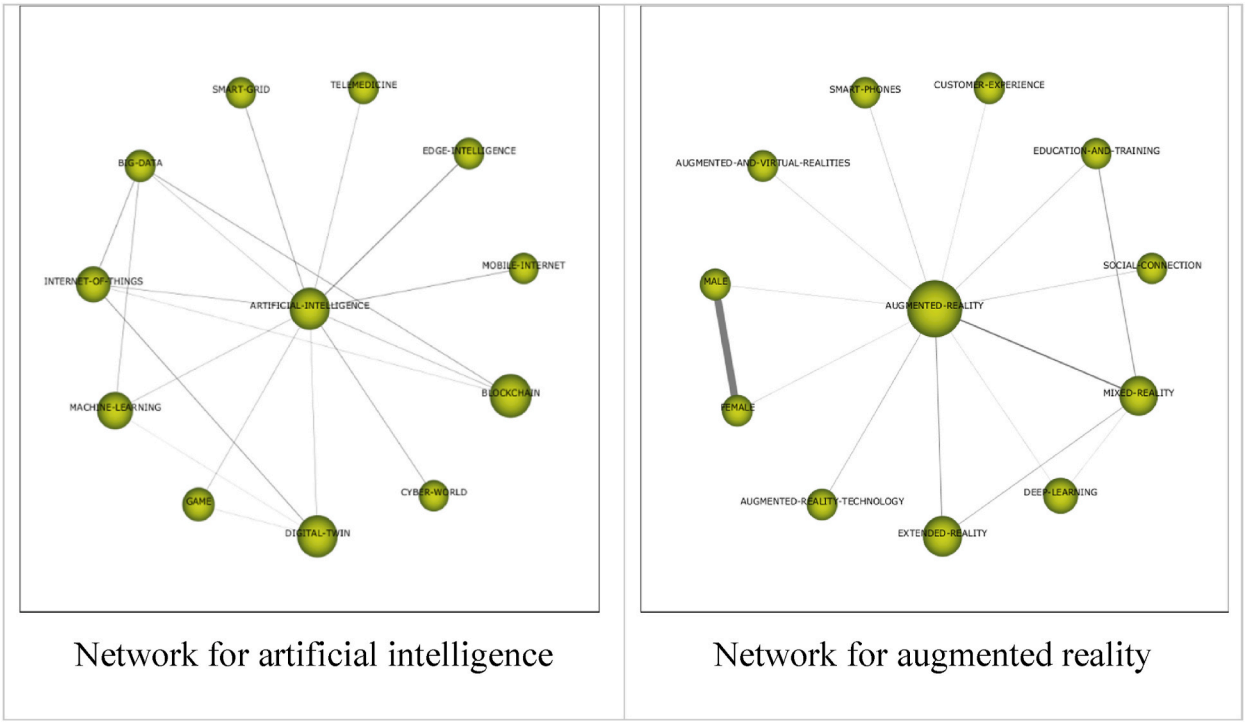

Fig. 6. Thematic networks for artificial intelligence and augmented reality.
Source: results from SciMat

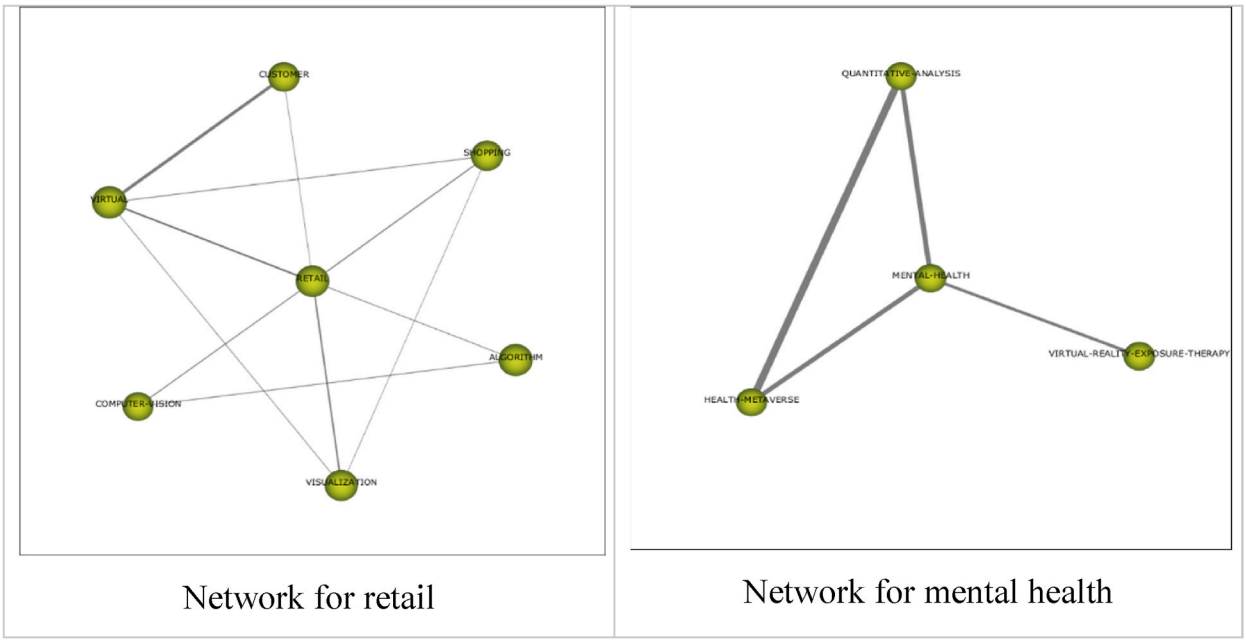

Fig. 7. Thematic networks for retail and mental health.
Source: results from SciMat

computer graphics and HMI technologies. These trends are closely aligned with the development of Industry 5.0, in which technological and social systems work in harmony to provide mass customisation of products and services [39]. On the other hand, there has been a big boom in smart worlds that require the application of technologies in different contexts [40], which form an ideal world for a

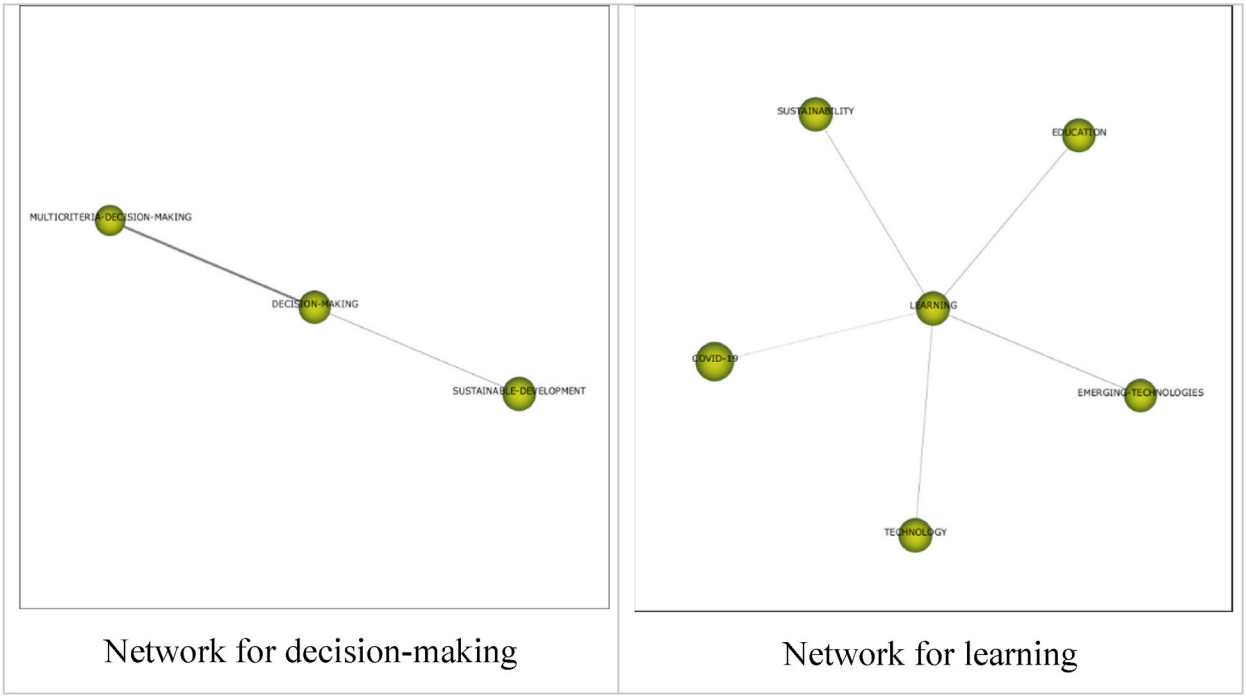

Fig. 8. Thematic networks for decision-making and learning.
Source: results from SciMat

Table 3
Knowledge structure of pioneering metaverse research.

	Well-developed topics	Basic topics	Motor topics	Emerging topics
Contexts	Haptic-interfaces		Virtual worlds 5G mobile communication systems Streaming medium Interactive computer systems	Human-machine interface Three-dimensional computer graphics
Technologies		Artificial intelligence Machine learning Augmented reality		Digital twin
Applications sectors	Mental-health Retail			
Purposes		Learning	Computer games	Decision-making

Source: own elaboration

Table 4
Highlights from pioneering metaverse research.

	Highlights
Contexts	One of the main application contexts of the metaverse is virtual worlds One of the emerging contexts of metaverse application is in human-machine interfaces
Technologies	Augmented reality and artificial intelligence are the technologies that have been most widely used in the implementation of the metaverse Digital twin is the emerging technology in the application of the metaverse
Applications sectors	Two of the sectors in which there are the most studies on the applications of the metaverse are retail and health
Purposes	Learning and computer games are the most studied purposes of the metaverse Decision-making is an emerging purpose of the metaverse

Source: own elaboration

new way to understand the metaverse.

In terms of technologies, the most analysed in recent years have been AI, machine learning and AR [41]. However, the key emerging technology is the digital twin [42,43]. In the future, it will be necessary to analyse the set of technologies associated with the metaverse as a complementary unit to all of those that have been used and can be developed. Thus, one of the most interesting avenues

Table 5
The metaverse value creation process.

Agents	Ecosystem	Inputs	Process	Outputs
Stakeholders	Virtual and/or real Smart Worlds	Data	Metaverse applied technologies	Customer co-value creation Technological, ethical and legal challenges
Companies	Virtual and/or real Smart Worlds	Knowledge	Innovation for creating products and services	Economic impact: entrepreneurship, business models Social impact: 2030 Agenda, ODS, applications for education, health, environment
Theoretical perspectives				
Stakeholders' perspectives	Knowledge management		Open and closed innovation	Value creation models

Source: own elaboration

for future study would be the application of smart technologies.

In the case of the sectors in which the application of the metaverse has been analysed, two stand out: health [44] and retail [45]. Although the metaverse can be applied to most sectors, it has been observed that, in some cases, it is not achieving the expected results. However, there are sectors in which its application as a new paradigm can have a great impact, such as the tourism sector [46,47], and especially, the smart tourism destinations [48–50].

In terms of the usefulness and purposes that the metaverse can have, its application for learning [9–11,51] and for games have been most analysed in recent years. In an emerging way, it is being incorporated into decision-making processes [52,53], and the usefulness it can have for companies' marketing strategies is also being highlighted. It would be of great interest to analyse the social and economic impact the metaverse can have and to propose conceptual models to see its impact on the creation of business and social value. Table 4 presents the highlights of the literature.

To complement the analyses carried out and help to better understand the usefulness of the metaverse in organisations, a five-step process for value creation through metaverse is proposed (Table 5). The first step presents the agents. The second step is to identify the ecosystems that can be combined – real and virtual – and to identify the smart world applications. The analysis of the inputs of the process – data and knowledge – is the third step. The fourth step reflects on the applicability of metaverse technologies to create innovative products/services (process). How the metaverse is used to create economic and social value (output) is the final step. The application and usefulness of the metaverse can be analysed from different perspectives (Table 5). From a knowledge management perspective, information from customers and employees can generate very interesting databases and knowledge bases to model customer behaviour. The management perspective can demonstrate if the application of the metaverse and its technologies are appropriate, viable and conducive to competitive advantage and innovation for social and economic value creation. Here, innovation management models can serve as a basis for various analyses and value creation models.

The application of the metaverse needs to be oriented towards providing different experiences for users, which can lead to the co-creation of value aimed at social and economic impacts. In social terms, the metaverse can play a relevant role in the development of the aspects included in the 2030 Agenda and the Sustainable Development Goals (SDGs). From a business point of view, the metaverse creates the need for changes in business models and the acceleration of the digital transformation of companies and the economy. It also opens up new opportunities for entrepreneurship and job creation.

Today, the applications of the smart world offer new opportunities to experience life through two ecosystems, one real and one virtual (in the metaverse). For example, an interesting aspect when considering the applications of the metaverse in smart worlds is to analyse its role in the "smartization" of tourism. However, there are few authors that consider these aspects by combining the terms "metaverse" and "smart tourism" [54,55]. Then, the emerging smart philosophy applied to tourism can be incorporated into future studies to consider new ideas for enhancing value by applying the metaverse to tourism.

For example, Buhalis et al. [47] highlight the interest in analysis of the value creation that the metaverse can have in the tourism ecosystem. The metaverse can create confusion about what is real and what is not and blur reality if it is not well delineated. It can reduce the capacity for critical thinking and the ability of the users to reflect on their experiences. It is therefore important to propose models that contribute to the understanding of the value creation process and the analysis of aspects such as its technological, economic, consumer experience, ethical and legal implications [47].

The smart tourism experiences are closely linked to the development of smart cities and go hand in hand with improvements in technologies such as AI algorithms, cloud computing, mobile applications, VR and AR, IoT, big data, digital twins or 5G, among others [56]. In that line, smart tourist destinations (STD) represent a completely different understanding of a destination, as opposed to the traditional concept derived from the digital revolution that generates knowledge and information accessible to all stakeholders, facilitating them in carrying out continuous innovation of their activities, as much as possible [46,57]. Additionally, smart tourist destinations can be based on the widespread use of advanced technologies and all types of data to improve overall destination management, and thus its prominence and competitiveness [47,58]. STD can include special cases of smart cities initiatives, which build upon the emerging technological infrastructure to enhance tourists' experience [59]. The usefulness of technological platforms and services generates the potential advantages and disadvantages of STD for businesses and consumers has also been considered [46,47,60]. Gretzel et al. [61] explain that smart tourism involves multiple components and layers of smart that are supported by ICTs, as they are smart destinations, smart business ecosystem and the experience acquired by smart tourists, but it is also changing processes and governance [62]. In this sense, an interesting topic within this line of research is to study the Metaverse as a tool for "smartizing"

tourism.

6. Conclusions

This article reviews the literature on the metaverse to answer the research question "What is the knowledge structure of pioneering metaverse research?" and uses a mixed methods approach.

The results of the literature review show that the metaverse is a very current topic, as more than 84 % of the literature on the metaverse has been published since 2020. In terms of the main topics studied, it stands out that technologies such as AR and AI are central topics, while decision making, and human-machine interface (HMI) are emerging topics. There are also well-developed studies on their applications in sectors such as retail and mental health.

Among the academic contributions, we highlight that several gaps in the literature are filled by complementing the results obtained in the works of Dhingra [4], Shen et al. [7] and Wider et al. [19]. Specifically, a review of the pioneering literature on the metaverse has been carried out combining qualitative techniques and using the Scopus database. A comprehensive analysis has been carried out to give structure to the original metaverse literature. Furthermore, it goes one step further than previous studies by considering the effects of the metaverse. Thus, a model for understanding the process of value creation through the metaverse is developed. This work represents a starting point for a reflection on metaverse applications that can contribute to productive and valuable advances in various research fields.

This paper also has other practical and social implications. The proposed model can serve as a guide and help managers and practitioners to create more value through the adoption of the metaverse. This model considers user behaviour towards the metaverse and its connection to the real world. For example, the application of the metaverse to business practice should be oriented towards offering different experiences to users. This will facilitate value co-creation and enhance social and economic impact.

In business terms, the metaverse requires changes in business model processes, opens up new opportunities for entrepreneurship and for the creation of new jobs and can help to realise the digital transformation of companies and the economy. For practical purposes, this paper also considered the two ecosystems that can be combined thanks to the metaverse, the real and the virtual. In both, the application of metaverse technologies can help to create innovative products/services.

Finally, this paper has highlighted the importance of analysing the economic and social value creation that the use of the metaverse can produce. In the case of social implications, one of the main challenges is to contribute to sustainable business development aligned with the SDGs.

Considering all the aspects developed in this paper, we can raise several research questions to extend the research in this field.

- What effect can metaverse technology applications have in business management models?
- What effect can metaverse technology applications have on models of open innovation management?
- Which SDGs can the metaverse serve?
- How can the metaverse create economic and social value?
- How is the metaverse being applied in smart cities, and how could it be applied to improve their performance?
- How is the metaverse being applied for the "smartization" of the tourism?

The scope of this work has its limitations. The bibliometric analysis carried out could therefore be complemented and updated. It would be very interesting to conduct empirical studies with qualitative and quantitative methodologies on the adoption of the metaverse. Future studies could develop further work to analyse the state of the art of the application of metaverse technologies in smart environments. In that line, an interesting theme is the delimitation and study of the applications of metaverse for "smartization" of tourism destinations and services.

Funding statement

This article has been financed with funds from OPENINNOVA High Performance Research Group (URJC-V1404).

Data availability statement

No data was used for the research described in the article.

Ethics declarations

Review and/or approval by an ethics committee was not needed for this study because there is no sensitive information or information requiring these actions.

No additional information is available for this paper.

CRediT authorship contribution statement

Virginia Ramírez-Herrero: Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Marta Ortiz-de-Urbina-Criado:** Writing – review & editing,

Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Jose-Amelio Medina-Merodio:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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