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Kick-start your scientific journey into the metaverse

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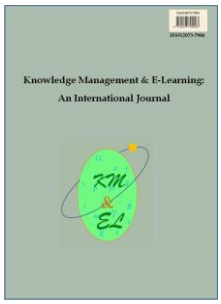

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Kick-start your scientific journey into the metaverse

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Abstract: The term "metaverse" first appeared in Neal Stephenson's 1992 science fiction novel Snow Crash. It was defined as a virtual environment shared through the Internet in which avatars represent people in three dimensions, and users can build what they wish. Since the publication of Stephenson's novel, technological advances have enabled the creation of several metaverses for widespread usages, such as virtual world platforms like World of Warcraft and Second Life. This paper aims to review studies on the metaverse using bibliometric analysis. The findings include a summary of the most important scientific articles and journals in the subject area and the most prolific and prominent authors, organisations, and nations. Furthermore, keyword co-occurrence analysis revealed the core research clusters and their sub-themes, allowing for more pertinent debates and viewpoints on crucial areas for future research. Finally, the implications for theory and practice have been addressed, offering a comprehensive overview of expected metaverse impacts on industry

and society.

Keywords: Avatars; Bibliometric analysis; Literature review; Metaverse; Virtual reality

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1. Introduction

With the coming of the fifth industrial revolution, many data and knowledge sources concerning people's choices are now available online (Asadnia et al., 2021; Zhou et al., 2018). Millions of people worldwide utilise massive multiplayer online games (MMOGs) and platforms to connect with the virtual world (Olasina & Kheswa, 2021). These virtual worlds have evolved from extensions of single-player games to self-contained virtual communities where business, trade, and transacting are tolerated and encouraged (Alahuhta et al., 2016; Chandra & Leenders, 2012; Chandna & Salimath, 2018; Nambisan et al., 2017). Virtual worlds have the potential to bring new added value by creating something that cannot be done or shown in traditional environments (Holmberg, 2012). As a result, business activities are changing toward more trustless, automated, and coordinated multi-objective and multilevel systems linked by diverse data and knowledge flows known as the metaverse (Goertzel et al., 2017; Rossmann et al., 2018). The term metaverse was coined in 1992 by the cyberpunk science fiction novel *Snow Crash* as a mix of "meta" and "universe" (Stephenson, 1992). Notably, the author claims that people can build whatever they want in this virtual environment in three dimensions: shops, offices, and more, which are theoretically open to users.

During the Meta presentation in 2022, Mark Zuckerberg defined the metaverse as "a network of 3D virtual worlds focused on social connection (Linkedin, 2022)". Starting from this definition, it is evident that the component of social interactions is essential in addition to the presence of a virtual environment. On the other hand, the metaverse will be more than simply a recreational virtual environment; it will also be a virtual twin of the actual world, where individuals can work, learn, and trade. The COVID-19 epidemic transferred most of the work to remote locations, and many hybrid situations arisen in this time are now exceedingly difficult to handle. On the other hand, the metaverse may transfer people to a remote area while giving them a sense of community through holograms or virtual rooms. Whether working or learning, virtual models can help users go deeper into a topic and better comprehend it, producing an engaging social learning atmosphere (Johnson et al., 2011). In the metaverse, e-commerce as we know it will be drastically altered, with products becoming more personalised than ever before and connections between sellers and creators becoming more direct.

Further proof of concept works on the metaverse have been developed recently. These prototypes are based on blockchain technology, allowing virtual spaces to be archived, mapped, shared, and reused among different applications (Ryskeldiev et al., 2018). The implementations range from university campus simulation (Duan et al., 2021) to maintenance activities training through smart glasses augmented reality viewers (Siyaev & Jo, 2021). As a result, the popularity of immersive projection-based display environments has been continuously increasing (Jaynes et al., 2003). However, few sparse and systematic assessments are available in the metaverse literature (e.g., Park & Kim, 2022).

The primary goal of this paper in this context is to undertake a bibliometric assessment of metaverse literature to define the new universe's key elements. The

remainder of the article is structured as follows. After the introduction, Section 2 analyses the review methodology and data collection process. Section 3 presents the results of bibliometric analysis, whereas Section 4 deals with the primary metaverse features, the expected impacts on industry and society, and future research trajectories. Finally, Section 5 reports the conclusions and implications of this research.

2. Methods and material collection

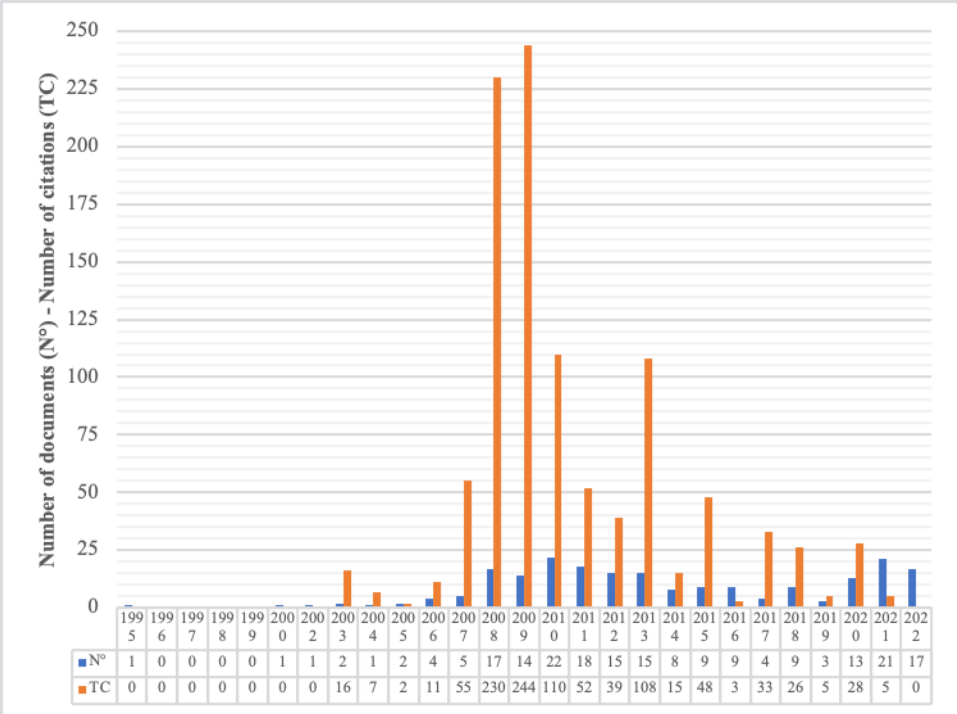
Due to its versatility and capacity to manage big datasets, bibliometric analysis is often used in various disciplines of knowledge (Shashi et al., 2021a). This methodology employs a quantitative tool to explain, assess, and monitor published literature (Dzikowski, 2018; Garfield et al., 1964), yielding a comprehensive summary of current scientific achievements (Gajdzik et al., 2020). This type of analysis provides a structured summary of the most productive authors, top journals and publications, as well as the most influential countries and research organisations (Gaviria-Marin et al., 2019), establishing how diverse elements (e.g., authors, publications, or keywords) are related in the study area using mathematical and statistical methodologies (Kipper et al., 2020). As a result, the proposed literature review method allows researchers to include previous studies and provide qualitative and quantitative insights on the topic under consideration (Centobelli et al., 2021), resulting in a complete, exact, and reproducible analysis (Cao & Alon, 2020). These tools have not yet been applied to study the existing metaverse literature. The assessment of research performance will chart the evolution of the research field over time and identify the most prolific, notable, and influential subfields (Shashi et al., 2021b). The papers under consideration were obtained from the Scopus database, one of the most dependable sources for conducting a literature study (Centobelli et al., 2016; Pattnaik et al., 2021). We found publications with “metaverse” in the title, abstract, or keywords. On the 10th of January 2022, a sample of 211 papers was chosen without regard to the period studied. We consulted peer-reviewed journals, conference proceedings, and books to get a broad understanding of the subject. In addition, we refined our analysis by only gathering data from papers written in English. As a result, the final sample contains 211 relevant documents.

3. Project background and research questions

3.1. Document distribution over time

Fig. 1 highlights the distribution of papers by year of publication and the number of citations they obtained in Scopus. It is interesting to note that since 2008 there has been an increasing number of papers published on the topic investigated, reaching a maximum of 22 publications in 2010. In these years, the boom of Second Life got 21.3 million accounts and an estimated GDP of $500 million. The technological advances that virtual and augmented reality has had, and the birth of this new gaming platform have significantly increased the interest in the metaverse topic. The possibility of creating avatars that gave the real feeling of being in another world and not losing grip on the reality in which he was immersed had incredible potential, not only for the gaming sector but also for many other industrial and social applications. Furthermore, Satoshi Nakamoto (2008) proposed the concept of blockchain in 2008, and the following year, it was built to serve as a record of all Bitcoin transactions. metaverse and blockchain are a technology combination capable

of delivering incredibly engaging experiences in terms of pure and simple entertainment as well as new economic prospects through an economy based on the development of the virtual real estate, assets, and virtual events. Consequently, the trend of the published articles is most likely related to the connection between the metaverse and the development of the first decentralised blockchain. Following that, the number of articles published decreased slightly before increasing again around 2020-2021, the period in which Mark Zuckerberg reintroduced the concept of the metaverse and announced the company's name change to Meta, claiming that the metaverse will reach a billion people in a decade, creating millions of jobs (Economy, 2021). As a result of companies' and academics' increased interest in the topic, the number of scientific studies will most likely expand in the following years.



	1995	1996	1997	1998	1999	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
N°	1	0	0	0	0	1	1	2	1	2	4	5	17	14	22	18	15	15	8	9	9	4	9	3	13	21	17
TC	0	0	0	0	0	0	0	16	7	2	11	55	230	244	110	52	39	108	15	48	3	33	26	5	28	5	0

Fig.1. Numbers of papers and citations over time

3.2. Top cited document

With a total of 180 citations, "*Avatars, people, and virtual worlds: Foundation for research in metaverses*" was the most cited document in the sample, followed by "*Second Life and the new generation of virtual worlds*", published in 2008 with 79 citations, and "*Making real money in virtual worlds: MMORPGs and emerging business opportunities, challenges, and ethical implications in metaverses*" published in 2008 with 51 citations. Davis et al. (2009) created a metaverse conceptual framework to enhance virtual team research and practice. Notably, the created conceptual model is built on five significant constructs: the metaverse itself, people/avatars, metaverse technology capabilities, behaviours, and consequences. The authors contend that communication, engagement, and technology constraints impede virtual teams and that the characteristics of metaverse technologies give

solutions to these difficulties. *Second Life* is one of the most well-known metaverses, with various companies, colleges, cities, embassies, artists, and individuals establishing virtual presences (Kumar et al., 2008). At its peak in January 2007, *Second Life* had 2.67 million users who spent $ 805,096 in a single day (Papagiannidis et al., 2008). Residents of *Second Life* use their avatars to move around in a digital 3D environment and communicate with one another in textual form (e.g., through comics that come out of their mouths), attend concerts by going to theatres where they are held, meet movie fans in a place specifically designed for them, shop in stores, or wander around to discover a vast world full of surprises. When developing a metaverse, immersive realism, ubiquity of access and identification, interoperability, and scalability are critical to consider (Dionisio et al., 2013). Notably, immersive realism refers to the virtual environment's potential to be realistic enough for users to feel mentally and emotionally immersed in a parallel reality. The ability to reach the metaverse's virtual locales with any existing digital device is ubiquity – that is, from desktops to tablets to mobile devices. Interoperability in virtual spaces refers to using standards so that digital assets used in the rebuilding or rendering of digital environments stay replaceable through specific implementations, and users can move between locations without disrupting their immersive experience. Finally, scalability refers to the server architecture's ability to allow many players to enter the metaverse without jeopardising the system's efficiency or user experience.

Table 1
Ranking of total publication and total citations

Total publication ranking					Total citations ranking				
Rank	Country	TP	TC	TC/TP	Rank	Country	TP	TC	TC/TP
1	United States	41	482	11.76	1	United States	41	482	11.75
2	Japan	20	80	4.00	2	United Kingdom	17	249	14.64
3	Turkey	18	10	0.56	3	South Korea	16	88	5.50
4	United Kingdom	17	249	14.65	4	Japan	20	80	4.00
5	South Korea	16	88	5.50	5	Spain	11	63	5.72
6	Spain	11	63	5.73	6	Portugal	5	32	6.40
7	China	8	4	0.50	7	France	5	22	4.40
8	Italy	7	4	0.57	8	Brazil	4	21	5.25
9	Australia	5	14	2.80	9	Colombia	4	20	5.00
10	France	5	22	4.40	10	Germany	4	20	5.00

3.3. Country analysis

The sample includes 41 countries, with 41% having published only one publication. As demonstrated in Table 1, the United States dominates metaverse research in publications (41 articles) and citations (482). It is not surprising, given that the United States is the epicentre of metaverse development. Many significant US corporations are investing in creating various metaverses, even though North America may lag Europe, particularly the United Kingdom, in terms of AR/VR adoption (Harrisson-Boudreau & Bellemare, 2022). The United Kingdom has averaged the highest number of citations for published publications. Furthermore, US consumers appear to be ideally suited to this new technology: the first "virtual" marriage in the metaverse was celebrated in the US last December. The ceremony featured a 60-year-old man and a 52-year-old woman and their personalised avatars for a real and digital wedding. Because they both work for a company

that specialises in communication in simulated environments, the couple had already met virtually. Their avatars will now be on their honeymoon as well. Most of the documents are single-country publications rather than multi-country publications, which signifies that the topic is very significant to the country's interests.

Focusing on the institutions, it is easy to note that Sabanci University (Turkey) has published the most documents (8 papers). If we look at the institutions with the most citations, the University of Nebraska at Omaha (United States) has 186 citations, followed by the Department of Computer Science at Princeton University (United States) and the Department of Computer Science at the University of Maryland (United States) with 79 citations.

4. Discussion

The metaverse is an immersive environment in which people will be able to do practically everything they can imagine, including work, learn, play, and shop. Users of the metaverse can express themselves in fresh, pleasant, and entirely immersive ways rather than staring through a little window. As a result, the experience of presence is the metaverse's distinguishing attribute. We will feel as if we are there with other people. We will be watching their facial expressions and body language. We will be immersed in these experiences rather than glancing at a screen. Everything we do online, from socialising to entertainment, games, and business, will be more natural and vivid. Screens cannot transmit the full range of human emotion and interaction, nor can they provide that profound sense of presence.

Avatars will be used to represent humans in the metaverse. They will be as prevalent as profile images today, but instead of static images, they will be living 3D representations, duplicating people's attitudes and gestures, allowing for richer interactions than currently feasible online. Aside from avatars, there is the home space. We will create it to look exactly how we want it to, upload our photos and movies, and store digital items. We will invite friends over, play games, and socialise. A home is a unique place where people can teleport to any location. In terms of teleporting, people will create a variety of various settings, such as rooms, games, and entire planets that we can teleport into and out of whenever we want. Teleporting through the metaverse will be like clicking a link on the Internet.

Interoperability and accessibility are required to realise the metaverse's full potential. There will be several software communications interfaces and various cryptocurrencies, allowing the establishment of a new online commerce idea based solely on purchasing digital 3D objects. Furthermore, we can travel between these distinct experiences on various devices, such as virtual reality and augmented reality glasses, on a computer or phone; this will allow us to swiftly enter the metaverse from existing platforms. The metaverse's server design must support many users without sacrificing system performance or user experience. Privacy and security must be embedded into the metaverse from the outset. As a result, users may choose when they want to interact with other users, when they want to block someone from appearing in their own space, and when they want to take a break and teleport to a private bubble to be alone. Technologies such as blockchain and NFTs (Non-Fungible Token), which enable the creation of distributed, hardly modifiable registers and cryptographic tokens representing the deed of ownership and the written certificate of authenticity on the blockchain of a specific transaction, undoubtedly

provide an additional tool to ensure user security and privacy. As a result, the metaverse is a parallel digital dimension that is constantly open and accessible, where one can buy and store virtual resources regardless of the technological platform or device through which it is accessed. To summarise, the metaverse's fundamental concepts are (1) presence, (2) avatars, (3) home space, (4) teleporting, (5) interoperability, (6) accessibility, (7) scalability, (8) privacy and safety, (9) virtual goods, and (10) natural interfaces. Emerging technologies such as virtual, augmented, and mixed reality, blockchain, motion tracking, cloud, particular 3D hardware, and software are all components of the metaverse's bridge to the digital future. These tools can be used in language learning to promote many features including interactivity, immediacy, and authenticity (Khan et al., 2022; Manca et al., 2016; Zou et al., 2018). The metaverse promises to make a more significant overlap of our digital and real lives accessible and easily useable globally. As a result, the metaverse's goals vary from interacting with friends to gaming and entertainment, invention, commerce, and work. It is also expected that the metaverse will strongly impact education. Using immersive learning content, such as the virtual learning simulation, doctors can learn new surgical techniques firsthand, practising until it goes well (Aghili et al., 2012; Davis & Davis, 2015; Lee & Berge, 2011). However, there will be many issues with each great technological advancement. Future metaverse studies could shed light on how this new technology can keep individuals secure and protect their privacy online, what data is collected, and how it is used over time. It will also be required to provide individuals with simple safety measures, age recommendations, and parental controls for children who use products. Lastly, collaboration across different institutions and geographic realities might undoubtedly lead to an acceleration of the subject, and major advances in the quality of the study carried out, as most articles have been conducted in homogeneous realities up to now.

5. Conclusion

This research will make significant theoretical contributions. First, bibliometric and network analyses are used in this study to identify the most influential papers and countries in terms of published articles and total citations. Second, metaverse scholars would be able to rapidly locate authors, institutes, and countries working in specific scientific fields. Scientists interested in collaborating on research initiatives, sharing ideas, and discussing their discoveries with top authors can do so. Furthermore, editors preparing special and regular metaverse issues will invite well-known authors and organisations. The gaming and education areas are the first where metaverse solutions were employed. These solutions demonstrate the main benefits of interacting with avatars/holograms while also emphasising the technical difficulties involved with the equipment and the possibilities of recreating a sense of reality in the virtual world. If research in the education and gaming industries continues to have wide margins for activity, the other sectors should follow suit soon. All activities connecting with the public should examine the benefits and challenges of employing sales strategies in the metaverse and how virtual sales might be integrated with real ones. Even though great care was taken to assure the study's validity, some limitations must be addressed below. Only documents published in the Scopus database were evaluated in the initial search, leaving out articles from other databases such as Web of Science and Google Scholar (Shashi et al., 2021b). As a result, future studies could compare the findings of other databases to the findings given in this paper.

Author Statement

The authors declare that there is no conflict of interest.

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