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Using Metaverse in Education: Bibliometric and Content Analysis on Applications, Tools and Impacts

Eğitimde Metaverse Kullanımı: Uygulamalar, Araçlar ve Etkiler Üzerine Bibliyometrik ve İçerik Analizi

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Abstract

The study aims to investigate the impact of metaverse technologies in the field of education. To achieve this objective, bibliometrics and content analysis were employed. During the study, a total of 178 studies were subjected to bibliometric analysis, while 112 studies specifically focused on education were examined through content analysis. The analysis revealed that most publications were concentrated in 2023 (n=98) and 2022 (n=67). Furthermore, the most frequently employed keywords in these studies included metaverse, virtual reality, augmented reality, education, and artificial intelligence. In terms of country distribution, the highest number of publications originated from China (n=103), followed by South Korea (n=73), India (n=34), and the USA (n=30). On the authorship front, the most prolific contributors were Kim, J., Lee, H., Lee, L. H., and Niyato, D. In the realm of metaverse utilization in education, virtual reality, augmented reality, mixed reality, and extended reality technologies emerged as the most prominent. Additionally, the analysis identified higher education and secondary education as the primary contexts for metaverse application. The recommendations presented in the examined studies were categorized into five groups: To Ensure a Quality Learning Experience, To Improve Student Experience, For Skill Development, To Support Education Activities, and For Material Use. Finally, regarding the limitations of metaverse technology in education, a six-category structure was identified, encompassing Technical Problems, High Cost, Ethical and Safety Concerns, Learning Requirements, Limitations of the Technology Used, and Health Problems.

Keywords: Metaverse, metaverse in education, virtual reality, virtual world, augmented reality.

Öz

Çalışma, eğitim alanında metaverse teknolojilerinin etkisini araştırmayı amaçlamaktadır. Bu hedefe ulaşmak için bibliyometri ve içerik analizi kullanılmıştır. Çalışma kapsamında toplam

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178 çalışma bibliyometrik analize tabi tutulmuş, bunun yanı sıra özel olarak eğitim odaklı 112 çalışma içerik analizi ile incelenmiştir. Analiz, yayınların çoğunluğunun 2023 (n=98) ve 2022 (n=67) yıllarında yoğunlaştığını ortaya koymuştur. Ayrıca, bu çalışmalarda en sık kullanılan anahtar kelimeler arasında metaverse, sanal gerçeklik, artırılmış gerçeklik, eğitim ve yapay zeka bulunmaktadır. Ülke dağılımı açısından en yüksek yayın sayısı sırasıyla Çin (n=103), Güney Kore (n=73), Hindistan (n=34) ve ABD (n=30) kaynaklıdır. Yazarlık açısından en üretken katkıda bulunanlar Kim, J., Lee, H., Lee, L. H., ve Niyato, D. olmuştur. Eğitimde metaverse kullanımı bağlamında sanal gerçeklik, artırılmış gerçeklik, karma gerçeklik ve genişletilmiş gerçeklik teknolojileri en belirgin olanlar olarak ortaya çıkmıştır. Ayrıca, analiz yükseköğretim ve ortaöğretimin metaverse uygulaması için ana bağlamlar olarak tanımlanmıştır. İncelenen çalışmalarda sunulan öneriler, Beşeri bir Öğrenme Deneyimi Sağlamak, Öğrenci Deneyimini İyileştirmek, Beceri Geliştirmek İçin, Eğitim Faaliyetlerini Desteklemek İçin ve Malzeme Kullanımı İçin olmak üzere beş grupta kategorize edilmiştir. Son olarak, eğitimde metaverse teknolojisinin sınırlamalarıyla ilgili olarak, Teknik Sorunlar, Yüksek Maliyet, Etik ve Güvenlik Endişeleri, Öğrenme Gereksinimleri, Kullanılan Teknolojinin Sınırlamaları ve Sağlık Sorunları olmak üzere altı kategorili bir yapı belirlenmiştir.

Anahtar Kelimeler: Metaverse, eğitimde metaverse, sanal gerçeklik, sanal dünya, artırılmış gerçeklik.

Introduction

The concept of Metaverse, which means “the other universe” in Turkish (Çelik, 2022), was first used in 1992 in the science fiction novel *Snow Crash* by the American writer Neal Stephenson (Maharg & Owen, 2007). Afterwards, game companies developed computer games such as *Cityspace* and *Active Worlds*, which consist of virtual worlds, to offer their users more realistic and unique experiences. In 2003, *Linden Lab*. Developed by *Second Life*, the most popular is (Schroeder et al., 2001). *Second Life* promises its users a second world where they can create their avatars and define all the features that are limited only by one’s imagination. In this world, people can socialize, buy real estate, and design the process. It can even create a fiction that includes extensive processes such as university education (Narin, 2021). Today, in the game world, examples of Metaverse, such as *Roblox*, *Zepeto*, *Sandbox*, and *Fortnite*, are increasing daily. Also, people who cannot go out due to covid-19 started to use it as a new social space for meeting and resting (Book, 2004), significantly augmented reality and virtual reality applications have become widespread. Finally, social media giants and big technology companies have defined Metaverse as the internet’s future, increasing the concept’s popularity and attracting wider audiences (Kye et al., 2021).

Metaverse is a multi-user and post-reality universe that combines the real and virtual worlds (Mystakidis, 2022; Kemec, 2022). It is a virtual world where users can interact with each other, create objects and simulate them (Farjami et al., 2011). In these environments, users choose an avatar and represent themselves with this avatar. Avatars enable people to engage in social, economic and cultural activities in the Metaverse world. For example, hundreds of thousands of people can come together to watch the concert of their favourite singer by participating in a festival held in Metaverse environments with the help of avatars (Book, 2004). This shows that Metaverse environments have a high potential as a new social communication field. It also offers a high degree of freedom in creating and sharing content, providing a unique and immersive experience.

However, due to the Covid-19 epidemic limiting face-to-face communication as much as possible, activities that may be offline have begun to be transformed into virtual reality (Xi et al., 2023), and this situation has spread rapidly in various fields such as education, medical care, fashion, and tourism (Flavián et al., 2019). When the developments within the scope of education are examined, Virtual World had enabled students to connect socially beyond borders as a new communication area, even when the

covid-19 epidemic caused the closure of schools worldwide (Kye et al., 2021). Since the beginning of the 2000s, the use of virtual worlds in education has been increasing slowly but steadily (Harris & Rea, 2009); it can be said that the covid-19 epidemic has accelerated this situation. Especially the unique learning experience provided by these environments has brought a different perspective to traditional and distance education (Sheehy et al., 2007). A separate parenthesis should be opened here for distance education. This technology allows students who are not physically in the same place to interact with other students and objects in the virtual environment in a way that appeals to many senses (Hirsh-Pasek et al., 2022). In this direction, it is known to be very useful especially in distance education if the necessary infrastructure is provided (Taş & Bolat, 2022).

Virtual World increases the motivation of the learner with the three-dimensional interaction opportunity it offers for its use in education (Christopoulos et al., 2018), provides the opportunity to learn by doing with the feeling of being in a real environment (Türel & Gür, 2016), accelerates learning and helps in obtaining permanent information (Thakral et al., 2010), eliminating geographical barriers in education (Duncan et al., 2012) and providing many benefits to both educators and learners in the learning-teaching process (Tokel & Cevizci, 2013). In addition to these contributions, it was emphasized that when students establish a relationship with others in the Metaverse environment, a game-centered relationship is established that is weaker than the interaction in the real world, and privacy problems arise due to the collection and processing of various personal information (Kye, 2021).

In the field of education, many studies on the use of virtual reality and augmented reality applications can be mentioned (Collins, 2008; Dionisio et al., 2013; Hyunmin, 2020; Jeong et al., 2016; Jeon & Jung, 2021; Ko et al., 2021; Kye et al., 2021; Mihwa, 2017; Reyes, 2020). Sometimes, the large number of studies carried out in the field brings some problems. The results of studies on a subject can both support each other and produce contradictory results. Those who research any subject have difficulty reaching all of the research on that subject or spend much time reaching them (Göktaş et al., 2012). At this point, the results of the content and meta-analysis related to the studies in a certain field provide essential conveniences to the researchers (Selçuk et al., 2014).

One of the methods of evaluating the literature, such as the content analysis method (Falkingham & Reeves, 1998), which helps to evaluate the existing literature in a field, is bibliometric analysis. Bibliometrics is concerned with examining various elements of academic publications with the help of numerical analysis and statistics. Bibliometric analyses can be descriptive in determining the number of articles published in a given year, or they can be evaluative in terms of citation analysis to reveal how an article has affected subsequent research (McBurney & Novak, 2002). Both methods are considered necessary in terms of guiding the researchers mentioned above.

Moreover, upon reviewing the existing literature, numerous bibliometric and content analysis studies related to the general use of Metaverse technology are observed (Abbate et al., 2022; Damar, 2021; Feng & Su, 2022; Shen et al., 2023; Shukla et al., 2023; Wider et al., 2023). In addition to comprehensive studies, there is a noticeable focus on specific areas such as health (Chen & Zhang, 2022; Liu et al., 2022; Zhao et al., 2022) and education (Ağaç et al., 2023; Battal & Taşdelen, 2023; Biçen & Adedoyin, 2023; Bizel, 2023; Chen et al., 2022; Kaya & Mutlu, 2023; Muktiarni et al., 2023; Sirvermez & Baltacı, 2023; Taş & Bolat, 2002; Tlili et al., 2022; Zhao et al., 2023). The study conducted by Ağaç et al. (2023) in the field of education is distinguished from others as it specifically focuses on health education. Except for the studies by Tlili et al. (2022) and Zhao et al. (2023), all other studies solely include bibliometric analysis. Generally, these studies cover variables

such as relevant journals, authors, universities and countries, citation status, keywords, and the number of publications over the years. In contrast to previous studies, this work includes, within the scope of content analysis, topics such as limitations and suggestions regarding the use of the metaverse in education. Additionally, in the study conducted by Muktiarni et al. (2023), publications up to February 2023 are considered, whereas all other studies cover publications before 2023. This article, encompassing studies up to September 2023, stands out as the most likely work to reflect the current literature positively compared to other studies.

The Trend of Metaverse Studies in Education in Türkiye

When examining studies on the use of the metaverse in education in Türkiye, it is noticeable that there is limited coverage in international indices. The majority of these studies have been conducted in recent years. The conducted research generally focuses on systematic literature reviews, examination of usage trends in education, investigation of the evolution and effects of the metaverse in education, testing user experience, literature reviews, discussing opportunities and challenges, exploring technical, economic, educational, and social opportunities, and examining the impact on language teaching (Al-Ghaili et al., 2022; Doma & Şener, 2022; Taş & Polat, 2022; Tlili et al., 2022). It is observed that these studies are concentrated in various fields such as science, technology, engineering, mathematics, design, and education, predominantly at the higher education level. The studies often focus on the use or examination of various technologies such as virtual reality, augmented reality, extended reality, blockchain technology.

Among the potential advantages of using the metaverse in education, researchers have identified several findings, including providing independent and rich communication opportunities, offering an interactive learning experience, enhancing learning efficiency, increasing students' levels of freedom and participation, creating a digital identity, improving social presence in the virtual environment, and supporting enjoyable learning through motivation and collaboration (Cali et al., 2022; Çelik & Yangın Eranlı, 2022; Taş & Polat, 2022). However, it is essential not to overlook the potential limitations and disadvantages highlighted by researchers. In this context, issues such as privacy, security, technological challenges and constraints, decentralization, adaptation problems, and teacher-student relationship-related challenges come to the forefront (Al-Ghaili et al., 2022; Cali et al., 2022; Saritas & Topraklıoğlu, 2022).

Researchers have made various recommendations based on the findings obtained from these studies. These recommendations include developing solutions focusing on data security and decentralization issues in the use of the metaverse in education, encouraging interdisciplinary studies to fully explore the potential of the metaverse in education and better understand its benefits, developing frameworks that support collaborative design, supporting its use in education and design processes, developing security solutions adaptable to the transmission diversity in the metaverse, and conducting comprehensive privacy studies.

As a result, Metaverse, which was defined as fictional about 30 years ago, has turned into a virtual universe where people feel entirely mentally with virtual reality devices (Narin, 2021). Metaverse is estimated to change our daily life and economy beyond the understanding of games and entertainment (Portugal, 2022). In this direction, the bibliometric and content analysis of this concept, which has been mentioned a lot in recent years and has become widespread in educational activities, is considered important in terms of determining the trend in this field. In addition, the data to be obtained as a result of this study can provide significant contributions in terms of guiding future

research, developing publication policies, and guiding researchers in the field. It will also serve researchers to identify important advances, trends and gaps in this field. It will also provide guidance to application developers, decision makers and especially educators on how to integrate Metaverse technology into educational activities and improve educational outcomes. This study aims to determine the impact of metaverse technologies in the field of education. In pursuit of this objective, it examines the recommendations and limitations presented in the existing literature, investigates the applications of metaverse in different educational levels, and analyzes the prominent tools and applications in the use of these technologies in an educational context. In line with this aim, answers to the following research questions will be sought in the study.

1. What is the distribution of the studies on using metaverse in education according to years?
2. What is the distribution of the keywords used in the studies on using metaverse in education?
3. What is the distribution of the studies on using metaverse in education according to countries?
4. Who are the most prolific authors in studies on the use of metaverse in education?
5. Which are the most cited publications in studies on the use of metaverse in education?
6. What are the suggestions for the use of metaverse in education in the studies analyzed?
7. What are the limitations encountered in the studies on the use of metaverse in education?
8. Which metaverse technologies were preferred in the studies on the use of metaverse in education?
9. How is the distribution of studies on using metaverse in education according to educational levels?

Method

In this section, the research methodology, sampling, data analysis and the research process are described. In addition, detailed information on how the studies analyzed under the sampling heading were determined is presented.

Research Design

In the study, bibliometric analysis and content analysis were employed to determine the impact of metaverse technologies in the field of education. The bibliometric analysis method is one of the tools used to analyze the research trends of publications produced in a field (Erfanmanesh & Abrizah, 2018). It is also a method in which qualitative and quantitative statistical techniques are used in a rigorous, systematic and innovative way to review the traditional literature (Misra et al., 2016). Content analysis, on the other hand, is expressed as the process of taking a large number of data sets and reducing them to qualitative data to determine the relationships and meanings between them (Patton, 2014).

Sampling

In order to reach the studies on “Metaverse in Education” in the literature, Web of Science (WOS) database was searched with related keywords. WOS database were searched with the keywords (“Metaverse” and “Education”) to reach the studies related

to the Metaverse. Relevant ones from these studies were taken and analyzes were carried out. Afterwards, 112 studies related to education were extracted from these studies. The steps related to this process are given in Figure 1.

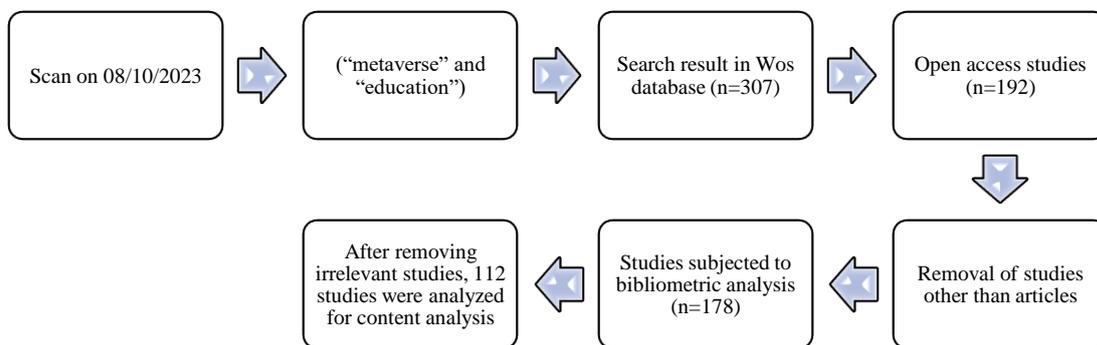


Figure 1. Selection: PRISMA Flow Diagram (Liberati et al., 2009)

As can be seen in Figure 1, bibliometric analysis was performed with 178 studies. Then 178 studies were analyzed by the researchers. After removing irrelevant studies, 112 studies were subjected to content analysis.

Data Analysis and Research Procedures

In the analysis of the studies reached within the scope of the research, bibliometric analysis and content analysis were used. Within the scope of bibliometric analysis, analyses such as distribution of studies by years, most used keywords, distribution of studies by country were made with the Rstudio and Vosviewer programs. In content analysis, another analysis method used within the scope of the study, the reflections of the studies on education were revealed. In this context, recommendations and limitations regarding using metaverse in education are discussed. Again, the metaverse technologies were used in studies on the use of metaverse in education and the use of metaverse according to educational levels are discussed.

Findings

This section gives the findings obtained within the scope of using metaverse in education in parallel with the research questions. In this direction, firstly, the findings obtained because of bibliometric analysis are given and then the findings obtained as a result of content analysis are given.

Distribution of Studies by Years

Within the scope of the research question, the distribution of the studies in the literature by years was examined. In this context, 178 studies were reached. The distribution of these studies by years is given in Figure 2.

study. Virtual reality (Oc= 47), augmented reality (Oc=31), education (Oc=26), artificial intelligence (Oc=14), extended reality (Oc=13), mix reality (Oc=12) were the most preferred keywords in related studies, respectively, along with Metaverse. The most minor keywords are *iot*, *big data*, *technology*, *future of education*, and *mirror world*. It can be said that the authors do not prefer these keywords. In addition, it is seen that the keywords used are grouped into nine different clusters. The distribution of the relevant keywords by year is given in Figure 4.

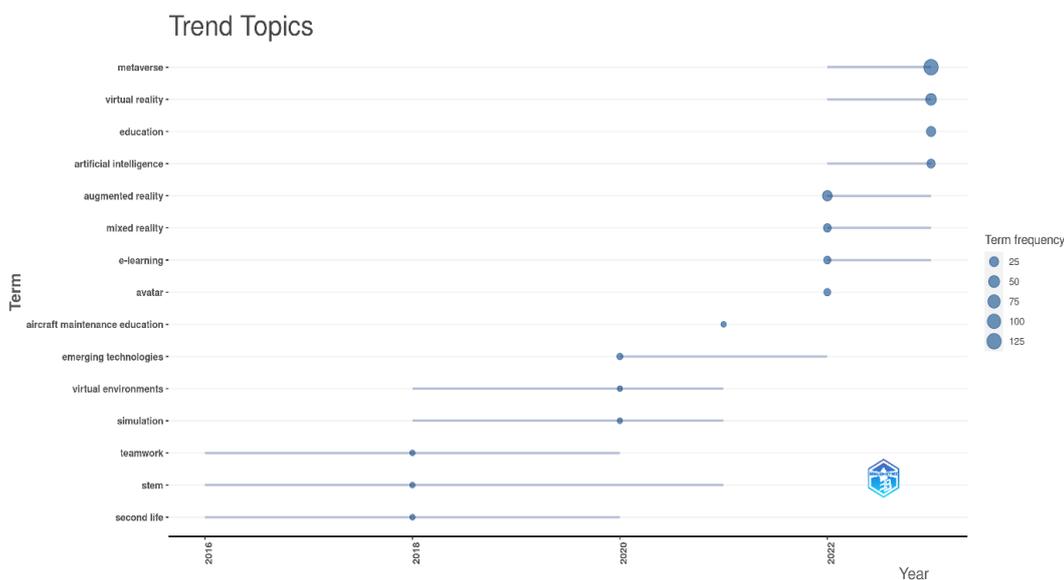


Figure 4. Trend Topics

When Figure 4 is examined, it is seen that the most used keywords are Metaverse, virtual reality and education, and it has become a trend in recent years. It can be said that different keywords were used in previous years. In addition, it is seen that words such as second life, stem and teamwork have been preferred for a long time.

Distribution of Studies by Countries

Within the scope of the research question, the distribution of publications by country was examined. In this context, the analysis results of the top 10 countries with the most publications are given Table 1.

Table 1. Most productive countries and citation counts

Region	Freq	Cited	Cited Per Publication
China	103	153	1.4
South Korea	73	73	1
India	34	46	1.3
USA	30	33	1.1
Spain	27	30	1.1
UK	23	286	12.4
Singapore	18	47	2.6
Mexico	17	12	0.7
Malaysia	15	61	4
Germany	13	4	0.3

When Table 1 is examined, the countries with the highest number of publications are listed as China (n=103), South Korea (n=73), India (n=34) respectively. In contrast to this ranking, the most cited countries are UK (f=286), China (f=153) and South Korea

($f=73$). The relationship between countries and the distribution of publications by country is given in Figure 5.

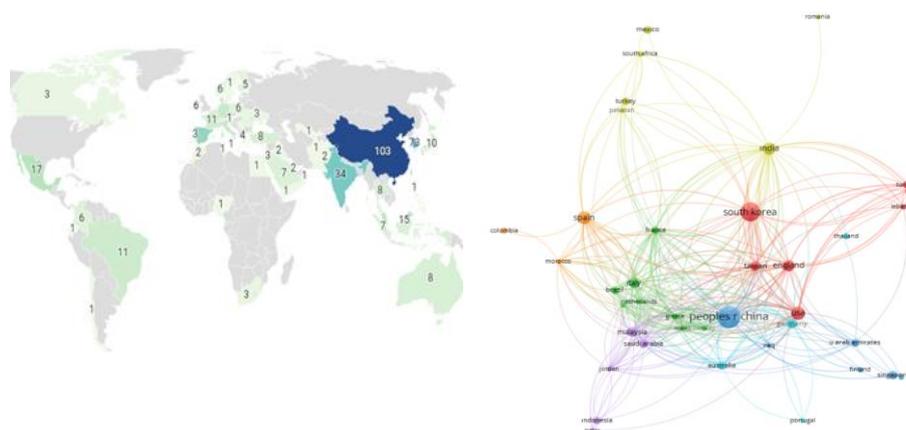


Figure 5. Distribution of publications by country

When Figure 5 is analyzed, it is seen that 56 different countries have published on the Metaverse. It is seen that many countries have conducted studies on the use of metaverse in education.

Distribution of Most Productive Authors

The studies on metaverse in education were examined and the authors with the most publications and citations were determined. The number of publications of the authors, citations to their publications and the number of citations per article are given in Table 2.

Table 2. Most productive authors and number of citations

Authors	Articles	Cited	Cited Per Publication
Kim, J.	3	26	8.6
Lee, H.	3	39	13
Lee, L. H.	3	36	12
Niyato, D.	3	5	1.6
Park, Y.	3	51	17
Yu, Z.G.	3	2	0.6
Aburayya, A.	2	17	8.5
Baabdullah, A.M.	2	28	14
Barry, D.M.	2	14	7
Buhalis, D.	2	28	14

Table 2 shows the 10 authors with the most publications. Kim, J., Lee, H., Niyato, D., Park, Y. and Yu, Z.G. are the prominent authors on metadata in education. Of these authors, Park, Y., Lee, H., and Lee, L.H. received the most citations, respectively. Park, Y., Buhalis, D. and Baabdullah, A.M. stand out regarding the highest number of citations per article.

Distribution of Most Cited Publications

Another point analyzed in the studies analyzed was the most cited studies. In this context, publications, publication year, journal information, citations and number of citations per article are given in Table 3.

Table 3. Most Cited Documents

Authors	Documents Name	Year	Journal	Cit.	C. Per Year
Dwivedi, Y.K.	Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy	2022	International Journal of Information Management	206	103,00
Kye, B.	Educational applications of metaverse: possibilities and limitations	2021	Journal of Educational Evaluation for Health Professions	121	40,33
Xi, N.	The challenges of entering the metaverse: An experiment on the effect of extended reality on workload	2023	Information Systems Frontiers	69	69,00
Tlili, A.	Is Metaverse in education a blessing or a curse: a combined content and bibliometric analysis	2022	Smart Learning Environments	55	27,50
Siyae, A.	Towards Aircraft Maintenance Metaverse Using Speech Interactions with Virtual Objects in Mixed Reality	2021	Sensors	52	17,33
Díaz, J.E.M.	Virtual World as a Resource for Hybrid Education	2020	International Journal of Emerging Technologies in Learning	46	11,50
Jovanovic, A.	VoRtex Metaverse Platform for Gamified Collaborative Learning Chat with paper	2022	Electronics	46	23,00
Suh, W.	Utilizing the Metaverse for Learner-Centered Constructivist Education in the Post-Pandemic Era: An Analysis of Elementary School Students	2022	Journal of Intelligence	44	22,00
Lee, H.	Virtual Reality Metaverse System Supplementing Remote Education Methods: Based on Aircraft Maintenance Simulation	2022	Applied Sciences	40	20,00
Almarzouqi, A.	Prediction of User's Intention to Use Metaverse System in Medical Education: A Hybrid SEM-ML Learning Approach	2022	IEEE ACCESS	40	20,00

Table 3 shows the 10 most cited studies. Of these, the study by DWIVEDI, Y.K. ranked first with 206 citations. This was followed by the studies conducted by KYE, B. and XI, N. Regarding the number of citations per year, DWIVEDI, Y.K., XI, N. and KYE, B. were ranked as follows.

Suggestions for the Use of Metaverse in Education

Suggestions for the use of metaverse in education and its potential in terms of education have been addressed by researchers in many studies as an important issue. By bringing together the suggestions in the reviewed studies, the findings on how metaverse

can be used in education and its potential and how this technology can be used in education are presented in Table 4.

Table 4. Suggestions for metaverse in education

Category	Code	Frequency (n)
To Ensure a Quality Learning Experience	Providing experiential learning	26
	Providing an interactive learning experience	15
	Providing effective learning experience	12
	Providing collaborative learning experiences	9
	Supporting individualized learning activities	8
	Creating social learning environments	8
	Providing flexible learning environments	6
To Improve Student Experience	Increasing student engagement	11
	Increasing motivation to learn	7
	Providing an active learning experience	6
	Increasing learning satisfaction	3
For Skill Development	Improving language learning skills	6
	Supporting cognitive development	3
	Developing digital literacy skills	3
	Developing problem solving skills	3
To Support Education Activities	Supporting vocational education	14
	Supporting private education activities	14
	Support distance and blended learning activities	8
	Supporting pre-school education	2
For Material Use	Reducing the cost of learning materials	4
	Use in teaching difficult and risky tasks	2

When Table 4 is examined, it is seen that the suggestions offered by researchers in studies on the use of metaverse in education are grouped into five different categories. These categories are as follows: to provide quality learning experience, to improve student experiences, to develop skills, to support educational activities and to use materials. While the suggestions with the highest frequency values in the category of suggestions for providing quality learning experience are providing experiential learning (n=26), providing interactive learning experience (n=15) and providing effective learning experience (n=12), the suggestions with the highest frequency values in the category of suggestions for improving student experiences are increasing student participation (n=11), increasing learning motivation (n=7), providing active learning experience (n=6) and increasing learning satisfaction (n=3). In addition, the suggestions with the highest frequency values in the category of suggestions for skill development have equal frequencies as developing language learning skills (n=6) and supporting cognitive development, developing digital literacy skills, developing problem solving skills (n=3), respectively. On the other hand, in the category of suggestions for supporting educational activities, the frequency values were determined as supporting vocational education and supporting special education activities (n=14) with equal frequency, while supporting distance and blended education activities (n=8) and supporting preschool education (n=2). Finally, in the category of suggestions for the purpose of using materials, the frequency values were listed as reducing the cost of learning materials (n=4) and being used in teaching difficult and risky tasks (n=2).

Limitations of Metaverse Use in Education

While Metaverse technology offers important opportunities for educational activities, it also brings along several limitations. In the studies examined, many

researchers mentioned some limitations regarding the use of Metaverse in education. In this direction, the findings about the limitations of using Metaverse in education are shown in Table 5.

Table 5. Limitations of using Metaverse in education

Category	Code	n
Technical Problems	Hardware and software issues	51
	Integration challenges	7
	Usability and interface design issues	6
	Platform incompatibility	5
High Cost	Difficult access for disadvantaged groups	41
	High installation cost	27
Ethical and Safety Concerns	Privacy and security concerns	36
	Ethical issues	19
	Concerns about being cyberbullied	3
Learning Requirement	The need to learn the system	21
	Technical knowledge requirement	10
	Pedagogical knowledge requirement	7
Limitations of the Technology Used	Limited learning experience	17
	Lack of physical and social interaction	14
	The need for extra time	8
	Content creation challenges	7
	Inadequacy of assessment tools	5
	Potential for distraction	7
Health Problems	Psychological and physical health problems (Addiction etc.)	7

When Table 5 is examined, the limitations mentioned by the researchers in the studies on using metaverse in education are grouped into six different categories. These categories are listed as technical problems, high cost, ethical and safety concerns, learning needs, limitations due to the technology used, and health problems. The limitations with the highest frequency values in the technical glitches category were hardware and software problems (n=51), integration difficulties (n=7), usability and interface design problems (n=6) and platform incompatibility (n=5), while the limitations in the high-cost category were difficult access for disadvantaged groups (n=41) and high installation costs (n=27). Moreover, the limitations in the category of ethical and security concerns were privacy and security concerns (n=36), ethical issues (n=19), and concerns about exposure to cyberbullying (n=3). On the other hand, in the learning requirement category, the need to learn the system (n=21), technical knowledge requirement (n=10) and pedagogical knowledge requirement (n=7) emerged. Limitations due to the technology used were listed as limited learning experience (n=17), lack of social and physical interaction (n=14) and need for extra time (n=8). Finally, in the category of health problems, psychological and physical health problems (n=7) were mentioned.

Metaverse Technologies Used in the Studies

Under this heading, the findings on which technologies were used in the studies on the use of metaverse in education are presented. The technologies used in the studies examined in the literature are shown in Figure 6.

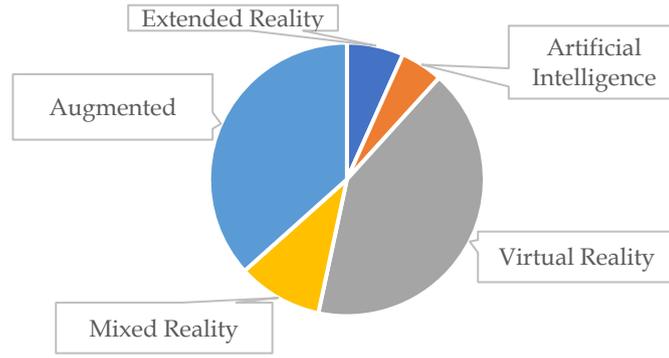


Figure 6. Metaverse Technologies Used in the Studies

As seen in Figure 6, the technologies used in the studies on the use of metaverse in education are listed as virtual reality (41%), augmented reality (37%), mixed reality (10%), extended reality (7%) and artificial intelligence (5%).

Metaverse Use According to Education Levels

It is seen that metaverse is preferred at different education levels in the studies analyzed. In this context, the distribution of the use of metaverse technology according to different education levels is given in Figure 7. This data shows at which education levels metaverse technology is used more intensively.

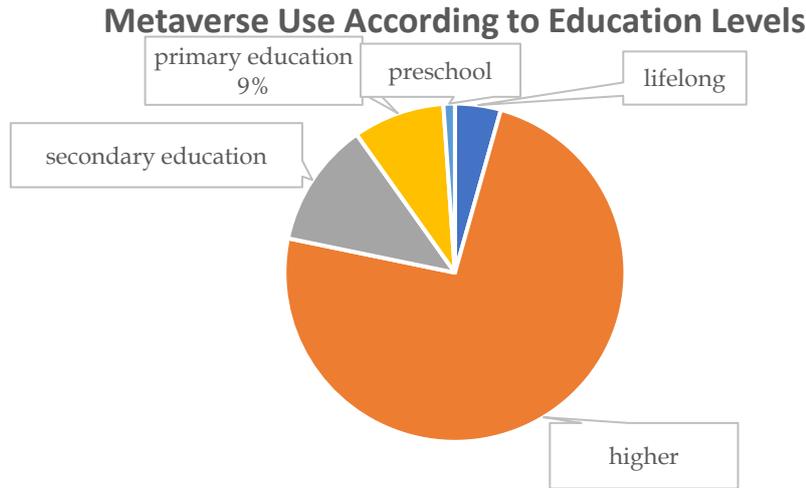


Figure 7. Metaverse Use According to Education Levels

According to Figure 7, higher education (74%) is the education level where metaverse technology is most preferred. Higher education was followed by secondary education (12%), primary education (9%), lifelong learning (4%) and preschool (1%). In addition, the rate of studies in which the level of education was not specified was determined as (8%).

Discussion and Conclusion

In this study, which reveals the trends of studies on the use of Metaverse in the literature within the scope of educational activities, it is aimed to approach the studies conducted in the field of education with a general perspective. For this purpose, within the scope of bibliometric analysis, the distribution of studies by years, the most used keywords and the distribution of studies by countries were examined. In the content

analysis, the reflections of the studies on education were revealed. In this context, suggestions and limitations regarding using metaverse in education were discussed. Again, metaverse technologies were used in studies on the use of metaverse in education and the use of metaverse according to educational levels was discussed.

As a result of the study, it was seen that the studies on Metaverse reached the highest level (n=98) in 2023. The increase in the popularity of virtual environments, especially the pandemic, and the large investments made by companies such as Facebook can be shown as the main reason for this situation (Abbate et al., 2022). Similar results were obtained in studies conducted by Chen and Zhang (2022) and Schmitt (2022). In this study, it was concluded that the studies conducted in recent years have increased continuously.

According to another study finding, virtual reality, augmented reality, education, artificial intelligence, augmented reality, and mixed reality were the most preferred keywords along with Metaverse. Among these keywords, Metaverse, virtual reality and augmented reality are words whose usage has increased in recent years. When the literature is examined, it is seen that keywords such as virtual worlds, AR and VR are the most frequently used keywords, similar to the study conducted by (Narin, 2021). Similar results were found in the studies conducted by Damar (2021) and Taş and Bolat (2022).

According to another finding of the study, a total of 178 studies from 56 different countries have been conducted on the use of Metaverse in education. The top three countries with the most publications are China (n=103), South Korea (n=73) and India (n=34). The fact that these countries invest heavily in technology in the category of developed countries can be stated as one of the main reasons for this result (Dwinggo Samala et al., 2023). In the studies conducted by Taş (2022), Tlili et al. (2022) and Schmitt (2022), similar countries were included in the general list, although there were changes in the rankings. Abbate (2022) also found that the USA is the country with the most research.

The most frequently repeated suggestions for the use of metaverse in education by researchers are about how metaverse should be used in education. In this context, researchers have made suggestions on providing experiential learning, providing interactive learning experiences, providing effective learning experiences, increasing student engagement, supporting vocational education and supporting special education activities. Experiential learning is defined as an approach to learning that emphasizes the learning activity through experience, reflection and practice (Choi et al., 2022). The metaverse aims to facilitate experiential learning by providing a comprehensive and interactive learning space for teachers and students and can also be used to meet the teaching and learning needs of teachers and students in both the physical and virtual world (Guo & Guo, 2022; Cantone et al., 2023). It is also emphasized that the metaverse is a virtual environment that offers students enhanced, immersive experiences and a more interactive learning experience (Teng et al., 2022). Hadi Mogavi (2023) describes metaverse as a revolutionary technology due to its potential to provide greater access to education for students with disabilities. Furthermore, based on the evidence found in the literature that metaverse technology increases student engagement and collaboration, De Gagne et al. (2023) conclude that the use of metaverse in education increases student engagement, knowledge, confidence, satisfaction, and performance. Jovanović and Milosavljević (2022) argue that collaborative learning on a metadata platform can provide students with a unique and immersive experience that can mimic real-life experiences. Again, Aiello et al. (2012) stated that it can enhance experiential learning with a wide range of sensory-motor interactions that cannot be achieved in real life due to high costs or risks, both cases emphasizing the potential of metaverse technology to support

vocational education.

The most frequently cited limitations to using metaverse in education were technical problems, high cost, learning requirements, and ethical and privacy violations. Min et al. (2023) noted that virtual worlds have technical problems that can always arise. In this context, the lack of fast internet access, appropriate computers and other necessary equipment can pose a significant problem (Bakhri & Sofyan, 2022). This highlights the fact that the use of Metaverse technologies in education involves certain resource and cost requirements. Metaverse technology can offer immersive experiences, but this requires considering its costs, such as hardware, software and training costs (Camilleri, 2023). Consequently, using the Metaverse in education may exacerbate existing inequalities as not all students may have access to the necessary technology or resources (Kaddoura & Husseiny, 2023). The fact that users' personal information can be collected and used in unintended ways, as well as tracked and monitored without their consent (Kharvi, 2023) is seen as a limitation in terms of privacy and security concerns. In the study by Alhalaybeh et al. (2023), this was cited as an important limitation. The use of the Metaverse in education, both by teachers and students, is linked to the fact that technology by its very nature requires a specific learning experience and process. Related to this issue, Moro (2023) study suggests that a learning curve may be necessary to be able to use the Metaverse effectively. Li et al. (2022) expressed their opinion that using Metaverse and adapting teaching methods to it may take time and this may affect its effectiveness.

The findings show that the technologies used in Metaverse studies are generally based on virtual reality and augmented reality technologies. In the study conducted by Dwinggo Samala et al. (2023), virtual reality and augmented reality technologies were the most preferred technologies in educational studies.

Finally, the use of metaverse technologies in education is generally concentrated at the higher education level. Metaverse technologies have gained popularity in higher education due to their potential to address the challenges of engagement and interaction, particularly in the context of distance learning (Al-Dhanhani et al., 2023). The use of metaverse technologies in higher education can transform the learning experience by providing new opportunities for engagement, interaction and collaboration (Sunardi et al., 2022).

As a result, bibliometric analysis was performed on 178 papers and content analysis on 112 papers. A review of metaverse educational studies over the last two years showed an increase in their number. The most used keywords were metaverse, virtual reality, augmented reality, education and virtual reality. Leading countries in publishing on this topic were China, South Korea, India and the USA, with prominent authors including Kim, J., Lee, H., Lee, L. H., Niyato, D. and Park, Y. These studies were mainly conducted in universities. The researchers also found that the dominant technologies in the metaverse include virtual reality, augmented reality, mixed reality and augmented reality. Some studies also focus on issues such as poor social networking, privacy concerns, support for mobile learning, and issues affecting disadvantaged groups. Additional studies focusing on the relationship between technology and pedagogy in these milieus may also be considered insufficient and should be undertaken.

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