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# The effect of metaverse technologies on education and human-computer interaction: A systematic analysis of the literature

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**Highlights**

- The most researched topic is how the Metaverse will affect its users.
- The most studied group consists of participants between the ages of 18-40.
- There is a need to design ethical rules for the virtual worlds, establish laws, and protect users' identity and personal data.

**Article Info:** Research Article

**Keywords:** *Web 3.0, metaverse, education, human-computer interaction, systematic analysis*

**Abstract**

Digital transformation encompasses all the principles of people, working methods, and technology that support organizations in achieving their goals with the possibilities provided by the constantly developing information technologies that are in almost every aspect of our lives. Today, the impact of digital transformation is visible in every field with constantly developing technologies, and there is a rapid transition to digital innovations in almost all sectors. Web 3.0 and Metaverse, which are two innovations that support each other, are technological developments that can be used in many areas, and it is curious what role they will play in daily life. This study aims to present research on how the education and human-computer interaction fields can be synchronized with Metaverse technology with the impact of the digital age. In this study, the articles accessed by using the systematic analysis method were examined under the headings of subject, journal, year, research method, study group and sample, data analysis method, data collection method, field, country, conclusion, and suggestions for future studies. As a result of the research, 61 articles were found in the Web of Science database. Thus, it is aimed to obtain and discuss the results of how Metaverse technologies are reflected in the fields of education and human-computer interaction, in which direction they evolve, and how they will be reflected in future studies.

## 1. Introduction

Metaverse, which has become popular in many areas, especially in education and training processes, was first mentioned in the 1992 science fiction novel “Snow Crash” written by Neal Stephenson. In 2021, Facebook's adoption of the Metaverse brought it back to the forefront and its popularity has increased significantly. Metaverse, as a concept, means beyond the universe / the universe beyond. Metaverse refers to a virtual universe beyond the universe we are in. It is a three-dimensional fictional reality that occurs beyond the physical world through virtual reality and avatars. The Metaverse, which first emerged with the game “Second Life”, has started to evolve towards a new realm of socialization that offers people a virtual version of the physical world outside the game world (Duan et al., 2021). Metaverse is a platform where users can shop and trade using cryptocurrency and NFT (nonfungible token), buy houses and land, go to

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concerts, cinemas, and cafes, travel not only the world but also galaxies, socialize, participate in educational activities, work, and experience everything with their avatars in a 3D virtual world in augmented reality (Calandra & Chiu, 2021).

Web 3.0 is a concept that explains the development of web interaction and usage, which enables web technology to transform into a database. It represents a period in which the infrastructure of web technologies can be improved by no longer focusing only on the front end. Web 3.0 is also expressed as a user-created platform with high-quality content and services that embrace Web 2.0 technologies (Shivalingaiah & Naik, 2008). Web 3.0 is also referred to as a technology created only by humans in the internet world. This technology provides interaction between devices and information on the Internet, and humans and machines can understand the relationship between this information. Just like artificial intelligence, machines keep all the information in their memory and share it in the needed areas (Kutup, 2010).

Although Web 3.0 and the Metaverse are conceptually different, they have a shared future. The Metaverse is a digital world, while Web 3.0 promises a decentralized internet. In this respect, Web 3.0 can serve as the basis for connectivity in the Metaverse. On the other hand, the creative economy in the Metaverse can perfectly integrate with the vision of Web 3.0 by developing an unorthodox new financial world by implementing decentralized solutions. Therefore, it is considered that the Metaverse and Web 3.0 technologies have a shared future, and as one develops, the other will also develop.

With the Covid-19 pandemic, technology companies started to focus more on digital education activities to overcome the problems arising in the field of education. Before the pandemic, the Metaverse was seen as an entertainment platform where people could socialize and play games (Sullivan, 2021). However, with the pandemic period, the metaverse has started to be actively used worldwide and applications such as real-time online distance education systems, business meetings, events, etc. have opened the doors to a potential new world, the Metaverse universe.

Today, Metaverse technology, which has made a name for itself in areas such as education, marketing, gaming, tourism, health, and real estate, is expected to take place in all sectors and affect every field in the coming years. It is thought that one of the sectors where the Metaverse will be most effective is education. It is obvious that virtual world applications such as Metaverse are important in knowledge and experience transfer processes, especially in the education sector. Many advantages can be expressed as experience-based education, content and scenario-based learning, prosperous and efficient, user-interactive learning, application of the knowledge obtained in the field and allowing trial and error method, the motivational element created by working in a real scenario, the ability to work with the content to be created on many possible scenarios brought about by being digital and the time, space and budget advantage it creates (Damar, 2021). The metaverse is a virtual world with a virtual economy, where the user interacts, makes sense of it, spends money, and has a virtual economy, far beyond the distance education, virtual and augmented reality environment. Therefore, Metaverse is a critical and very important tool for educational technology. For this reason, teaching and technology can be effectively combined with the Metaverse and contribute to the well-equipped upbringing of new generations. In their study, González et al. (2013) examined the potential benefits of virtual worlds for learning, collaboration, motivation and improving students' academic performance. They explained that the students felt comfortable in the virtual environment and thought it was beautiful, comfortable, spacious, and suitable for learning. They also stated that students' motivation increased because they thought the content taught through the virtual world was appropriate. MacCallum and Parsons (2019) examined the effect of metaverse environments on learning in their study. They examined the content development by training teachers and the effect of this practice on teachers. As a result, they stated that metaverse applications lead to new ideas about how they can be applied in education. Still, appropriate professional development should be provided to pre-service teachers to produce these new ideas. Díaz et al. (2020) implemented education that promotes self-directed and collaborative learning for university students in a metaverse environment in a mathematics course. They stated that virtual worlds increase flexibility and classroom dynamics in education by facilitating the teacher's use of classroom and collaborative learning pedagogies. As can be seen, many studies in the

literature show that including metaverse technologies in educational processes is essential for all stakeholders. For this reason, in this study, while the effects of Metaverse on all sectors are discussed, how it will take place in education is examined in more detail and it is aimed to reveal the studies and applications related to Metaverse in the field of education. In this descriptive study, the data used was obtained through a literature review and the data obtained was compiled and presented.

It is possible to come across various systematic review studies in the literature. In their study, Orman et al. (2022) examined the academic studies on the Metaverse conducted between 2005 and 2022 regarding distribution by years, scientific fields, ethical and regulatory issues, and social responsibility. It is seen that they focus on social responsibility and ethical issues in their studies. Gadekallu et al. (2022) conducted a comprehensive review of blockchain applications for the metaverse better to understand the role of blockchain in the metaverse. Han et al. (2023) conducted a systematic review on using Roblox, an essential platform of the metaverse, in learning. Alfaisal et al. (2022) systematically evaluated metaverse research in education in terms of theories/models of information systems evaluation. They conducted a study that can help academics to conduct additional research on metaverse acceptance. It is seen that the researches are specialized according to various fields or topics. This study focuses on the fields of education and human-computer interaction and is different from other studies in this respect.

Literature review studies are one of the studies to assess the state of knowledge of the current situation. Published literature review studies include discussions on the direction of future research. Discussions in this area are essential in terms of identifying productive lines of inquiry and helping to integrate existing knowledge with future findings (Guzzo et al., 1987). This systematic review aimed to initiate a discussion on how Metaverse technologies are used in the fields of education and human-computer interaction, in which direction they are progressing, and the research to be carried out in the perception of their importance. In this way, it is aimed to contribute to the adoption and development of Metaverse technologies in the fields of education and human-computer interaction. It is also expected to contribute to possible studies with a systematic perspective on what can be done in adopting and developing these technologies.

## 2. Method

Literature review studies can be conducted with various methods, and review studies are conducted in three different ways in the literature. These are traditional, narrative review, systematic review, and meta-analysis. This study was conducted using the systematic review method, which is one of the literature review methods. A systematic review is a detailed investigation of all studies published in the field to answer a clinical question or find a solution to a problem, including various inclusion and exclusion criteria and assessing the quality of studies to determine which studies should be included in the review (Burns & Grove, 2007; Higgins et al., 2019). A systematic review can evaluate quantitative and qualitative findings or two or more types of findings, referred to as a “mixed systematic review” (Hemingway and Brereton, 2009). The systematic review is a research method in which the most substantial evidence is produced for evidence-based practices. A search strategy is developed using keywords specific to the systematic review question. The most appropriate electronic database is selected for searching. Digital search is performed using the selected appropriate databases. The data extraction phase should follow the aim of gathering and organizing all relevant data coherently and organized.

In this direction, the following strategies were applied in this study. Firstly, a systematic review strategy was determined following the literature review method. The search was carried out in two stages. The database, keywords, and data analysis method were decided in the first stage, and the search was carried out accordingly. In the second stage, the articles reached because of this review were analyzed and evaluated according to the criteria of subject, year, research method, study group & sample, data analysis type, data collection method, country, results, and suggestions for future studies.

### *2.1. Systematic Review Methodology*

This study is based on digital databases as primary sources. Web of Science was selected as the most widely used digital library and a database with important indexes. "Metaverse" was chosen as the keyword. "Education & Educational Research" and "Human-Computer Interaction" were chosen as the field of study. The article was selected as the document type and early access studies were included. Thus, it was aimed to evaluate the research topic more clearly by selecting the keyword and the field of study and limiting the search. Thus, this study was limited to education & educational research and human-computer interaction. Those that were not document-type articles were excluded from the study. All years in the database were selected as the year and studies were analyzed without any year limitation. The system automatically retrieved studies between 2005-2022. The following query was obtained: Topic=(METAVERSE) Refined by: CitationTopics.meso=(EDUCATION & EDUCATIONAL RESEARCH OR HUMAN COMPUTER INTERACTION) D o c u m e n t T y p e s= ( A R T I C L E OR EARLY ACCESS) Publicationyears=(ALLYEARS) WebofScienceIndex=(SSCI, SCI-EXPANDED, ESCI, A&HCI).

### *2.2. Systematic Review Process*

In the first stage, which runs the query in the searching strategy, 603 articles were reached. Then, to reach the main objective of the research, the search area was limited by including education & educational research and human-computer interaction studies as the subject of the search process. As a result of this search query, 112 articles that met the research criteria were found. This analysis excluded studies that did not qualify as articles, and only those were considered document types. Early access studies were also included. After the articles were verified, a total of 63 articles were obtained. Each article in the literature, which was expanded as much as possible with the systematic review strategy, was examined within the determined criteria and 2 articles that were not allowed access were excluded from the research. Finally, 61 articles were identified for the present analysis. It is illustrated by the PRISMA flow diagram (see Figure 1). The 61 articles are presented in Appendix 1. Within the scope of this study, the research was limited to education and human-computer interaction studies, although there are many areas where Metaverse is used. The field of human-computer interaction, which often includes metaverse studies, is included in this study because it also includes educational studies.

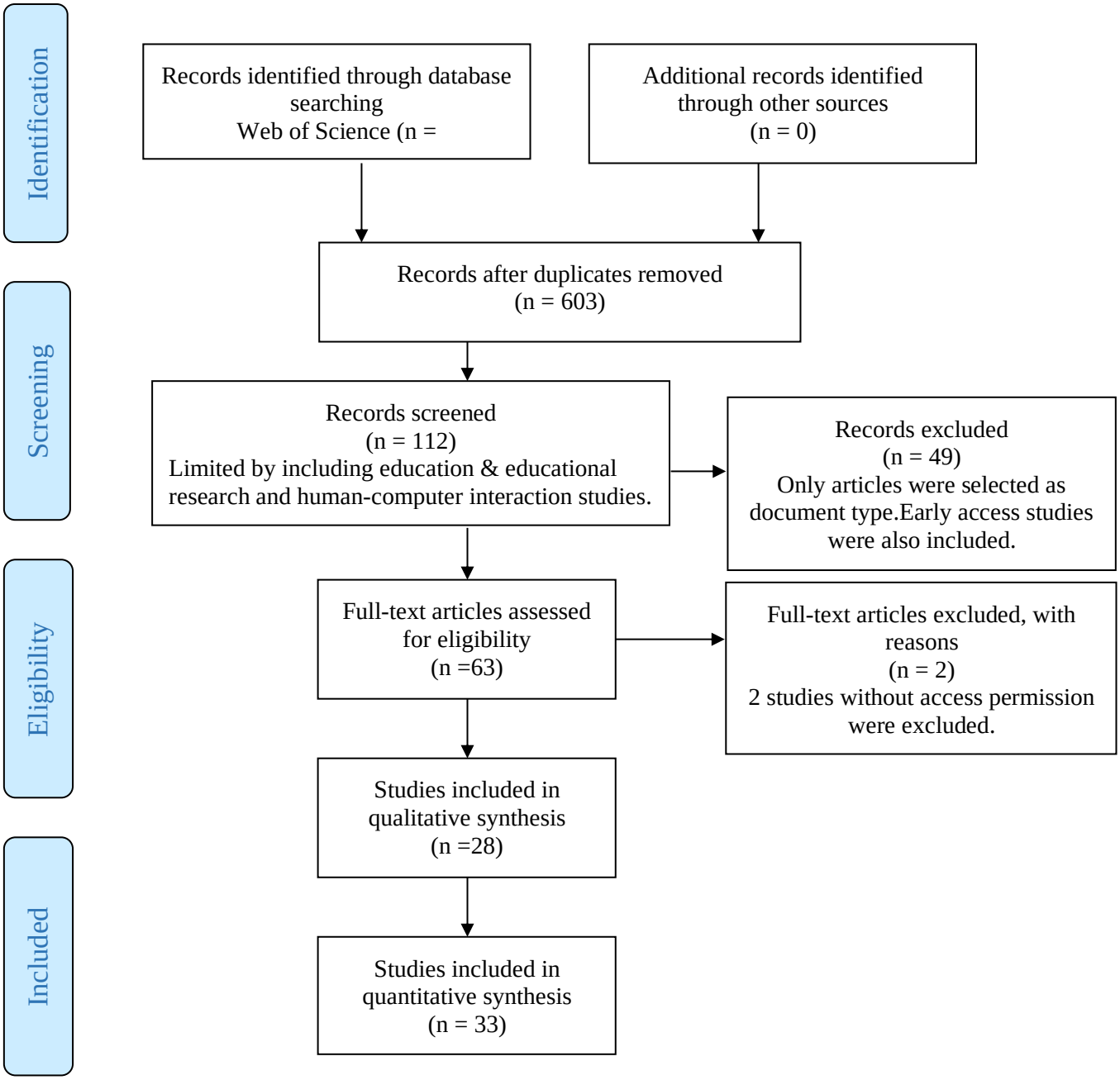


**Fig. 1:** PRISMA Flow Diagram of the Search Process

### *2.3. Reporting of the search process*

The 61 articles were analyzed based on the following headings (criteria): These criteria were chosen because they can enable research to be analyzed in all aspects and are thought to shed light on the purpose of the study. Especially the “conclusion and suggestions for future studies" criteria was chosen to obtain essential findings that would contribute to the fields of education and human-computer interaction.

- Bibliography of the article
- Year of publication

- Country
- Research Methodology
- Study group & sample
- Type of data analysis
- Data collection method
- Topic covered (Field)
- Conclusion
- Suggestions for future studies

### *2.4. Validity of the searching*

The 61 articles examined during this study were analyzed using an Excel data form according to the criteria set out above. In this way, each independently generated data cell had the opportunity to be compared with each other. When non-identical data cells appeared, the relevant study was re-analyzed. Each table cell was examined and checked repeatedly, and the final version was decided upon when the correct result was reached. The researchers conducted the systematic review in accordance with these strategies. Two researchers collaborated to review the literature with high inter-rater reliability (k = 0.89). In cases where a consensus could not be reached, it was discussed, and a third researcher was asked when necessary.

## 3. Findings

### *3.1. Findings Related to the Topic Covered*

As a result of the search based on the keyword Metaverse, 43 articles in the field of human-computer interaction and 18 articles in the field of education & educational research were found. When analyzing the content of the articles, the focus in the field of education was on the use and efficiency of Metaverse technologies within the scope of primary education (motivation of students in the classroom, interaction with each other, learning level, etc.). In the field of human-computer interaction, the interaction, development, and future of metaverse technologies with existing sectors were evaluated. In the field of human-computer interaction, the most examined subject was articles on information systems. At the same time, integrating marketing, medicine, and transport sectors with Metaverse technologies was also popular.

**Table 1.**

Data related to the topic covered

| **Education Area** | **Number of Articles** |
|---|---|
| Education and training | **18** |
| **Human-Computer Interaction Area** | **Number of Articles** |
| Information Systems | **18** |
| Marketing | **6** |
| Medicine | **3** |
| Transport | **3** |
| Psychology | **2** |
| Sociology | **2** |
| City Planning | **2** |
| Advertising | **1** |
| Architecture | **1** |
| Journalism | **1** |
| Health | **1** |
| Production | **1** |
| Art | **1** |
| Tourism | **1** |

### *3.2. Findings Related to the Research Method*

Regarding the research method, 61 articles were mainly prepared using experimental and qualitative research methods. While evaluating the studies related to the Metaverse, there is a great interest in experimental studies (Table 2). In total, 51% of the reviewed studies used experimental research methods. Notably, the qualitative research methods used in the articles reached because the research constitutes 45% of the existing literature. Qualitative analysis methods are used to obtain a more precise analysis of the adoption factors related to the Metaverse and the conditions that support or hinder users.

**Table 2.**

Data related to the research method and data analysis type

| Research Methodology | Data Analysis Type | Number of Articles |
|---|---|---|
| Experimental Research Method | Quantitative | **31 articles** |
| Qualitative Research Method | Qualitative | **28 articles** |
| Action Research | Quantitative | **1 article** |
| Design Research | Quantitative | **1 article** |

### *3.3. Findings Related to the Data Collection Method*

Regarding the data collection method, the most frequently used method was a questionnaire, while the other frequently preferred methods were literature review and document analysis.

**Table 3.**

Data related to the data collection method

| Data Collection Method | Number of Articles |
|---|---|
| Questionnaire | **20** |
| Literature Review | **15** |
| Document Analysis | **13** |
| Observation | **9** |
| Questionnaire + Interview | **1** |
| Questionnaire + Observation | **3** |

### *3.4. Findings Related to the Study Group*

Regarding the study group, general participants were mostly aged between 18 and 40. Then, the student study group was selected from university students. In some educational studies, it was also observed that students and teachers were participants together.

**Table 4.**

Data related to the study group/sample

| Sample | Number of Articles |
|---|---|
| General Participants (18-40 age range) | **26** |
| University Students | **20** |
| Primary School Students | **6** |
| Students+Teachers | **3** |
| Students+Staff | **2** |
| High School Students | **1** |
| Managers | **1** |
| Metaverse Users | **1** |
| Researchers and theatre actors | **1** |

### *3.5. Findings Related to the Research Year*

Regarding the research year, many of the studies were conducted in 2022. From this perspective, it is understood that the popularity of the Metaverse has increased in recent years, while very few studies have been conducted in the past years.

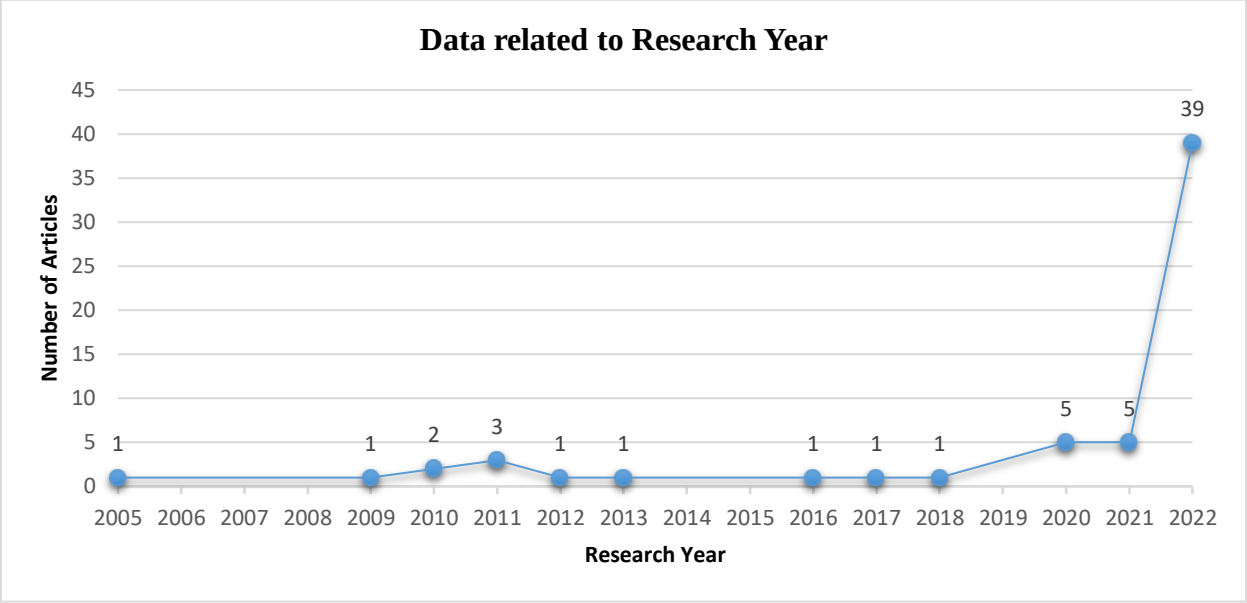


**Figure 2.** Data related to Research Year

### *3.6. Findings Related to Countries of the Researches*

As a result of the review, an important detail about the countries of the research was observed. Metaverse research is particularly important in Asian countries such as South Korea and China, and there is much more research on the future of the Metaverse, especially in South Korea than in other Western countries. This finding is a clue as to which countries may shape the future of the Metaverse. Other countries with the highest number of literature studies are the United States of America, followed by the United Kingdom. Other European and Asian countries such as Serbia, Mexico, and Ecuador have one study each. In addition, while it is noteworthy that other developed countries do not have many studies on this subject, studies have been carried out in Türkiye.


**Figure 3.** Data related to the countries of the researches

## 4. Discussions of Researches

### *4.1. Findings Related to the Results of the Researches*

When the results of the researches are evaluated, the view that the use of Metaverse in the field of education will significantly benefit students comes to the fore. An educational approach that includes virtual reality, augmented reality, and mixed reality significantly improves students' performance. 3D simulation environments have been shown to increase the productivity of students by encouraging students to learn and have positive contributions to communication and interaction (Chen, 2022). When the relationship of the Metaverse with other fields is analyzed, it is found that the variables of perceived usefulness and usability of users in terms of cognitive results are the most researched topics in the literature. This is thought to be related to analyzing the cognitive states of users, especially in Metaverse environments (Makransky & Mayer, 2022). This finding is also reflected in the reviewed literature.

In almost all of the research reviewed, the overall positive effects of the Metaverse and its technologies were revealed. However, some researchers also mentioned negative aspects. For example, Lukava et al. (2022) mentioned the problems that people with neurological disorders may experience in Metaverse experiences. In addition, the issues that software developers should pay attention to show that the negative effects of Metaverse are evaluated. The technological requirements (such as the need for hardware and web connection) that may arise in Metaverse applications have not been emphasized much in educational studies (Bilhao Gomes & Klein, 2013). In the literature review, there is very little mention of potential concerns and negative consequences of Metaverse, and the studies have mostly addressed the positive effects of Metaverse technologies.

### *4.2. Findings Related to Suggestions for Future Studies*

According to the suggestions of the researchers for future studies, the most emphasized suggestion in the literature studies is being very little information about the Metaverse, that the existing studies are insufficient, and that there is a need for more different and wider research by giving the necessary importance. In future studies, it is recommended to expand the scope of Metaverse applications, for example, to investigate these technologies in different sectors and different Metaverse environments (for example, virtual shopping using AR and VR technologies together). It is also suggested to determine the characteristics of virtual objects designed in virtual environments such as color, size, location, etc. based on user satisfaction (Choi & Kim, 2022). In this way, differences in user satisfaction can be seen more

clearly. In addition, it is one of the noteworthy propositions that Metaverse organizers should make the existing regulations even easier when designing the Metaverse and design it in a way that everyone can access it (Choi & Kim, 2022). Finally, it is pointed out that there are very few existing legal regulations regarding the Metaverse. It is suggested that Metaverse users and businesses should make some legal arrangements against the negative effects that may arise in this virtual world. Thus, turning the Metaverse into a safe and socially acceptable platform is an important point to be emphasized, and there is a need to design ethical rules for the Metaverse, create a law, and protect the identity of users (Lombardi & Lombardi, 2010).

## 5. Conclusion and Discussion

As a result of the systematic review conducted in this study, 61 articles that met the criteria were found; in these articles, the effects of Metaverse technologies on human-computer interaction and especially in the field of education were examined. The articles were analyzed under the following headings: topic, year, research method, study group & sample, data analysis type, data collection method, country, results, and suggestions for future studies.

In the systematic review of the articles, the most researched topic is how the Metaverse will affect its users. The research in the field of education generally includes scenarios about the changes that Metaverse technologies will bring about in students' learning capacities and interactions (Chen, 2022). In terms of educational scenarios, the Metaverse will be a learning method that can overcome the limitations of time and space and that everyone can experience directly, unlike traditional education. Students can guide their educational processes, monitor their progress, and learn just like playing a 3D game. The idea was also put forward that the unequal distribution of educational resources could be effectively addressed. While Metaverse education opens the doors to an immersive and fun educational approach, it can also bring many problems such as technical development difficulties, content production, and game addiction (Chen, 2022). It is thought that it is necessary to be prepared for such negative scenarios. According to Zhang et al. (2022), with the Metaverse, students can feel as if they are in a real-world educational environment, and the application of the Metaverse in education can create a variety of fantastic learning experiences for students. However, according to the researchers, although metadata offers us innovative perspectives for education, one should be cautious about a few challenges related to metadata for both educational and other purposes. Educators working together with developers to develop new teaching models related to the Metaverse can help reduce negative situations that may arise in the future.

While many results support the use of Metaverse in the educational field, there are very few studies that reveal the suitability for children with special needs such as autism or physical disabilities (Suh & Ahn, 2022), which shows that more information needs to be collected on this subject. To improve the effective use of Metaverse technologies in the educational field, it would be beneficial to design learning environments considering the physical differences of students.

While most researchers have tried to answer the question of what an ideal Metaverse platform should be in the field of education, some researchers have evaluated the existing leading platforms in the Metaverse. For example, it has been argued that transforming the Second Life platform into an educational platform with features such as graphic richness, high level of interaction, creative possibilities and networking can contribute to students' learning levels (Márquez, 2011). In another study, the innovative design and security advantage of the Vortex platform could host its use in the education field (Jovanović & Milosavljević, 2022). User evaluations of existing platforms are very important for the development and further enrichment of Metaverse platforms that will carry out virtual education activities. In this context, testing of existing platforms will also guide future studies.

Metaverse is also thought to contribute to students in terms of communication and teamwork (Bilhao Gomes & Klein, 2013). Metaverse technologies will contribute to the development of interpersonal social relations by providing people with opportunities such as planning, acting, and interacting. Metaverse will lead to social and cultural interaction experiences, and it will go beyond being just a game or social media platform and will exist in a complementary way with the real world. According to Park and Kim (2022),

with the Metaverse, students can represent themselves in the virtual world in a completely different way with their avatars. They can use their digital identities (i.e. avatars) in customized, realistic and dynamic ways to participate in lessons. Thus, learner identity is formed and their motivation and belonging to the course process can increase.

In research on human-computer interaction, essential conclusions have been drawn from the relationship between user characteristics and the Metaverse experience. In most studies, a measure of user satisfaction has been identified and inferences have been drawn about which criteria should be emphasized to increase user acceptance of Metaverse platforms. In addition, the features of Metaverse have been discussed, including the advantages of Metaverse's multi-technology use, social features, and lack of time-space limitations. However, these applications need to be tested and developed in other areas such as education. Studies in these areas will be seen as an important potential area for future research. Studies on the adoption of Metaverse technologies by students and users can contribute to the field and applications.

Another factor that stands out in the research on human-computer interaction is the extent to which Metaverse technologies will be useful for educational purposes in different fields (e.g. urban planning, marketing, medicine, aircraft maintenance). Metaverse technologies are a promising application in nursing education, especially against situational or economic limitations that may be experienced after the Covid-19 outbreak (Zhao et al., 2022). It has been emphasized that it improves the ability of medical personnel to overcome health emergencies when traditional training methods are insufficient under adverse conditions. Since all training activities in the Metaverse system take place in a virtual environment, the applicability of complex and difficult training in terms of simulating high-cost and high-risk scenarios is one of the most important advantages of Metaverse training. The contribution of the system to the learning effect in a technical training field such as aircraft maintenance has been confirmed by researchers (Lee et al., 2022).

When the articles are analyzed according to the study group and sample size, the most studied group consists of participants between the ages of 18-40. Mostly young and middle-aged samples are used to determine the user experiences of the Metaverse. The possible reason for this finding is considered as follows; since Metaverse is a new technology, it may be appropriate to prefer the age range that is both prone to technology and uses it effectively to obtain more accurate and reliable results. Because Metaverse users need to adopt and use these technological innovations effectively. After the participants were selected from the 18-40 age range, the most studied group is university students. The fact that the student subjects in the study were generally selected from university students may be because the researchers work at universities. In addition, the studies conducted with teachers were generally conducted with students. It is noteworthy that there are few studies conducted with primary school students and high school students. To increase the effectiveness and generalizability of the studies, there is a need to conduct different studies by increasing the number and diversity of the sample group.

As a result of the review, it is noticeable that the effects of the studies on Metaverse technologies have only recently begun to be investigated. The importance of Metaverse is just beginning to be understood and more studies should be done for its promotion. Metaverse can solve both real-world and virtual-world problems. Metaverse designers should design existing designs to be easily accessible to everyone and create policies to promote the Metaverse industry. There is a need for further research on Metaverse technology and further development of these technologies. In addition, it has been noted that there are ongoing discussions in the existing literature about the legal regulations of this new virtual world. According to Zhang et al. (2022), it is possible that students may be exposed to criminal incidents and face situations that may violate students' privacy. In this case, relevant rules and regulations need to be put in place to ensure that the metaverse is not a lawless digital space. As the Metaverse has a high degree of freedom, it has users from all over the world (Kye et al., 2021). This raises new concerns that may cause inter-racial, inter-religious, or inter-gender ethical challenges (Park & Kim, 2022). Therefore, it is important to transform the Metaverse into a good ecosystem with well-defined rules and to develop learners' metaverse citizenship through ethics and legal education (Zhang et al., 2022). There is a need to design ethical rules for this world, establish laws, and protect the identity and personal data of users.

## 6. Limitations and Suggestions

Based on the results of the review, a framework for the impact of Metaverse technologies as an innovation in the field of human-computer interaction, especially in education, is established and suggestions are made for possible future research. This study is limited to literature studies that examine Metaverse technologies in the context of education and human-computer interaction. Accordingly, studies from different sectors (e.g. management, software engineering, entertainment, sports) or non-article studies are not presented in this review. To conduct comprehensive systematic literature searches, certain criteria were followed and various possible search words were carefully considered, but there may be studies that analyze Metaverse technology under other terminology and therefore were not found during the search phase. Also, it was noticed that the reviewed papers were from countries such as South Korea, the USA, and China, where the Metaverse technology has matured and is widely used in various industries. The results can be extended in the future by extending the case studies on the Metaverse to other countries. However, it is believed that this research will provide a broad and detailed picture of the latest research on the Metaverse and will guide future research in this field.

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The author(s) declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

### Availability of data and material

Data is available on request due to privacy/ethical restrictions.

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The author(s) contributed to and have approved the final manuscript.

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**Appendix 1**

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