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Metaverse in education in the era society 5.0: A systematic literature review

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ABSTRACT

Metaverse emerged as a key concept in the Age of Society 5.0. The metaverse has the potential to be particularly relevant in distance education to overcome limitations as a two-dimensional web learning tool. This research aims to explore the utilization of the metaverse in education, highlighting the distribution of studies by year, country, field, type of research, and technological context. The approach used in this study is SLR (Systematic Literature Review). The library sources used are sourced from five academic studies that have been indexed by Scopus. The results showed that the metaverse can create a participatory and continuous learning environment, the efficiency of the learning process can be maximized, facilitate synchronous and asynchronous learning, as well as the flipped classroom method and fun cooperative learning to provide motivation and cooperation. In conclusion, the development of the metaverse in education reflects the dynamics of technological changes and the demands of the society 5.0 era. With the continued development of metaverse technology, future research is expected to provide deeper insights into how the metaverse contributes significantly to achieving learning goals in an era that is increasingly integrated between the virtual world and the physical world.

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ABSTRAK

Metaverse muncul sebagai konsep kunci dalam Era Society 5.0. Metaverse memiliki potensi sangat relevan dalam pendidikan jarak jauh untuk mengatasi batasan sebagai alat pembelajaran web dua dimensi. Penelitian ini bertujuan menggali pemanfaatan metaverse dalam pendidikan, menyoroti distribusi studi berdasarkan tahun, negara, bidang, jenis penelitian, dan konteks teknologi. Pendekatan yang digunakan pada penelitian ini adalah SLR (Systematic Literature Review). Adapun sumber pustaka yang digunakan bersumber dari lima studi akademis yang telah teindeks scopus. hasil penelitian menunjukkan bahwa metaverse dapat menciptakan lingkungan pembelajaran yang partisipatif dan berkelanjutan, efisiensi proses pembelajaran dapat dimaksimalkan, memfasilitasi pembelajaran sinkron dan asinkron, serta metode kelas terbalik dan pembelajaran kooperatif yang menyenangkan untuk memberikan motivasi dan kerja sama. Sebagai kesimpulan, perkembangan metaverse dalam pendidikan mencerminkan dinamika perubahan teknologi dan tuntutan era society 5.0. Dengan terus berkembangnya teknologi metaverse, penelitian di masa depan diharapkan dapat memberikan wawasan lebih mendalam tentang bagaimana metaverse berkontribusi nyata dalam mencapai tujuan pembelajaran di era yang semakin terintegrasi antara dunia maya dan dunia fisik.

Kata Kunci: *systematic literature review; metaverse; society 5.0; pendidikan*

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INTRODUCTION

Considering that the development of computer technology occurred in several stages, the first stage involved the development of personal computers, the second stage was the introduction of the Internet, and the third stage was the development of mobile devices (Zukhrufillah, 2018). We are currently in the fourth stage, where immersive environments created by digital reality technology are becoming increasingly present in everyday life. It can be clearly observed that digital reality technology has the potential to transform the fields of education, remote work, marketing, economics, and the entertainment industry, and has begun to create new paradigms of information communication. This development is inseparable from the innovations introduced by experts in the fields of computers and the internet, creating a new, more modern ecosystem. Currently, we are on the edge of a transition toward Society 5.0, which is referred to as The Super Smart Society or '*masyarakat super pintar*' (Huang et al., 2022). As mentioned, Society 5.0 was introduced by the Japanese government in January 2016, defining it as a concept where technology coexists with humans to sustainably improve the quality of life (Barlian & Ismelani, 2022). It can be said that a new paradigm has emerged, formed around the concept of the Metaverse (Mystakidis, 2022).

It can be observed that major technology companies are competing to create Metaverse infrastructure and standards by continuously developing hardware and software, while also addressing privacy and security issues (Sulistianingsih *et al.,* 2023). As a result of this competition, it is naturally expected that issues such as user privacy rights must be protected so that the Metaverse will be inclusive for the education sector, and that digital reality-based hardware needs to be produced that is ergonomic, comfortable, and lighter (Han et al., 2022). As the Metaverse becomes increasingly important and interesting, especially in the field of distance learning, research is needed to investigate the effects and practices in this area of study. By exploring the use of the Metaverse in education, suitable and applicable variations and innovations can be found for educational institutions in Indonesia. Therefore, this study aims to examine studies on the use of the Metaverse in education, determine the distribution of Metaverse studies by year, country, field, research type, and technological context, and provide suggestions for future research based on the findings of this study.

The metaverse refers to a world where virtual and reality interact and develop simultaneously through social, economic, and cultural activities carried out to create entities and value. Metaverse technology is rapidly entering our lives, and some of its applications are already being used in education (Lee et al., 2022). The concept of a maximized Metaverse can be optimized for distance learning, which seems promising (Barlian & Ismelani, 2022). Therefore, it is essential to clearly define the boundaries and meaning of the Metaverse concept from the outset, thereby establishing a solid foundation for its use in education. One example of an activity in the Metaverse application in the economic field is that people will be able to use the Non-Fungible Tokens (NFTs) they generate and share their virtual products, for example, digital land. In addition, an example of Metaverse usage in the social field is that users will be able to create spaces for socializing, entertainment, and learning on interoperable platforms, thereby becoming part of a global community (Allam *et al*., 2022; Bojic, 2022; Visconti, 2022).

The term "Metaverse" is formed from the combination of the word "meta," meaning "beyond" or "after," and the word "universe." Since the Metaverse is composed of words that mean "beyond" and "universe," it also implies a realm beyond the universe. The metaverse can have different meanings for various disciplines or environments. However, essentially, it is a multi-user platform and technological innovation, i.e., a digital reality environment that surpasses physical reality in terms of computer technology or educational technology.

The metaverse was first introduced to the world in 1992 thru Neal Stephenson's science fiction novel titled Snow Crash (Duan et al., 2021). Many efforts and research have been undertaken to transform Metaverse technology from mere book fiction into technology that can be used in real life (Kye et al., 2021; Putri,

2022; Apridar, 2022). A research organization called "The Acceleration Studies Foundation" (ASF) announced its Metaverse roadmap in 2006, including augmented reality, virtual worlds, mirror worlds, and lifelogging. Ball describes the Metaverse as a massively and interoperably real-time rendered three-dimensional network that can be experienced simultaneously and permanently by an unlimited number of users (see: https://www.matthewball.vc/all/forwardtothemetaverseprimer). Bosworth and Clegg state that the Metaverse is a series of "sandboxes" that you can create and explore with others who are not in the exact physical location (see: https://about.fb.com/news/2021/09/building-the-metaverse-responsibly/). They define the Metaverse within a framework where the perception of reality is created, the real world merges with virtual space, and reality is extended into virtual space.

In the ever-evolving educational landscape, the integration of Metaverse technology is becoming a transformative force that permeates traditional learning paradigms. This research aims to explore and compare the utilization of Metaverse technology in education. In exploring the complexities of Metaverse adoption, the opportunities and challenges encountered can serve as a gap in educational innovation, particularly in the implementation of the Metaverse in the educational sector.

LITERATURE REVIEW

The Metaverse is an interconnected social network that creates an immersive environment within digital platforms, with a sustained presence of many users. The development of the Metaverse includes the implementation of technological forms such as Augmented Reality and Virtual Reality (Pangestu & Rahmi, 2022). The utilization of Metaverse technology has potential in the education sector as an educational tool that supports the learning process (Endarto & Martadi, 2022; Indrabayu et al., 2022; Istianah, 2021). Today's young generation is often referred to as digital natives, referring to a group of individuals born and raised in a digital environment characterized by the presence of computers, the internet, smartphones, and video games. They are dependent on the digital technology around them (Nursyam, 2019; Puspianto, 2022).

As for how the metaverse works, it involves the extensive use of virtual reality technology, allowing time in the real world and the virtual world to run simultaneously. In the metaverse, the use of augmented reality enables the integration of the virtual world with the real world, creating a more immersive and engaging virtual experience. Additionally, the metaverse also utilizes motion capture technology, which works by recording the movement of objects in the real world and projecting them into a virtual environment. This projection provides a real-world experience for users (Endarto & Martadi, 2022).

According to Rizal et al. (2022), in this case, the metaverse, with its use of AR technology, has three advantages, making it an alternative medium for use in various sectors. These three advantages include user perception, user experience, and the ability to use various devices. User perception provides a broader picture for users. Not limited to just the external appearance, users can take a deeper look, creating different perceptions from various perspectives. User experience suggests that users are not merely passively observing, but are also able to interact with and learn about an object. This interactive experience feels more immersive and realistic. Then the final advantage is that AR can be used on a variety of devices. The increasing number of companies competing in the development of AR technology provides a wide variety of applications that can be used. Besides the wide variety of applications available, potential users can also consider the quality and suitability of their needs simultaneously.

This continuously evolving metaverse technology is giving rise to diverse and sophisticated applications that can replace human roles, making life activities feel fast, advanced, and practical. As for Indarta *et al.* (2022), they believe that the application of the Metaverse in education will push online learning to its limits, making virtual meetings as effective as in-person meetings. This can overcome geographical limitations in the learning process.

This learning opportunity, not limited to physical space, opens the doors of education to all segments of society. Additionally, collaboration in a virtual environment prepares students for an increasingly globally connected world. This environment signifies that the metaverse can provide inclusivity for all groups. The benefits of learning that applies the metaverse concept promise to improve the quality and effectiveness of education (Yuda *et al*., 2024). Furthermore, Yuda *et al.* (2024) also highlighted the benefits of implementing the metaverse in educational settings, including more profound learning experiences, global collaboration and inclusivity, realistic simulations for practical learning, the use of Augmented Reality (AR) technology in learning, flexibility and self-directed learning, and the development of both hard and soft skills. Additionally, Rizal et al. (2022) noted that the use of AR in learning can enhance material achievement without requiring repeated practice.

The concept of learning that adapts to the metaverse ecosystem needs to emphasize creativity, innovation, communication, initiative, and collaboration. The design principles of the metaverse serve as a basis for educational media, making the learning process easier, more effective, efficient, innovative, and engaging (Gusteti *et al.,* 2023; Al Ardha, 2022; Ulum et al., 2023; Wang et al., 2022). In addition, Rasyida *et al.* (2023) stated that the implementation of the metaverse in education aims to provide students with a more engaging, entertaining, and interactive learning experience. Even through virtual world experiences, students can participate in realistic simulations that are difficult or impossible to do in the real world.

An example of a metaverse application in education is the use of AR and VR as educational media. AR as an educational medium displays attractive 3D visuals and facilitates the teaching and learning process in a fun and engaging way, thanks to the involvement of tangible objects during the learning process. Meanwhile, learning that incorporates VR provides a deeper simulation and interaction experience in a digital environment, thus creating a more impressive learning ecosystem.

The various benefits gained from implementing the metaverse in education are expected to enhance the quality of education at all levels, including primary, secondary, and tertiary. Therefore, to understand the implementation of the metaverse in education, the author conducted a review of relevant literature. The time and location of the research conducted were considered in this review. Additionally, features such as study type, sample size (if applicable), sample type (if applicable), type of Metaverse technology used (if applicable), research objectives, research findings, and the definition and context of Metaverse technology are included in the review. First, the titles and abstracts of all studies were examined, and then the entire text of each study was evaluated in detail according to the inclusion and exclusion criteria.

Table 1. Sources reviewed for the research

Label	Country	Year	Research Type	Method	Education	Technology
P1	Serbia	2022	Descriptive	Design-based research	High education	3D Software
P2	South Korea	2021	Descriptive	Design-based research	-	Hololens
P3	Japan	2020	Exploratory	SLR	-	3D Software
P4	Columbia	2020	Exploratory	Mix research	High education	3D Software

Label	Country	Year	Research Type	Method	Education	Technology
P5	Singapore	2017	Exploratory	SLR	-	-

Source: Research of 2023

Five research sources were analyzed in terms of their objectives. These five sources provide information related to the implementation, opportunities, and obstacles of the Metaverse concept in education. The differences in the results from these five sources offer a variety of answers that can serve as a source of knowledge and address the research questions. The study is categorized as exploratory and descriptive research based on its objectives. Exploratory research is a type of research that aims to describe a phenomenon by exploring or familiarizing oneself with specific aspects of it (Mudjiyanto, 2018; Séjourné et al., 2018). At this stage, exploratory research focuses on the "what" question, aiming to provide an in-depth understanding of the object.

Descriptive research is a type of research used to describe the characteristics of a sample. Descriptive research aims to obtain an overview of the subject or activity of interest. Cause-and-effect relationships are not typically sought in descriptive studies; however, some basic statistics can be used (Aggarwal & Ranganathan, 2019; Zellatifanny & Mudjiyanto, 2018; Syahrizal & Jailani, 2023). Despite this technology, one study using mixed reality glasses was observed, which we believe is compatible with the current understanding of the Metaverse. This research uses Microsoft HoloLens (see Figure 1).

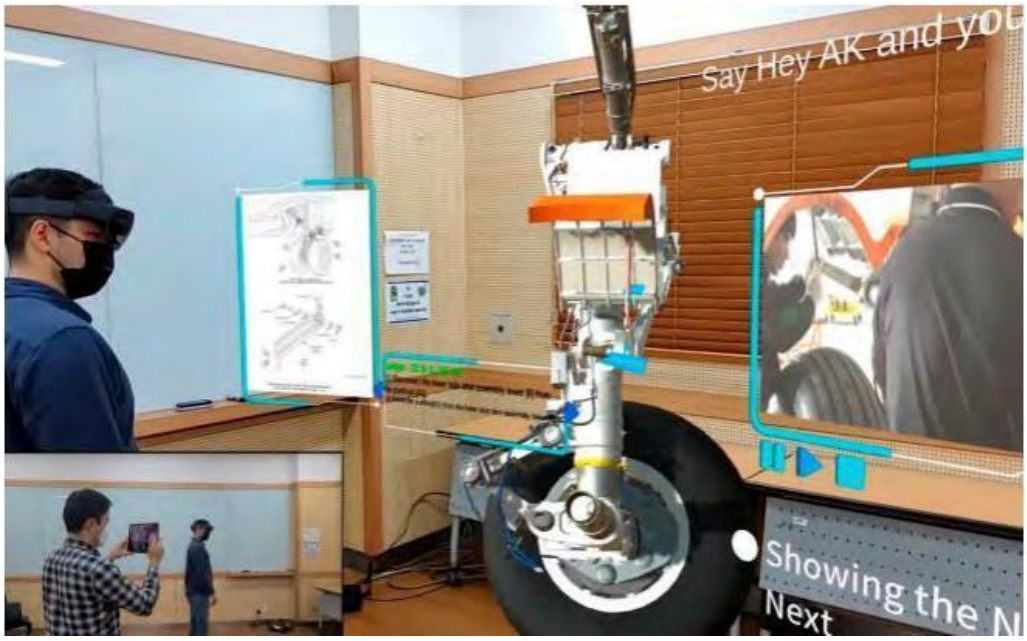

Figure 1. The use of HoloLens technology in education
Source: Siyaev & Jo, 2021

Table 2. The objectives of the reviewed research

Label	Research Objectives
P1	Create educational experiences in the virtual world to overcome the limitations of the pandemic.
P2	Conducting mixed reality training for Boeing 737 aircraft maintenance using smart glasses developed with deep learning speech interaction modules.
P3	Analyze devices in the virtual world, introduce the latest learning systems, examine virtual learning systems, and propose a concept for a learning system in the Metaverse.
P4	Acceptance level of the metaverse among students and teachers.
P5	Collaborative virtual and augmented reality environments.

Source: Research of 2023

The purpose of P2 research using digital reality-based Metaverse technology is to conduct aircraft maintenance training with mixed reality glasses. The aim of the design-based research (P1 and P2) is to create an educational experience in the virtual world. The objectives of the research (P3 and P5) can be summarized as aiming to explain the concepts, techniques, and limitations of the Metaverse, and to propose a learning concept within this virtual environment. Meanwhile, the objective of P4 research is to determine the level of acceptance of the Metaverse by students and teachers.

METHODS

The approach used in this study is a Systematic Literature Review (SLR). This method employs a structured and systematic approach to data collection, aiming to produce a comprehensive and consistent review of the existing literature. The library sources used in this study consist of 5 Scopus-indexed academic studies. The source search technique was conducted by considering the content and substance of the articles, particularly information related to the Metaverse in education within the Society 5.0 era.

RESULTS AND DISCUSSION

Results

The results of this research, as presented in the review, varied depending on the research objectives and the specific problem situation at hand. By examining the research results, the aim is to gain an understanding of the effectiveness of the Metaverse, specifically its impact on the variables being studied. Additionally, this study aims to investigate the impact of Metaverse technology on the field of education (see Table 3).

Table 3. Research Results

Label	Research Objectives
P1	The use of the Metaverse in online learning can overcome limitations during epidemics like COVID-19.
P2	The Aircraft Maintenance Metaverse is increasingly enhancing aircraft maintenance training by providing intuitive and efficient control over operations and strengthening voice interaction within the mixed reality of smart glasses.
P3	The metaverse should be integrated into the education system to provide students with the sense of vitality and reality necessary to maximize learning effects.
P4	Facilitating the use of pedagogies such as flipped classrooms and collaborative learning resulted in a high level of acceptance for navigating and interacting in the virtual world. This facilitated the educational process both inside and outside the classroom, in both synchronous and asynchronous settings. This needs to be measurable. Several technological and pedagogical challenges have been identified that need to be considered when implementing the metaverse.
P5	Facilitating the use of pedagogies such as flipped classrooms and collaborative learning resulted in a high level of acceptance for navigating and interacting in the virtual world. This facilitated the educational process both inside and outside the classroom, in both synchronous and asynchronous settings. This needs to be measurable. Several technological and pedagogical challenges have been identified that need to be considered when implementing the metaverse.

Source: 2023 Research

The research findings (P1 and P5) that provide conclusions about the future of the Metaverse are as follows: The Metaverse platform is expected to be used to address shortcomings in online learning environments; It is expected that Metaverse technology based on digital reality will reach a level indistinguishable from reality with the help of brain-computer interface development and the provision of additional features such as haptic senses.

Research findings such as P3, P4, and P5 provide suggestions for further development of Metaverse technology in the teaching environment, which can be listed as follows: an active learning environment based on experiential learning and gamification should be created; storytelling should be prioritized over visual effects; real-life elements should not be ignored; features such as scalable Metaverse technology and speech detection should be used in conjunction with Artificial Intelligence technology; and student learning should be supported by pedagogy and content knowledge. Research labeled P4 and P5 reached conclusions about the weaknesses of using the Metaverse in educational settings. They cited losses such as technical difficulties related to bandwidth and servers during Metaverse use; the extra time or work required to design and develop the Metaverse environment where learning and teaching processes will take place; limitations and restrictions of the Metaverse Platform that may hinder teaching practices; and real-life movements may be reflected late on the Metaverse Platform.

From the five studies reviewed, it was found that all studies reached conclusions about the beneficial aspects of using the Metaverse in education. The results are as follows:

1. A participatory and sustainable learning environment can be created.
2. The efficiency of the learning process can be maximized with the Metaverse.
3. The metaverse can facilitate the use of synchronous and asynchronous learning, as well as methods such as flipped classrooms and cooperative learning.
4. The metaverse can be used to ensure student attendance.
5. The metaverse can be used to ensure student attendance.
6. The metaverse contributes to the development of trust-building, increased awareness, communication skills, interaction, product creation, and team management processes.

Discussion

Findings Implication

In the studies included in the systematic review, Metaverse technology appeared in two distinct contexts: three-dimensional computer software-based Metaverse platforms and digital reality-based Metaverse platforms (see Table 4). Some studies (P1 and P5) singularly used the Metaverse concept, although they discussed it in both of the above contexts. Table 4 below summarizes the definitions of the Metaverse concept and the technological context of the Metaverse (based on 3D software or digital reality). The definition of the Metaverse in the studied research and its perception based on this definition were also examined. Based on Table 4, it is evident that numerous definitions of the Metaverse have been proposed. In this definition, the Metaverse is described as a virtual world, virtual environment, or virtual space (P2, P3, P4, P5), as well as a three-dimensional world (P2). There is research (P1, P2, P3, P4) that refers to the Metaverse as a mixed reality world or discusses human avatar features with digital twins. Definitions in many studies (P1, P2, P3) emphasize the interaction features of the Metaverse. Based on these definitions, the Metaverse is currently considered a virtual world where people exist and interact through their computer-generated avatars, connected by blockchain technology, and also supported by digital reality technology.

Table 4. Definition of the Metaverse and Technological Context in the Examined Research

Label	Definition of the Metaverse and Technological Context
P1	"A simulation space based on interaction with a computer, inhabited by multiple users, represented by iconic images called avatars, capable of communicating with each other synchronously." (Based on 3D software and digital reality)
P2	"The world of mixed reality in the physical world, where users gather and interact in a 3D virtual environment." (Based on digital reality)
P3	“The three-dimensional computer environment where the user is located with their avatar.” (3D software-based)
P4	“A digital structure where participants interact through avatars, attempting to reproduce real life in a virtual metaphorical environment without space-time limitations.” (3D software-based)
P5	“The parallel world existing in virtual space is supported by interconnected computers.” (Based on 3D software and digital reality)

Source: Research of 2023

Based on the five reviewed reference sources, the concept of the metaverse can be understood as an artificial, three-dimensional digital world that utilizes modern supporting devices—such as metaverse implementations.

Limitations and Opportunities for Future Research

The limitations of this study encompass several factors that need to be taken into consideration. First, this research is limited by the sources of information, which are restricted to literature accessible through the Scopus database. Therefore, some relevant sources may be omitted from this analysis. Second, the research's focus on the educational context may result in findings and conclusions that are not fully applicable to the Metaverse context outside the educational realm. Additionally, the time constraints of the research should also be considered, given that most of the analyzed literature covers a specific period, and recent developments in the Metaverse may not be fully reflected in the research results.

Nevertheless, this research opens up opportunities for more in-depth and diverse future studies. Further research could focus more on the impact of the Metaverse in achieving learning objectives, skill development, and student participation in the context of primary, secondary, or higher education. Detailed studies on the technical development of the Metaverse, hardware implementation, and technology security could also be developed as research topics, as they can provide more detailed insights. Future research could adopt a comparative approach, examining the implementation of the Metaverse across different countries and cultures to gain a deeper understanding of its challenges and benefits in various contexts. Additionally, ethical, privacy, and security aspects of Metaverse use in education could be valuable areas of research. Developing innovative learning models that fully utilize the potential of the Metaverse is also an exciting area of research. Additionally, studies on the perceptions, participation, and experiences of students and lecturers in using the Metaverse can provide a more holistic view. Thus, this research, while providing initial insights, paves the way for future, more in-depth and diverse studies.

CONCLUSION

The concept of the Metaverse and its technology has evolved over the years, and it is evident that there has been a significant shift from a three-dimensional software-based Metaverse to a digital reality-based Metaverse. An analysis of research distribution reveals that Metaverse research has not only continued in recent years but has also been ongoing for the past decade and possibly even earlier. An interesting finding is that the concept of the Metaverse is increasingly linked to popular Augmented Reality and Virtual Reality technologies, providing users with an immersive experience.

Geographically, developed countries in Asia, such as Japan, South Korea, and Singapore, are at the forefront of Metaverse research. This is related to the high cost of Metaverse technology and the high level of technological literacy in those countries. However, with the development of blockchain technology, opportunities have emerged for this shift, as it can provide a new perspective on the Metaverse concept. The development of a digital reality-based Metaverse is expected to lead to broader and deeper research on its influence on dependent variables.

The development of the Metaverse in education reflects the dynamics of technological change and the demands of the Society 5.0 era. As Metaverse technology continues to evolve, future research is expected to provide a deeper understanding of how the Metaverse can make a real contribution to achieving learning goals in an era that is increasingly integrated between the virtual and physical worlds.

AUTHOR'S NOTE

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