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Smart Learning in Virtual Worlds: A Systematic Literature Review on the Usage and Applications of Metaverse in Education

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Abstract. Interactive digital applications have made their way into the educational field. Since the COVID-19 pandemic, numerous countries have resorted to various platforms to reinvent teaching methodology in the digital era. One of these platforms is the metaverse, which presents itself as a resourceful way to teach in the future, with potential applications such as digital interaction among peers. It further offers more dynamic and immersive learning, as students can engage in virtual simulations, role-playing activities, and collaborative projects with other students globally. In an era of constant technological advancement, studying the metaverse and its applications in the educational field seems

like a valid starting point to enrich the current teaching methodologies and those of the future. It is an acknowledgement of its impact on education, its usage, challenges and advancements, as well as its influence on the future of education. Therefore, this paper's objective is to gather and analyse the current literature available relating to the application of the metaverse in the field of education. A systematic literature review (SLR) was conducted across the journal databases of IEEE Xplore, Scopus, ProQuest, ScienceDirect and ACM Digital Library. A total of 31 articles were reviewed according to criteria. The results of this SLR determined that, while research shows the significant potential regarding the usage of the metaverse in education, a set of concrete applications has yet to be investigated thoroughly in order to exploit this technology's immense potential fully in the field of education.

Keywords: metaverse; education; smart learning; artificial intelligence; virtual reality

1. Introduction

Due to the COVID-19 epidemic, an unforeseen change was made in education, catapulting distance learning into the mainstream. However, many students were not ready for the abrupt changes in the educational landscape. In response, schools and governmental organizations had to act swiftly to remedy this by giving learners access to crucial resources such as computers, iPads, and the Internet. Additionally, in order to promote interaction, reduce feelings of isolation, and boost student involvement, educators had to adjust to new technologies. Emerging technologies, including virtual reality (VR), augmented reality (AR), and artificial intelligence (AI), among others, started to alter the learning process drastically on a global scale in this scenario (Garlinska et al., 2023). Additionally, several of these technologies were put into use so quickly in response to the COVID-19 outbreak that it was anticipated that they would continue to be employed even in conventional classroom settings.

As Chang et al. (2023) stated, technological advancements are enabling the development of new and improved educational practices, which in turn are transforming the educational landscape. Previously, smart education primarily consisted of qualitative studies that described the conceptual framework of what a smart educational system could be. While these conceptually structured systems have the potential to enhance student learning, peer-to-peer interaction and teaching practices that provide real-time guidance in a virtual context need further exploration to validate their effectiveness in the era of smart education. Furthermore, according to Chauhan (2023), the future of education will be dominated by factors such as education outside traditional classrooms, through digital devices and AI-based learning. The need to attend an offline campus physically to pursue careers will become more flexible, gradually changing to a more mobile-focused education in the years to come.

Because of the accelerated adoption of digital learning technologies caused by the Covid-19 pandemic, educational institutions were forced to work online, which created a necessity for further study regarding the role of information

communication technology (ICT) within the field of higher education. This was an attempt to assess the necessity to improve student engagement in virtual classrooms (Shettar et al., 2021). In this sense, new technologies such as AR become an effective solution to improve the learning process through engaging in digital scenarios enhanced by computer-generated content, facilitating ubiquitous learning (Yuen et al. 2011).

As the learning process evolves to a more technology-based focus, several tools based on AI, VR or AR are promoting the transmission of knowledge in the educational context through the assistance of interactive tools in a virtual context. In this sense, AI can already provide assistance as part of the learning processes and generate effective methodological resources (Rusillo et al., 2023). In addition, the combination of this technology with VR or AR facilitates the learning of more complex subjects through the use of interactive scenarios such as the metaverse.

Integrating the metaverse in education represents a groundbreaking shift in pedagogical approaches and educational theories such as constructivism, which proposes that learners should actively participate in their learning process through constructing their understanding of the world by building upon their own experiences (Schreiber & Valle, 2013). According to this theory, the metaverse becomes a dynamic playground where students immerse themselves in collaborative and interactive learning environments that allow such creation of knowledge through exploration and experimentation. In this way, students become more active participants in their learning process, gaining the opportunity to engage in deeper construction of knowledge through hands-on experiences and simulations that hone problem-solving skills.

As mentioned, the COVID-19 pandemic prompted a reevaluation of teaching and learning methods. The metaverse, as a digital space that combines elements of the real and virtual worlds, has emerged as a highly anticipated trend in future education, offering the ideal scenario to develop new ways to engage in smart education and innovate upon the existing technology. However, there is a need for further research and discussion regarding the metaverse and its educational applications (Zhang et al., 2022).

The following image, adapted from the work of Zhang et al. (2022), showcases some characteristics that the metaverse usage can bring to the learning process, compared to traditional and blended methodologies:

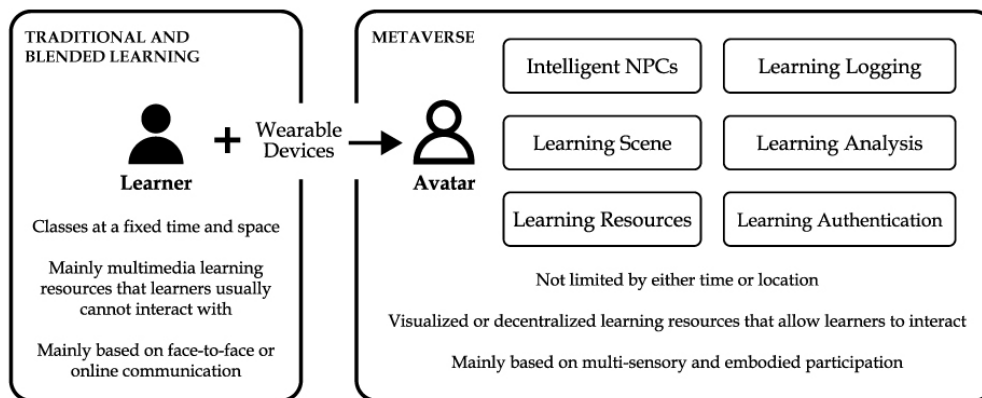


Figure 1: Framework and advantages of metaverse in education

Durak and Cankaya (2022) suggest that each novel technological advancement presents opportunities within the domain of education, thereby exerting an impact on the learning processes of numerous students. To optimize the quality of education provided to students, it is necessary to explore strategies for integrating these technologies within the classroom setting.

Furthermore, while the metaverse has historically been linked to recreational and amusement purposes, educational implementations are presently being introduced into the virtual realm to augment the learning experience, foster innovative pedagogical approaches, and adapt to the requirements of contemporary technological environments in an era characterized by ubiquitous intelligent learning.

Taking the above into consideration, regarding the importance of this subject, this study's objectives is to gather sufficient knowledge in order to understand the impact regarding the usage of the metaverse in education. In addition, its applications, challenges and advancements presented by the use of this technology in the educational field, as well as how the metaverse will impact the future of education are also considered.

2. Research approach

2.1. Acknowledging the subject

It is necessary to bridge the knowledge gap surrounding the utilization of the metaverse in the field of education. While this kind of technology holds tremendous potential for transforming the learning experience, it is necessary to research the subject further in order to obtain a comprehensive understanding of its applications in the educational field. Exploring, analysing and understanding the factors that integrate the metaverse in an educational context will fill the knowledge gap. In this way educators and students will be empowered with the necessary insights and strategies to embrace the advantages effectively that the metaverse has to offer in the educational field, such as its immersive capabilities and interactive learning environments. The metaverse is a digital scenario that offers an immersive experience, which is one of the key reasons for its enduring presence, working alongside technologies such as VR, AR and AI.

These features aim to reduce barriers that students with specific physical or emotional needs may encounter in traditional classrooms. Therefore, the convergence of the metaverse and education holds great promise as it introduces a new realm of innovation and addresses challenges related to physical limitations and more (Digital Learning Network, 2023). By making education engaging and accessible, the adoption of the metaverse in the educational field would be an interesting topic to address for the years to come, increasing the demand for further investigation on the subject matter.

2.2. Research questions

In order to conduct a thorough research and compare the knowledge available regarding the subject at hand, it was necessary to elaborate a set of questions that would motivate the study and resolve its inquiries in the best way possible. Therefore, to optimize the research process, a research question was proposed, which in itself was sub-divided into a set of four specific research questions. In this way, the search results gathered would be filtered regarding how much relevance they bring to answer the questions of this SLR (Guyatt et al., 2008).

Table 1 shows the proposed research questions used to conduct this SLR:

Table 1: Research questions

Specific Question	Purpose of the Question
Q1: What is the impact regarding the usage of the metaverse in education?	It is necessary to understand how metaverse usage impacts on the field of education in order to understand its applications.
Q2: What are the applications of the metaverse in education?	It is also necessary to know the applications of metaverse regarding the educational field to build a complete landscape within the field.
Q3: What are the challenges and advancements presented by the use of the metaverse in education?	In order to understand the scope of the metaverse and its reach within the educational field, it is necessary to know the challenges it faces and the advancements the metaverse proposes.
Q4: How does the metaverse impact the future of education?	Lastly, further knowledge is needed regarding how the metaverse can impact the future of education to understand how its application in the field can be impactful and resourceful for the years to come.

3. Methodology

3.1. Systematic Literature Review

Having established that a knowledge gap is present regarding the use and applications of the metaverse in the educational field, and taking into consideration the necessity to look for available knowledge that could answer the research questions proposed before, a SLR was conducted in order to search for the specific knowledge that would help to answer the research questions directly and assess the subject at hand. This way, with the help of keywords and search criteria to filter the results available through the research, the SLR proves extremely effective in gathering the necessary literature to fill in the knowledge gap and provide enough resources to analyse the subject at hand and assess it more directly (Nightingale, 2009).

Conducting an SLR on the use of the metaverse in education presents several inherent limitations. Firstly, the field of the metaverse in education is rapidly evolving, and the literature may not capture the latest developments and trends. Additionally, the concept of the metaverse is relatively new, which means that there may be a scarcity of empirical research and established frameworks to draw upon. Furthermore, studies in this area may exhibit varying methodologies, making it challenging to compare and synthesize findings systematically. Nevertheless, conducting an SLR permits investigators and academics to gather enough articles, studies and other academic work regarding the subject matter and elaborate a systematic collection of literature that approaches the object of study by various means. This collection of knowledge therefore enables investigators to answer the proposed research questions and have enough academic resources that could fill the knowledge gap previously assessed (Moreno et al., 2018).

For this study, the SLR consulted the journal databases of Scopus, ACM Digital Library, IEEE Xplore, ProQuest and ScienceDirect. These databases were selected because of the extensive coverage they present, as well as their established reputation and capabilities to conduct advanced searches, showcasing a plethora of peer-reviewed journals and up-to-date studies that qualify with the standards needed to ensure their credibility and resourcefulness when consulted. All in all, these reliable sources offer enough relevant academic resources to assess the subject of study, enhancing the quality of knowledge gathered through the research. The study did not consult any other databases owing to their limited scope and niche focus, as this SLR needs a more interdisciplinary approach within the educational field. Also, accessibility was a key factor regarding the usage or exclusion of some databases while conducting the SLR. Other factors such as language barriers and incomplete coverage were also taken into consideration.

In synthesis, after selecting the journal databases, a selection of keywords and research criteria were used to find and filter the academic resources needed to gather enough knowledge that answered the research questions proposed by this study. From these filtered results, an analysis of the identified literature was conducted in order to categorize each article and align them to every research

question. The result was a solid collection of literature with rich knowledge assessing the usage and applications of metaverse in the field of education.

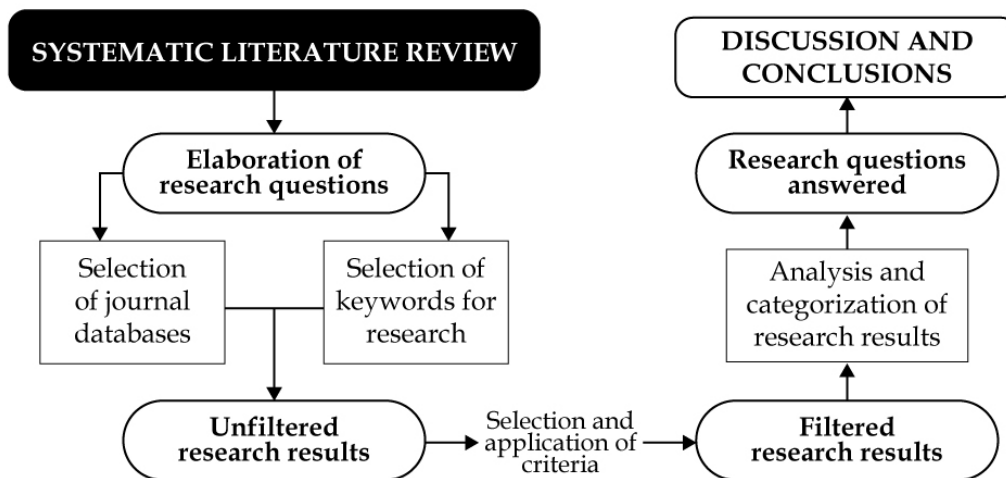


Figure 2: Workflow of the systematic literature review conducted

3.2. Conducting the Systematic Literature Review

As already established, once the research questions are defined, it is necessary to search through the selected journal databases using specific keywords. These keywords are designed to collect relevant information within the field of study and ensure its suitability for later analysis. The keywords employed to filter the search results in each of the chosen journal databases were the following:

((“Metaverse”) AND (“education” OR “learning” OR “smart learning”) AND (“artificial intelligence” OR “virtual reality”))

The selected keywords served as a useful tool to navigate through the search results obtained from the consulted databases. They enabled the categorization of the literature found and facilitated the review of articles relevant to the subject of study. However, if the objective of the SLR was to acquire more specific and comprehensive knowledge for this research, relying solely on these keywords would not be sufficient. Therefore, certain criteria were employed to exclude articles that did not align with the purpose of the study. Table 2 illustrates the criteria used to filter out any irrelevant literature that did not contribute valuable insights to this research:

Table 2: Inclusion and exclusion criteria

Criteria	Criteria description	Inclusion and exclusion status
Language	Articles written in English	Article is included
Year of publication	Articles published in the last three years	Article is included
Field	Articles that are related to the educational field	Article is included

	Articles related to the learning process or teaching methodologies within the field of smart education	Article is included
	The article is not related to the educational field or to tech-based teaching methodologies in any way	Article is not included
Article content	The article has to mention the metaverse	Article is not included
	The article does not mention the metaverse or intelligence-based technology in any way	Article is not included
	Articles that have high similarities across databases	Article is not included
	Article data is inconclusive	Article is not included
Relevance of content	The article references different applications and usage of the metaverse in the educational field	Article is included
	The article references the application and usage of the metaverse in other fields besides education	Article is not included

A series of articles were collected after applying these criteria, filtering out the articles that were not of relevance for this study. Based on these criteria, Table 3 shows the number of articles found in each database selected:

Table 3: Number of articles by journal database

Journal database	Number of articles
IEEE Xplore	11
Scopus	9
ProQuest	4
ScienceDirect	4
ACM Digital Library	3
TOTAL	31

By gathering the necessary data for this SLR, it becomes possible to develop a clearer comprehension of various applications of the metaverse in the field of education as well as its influence on educational practices. The objective of this research is to identify the diverse ways in which this technology is employed in educational settings and determine how it impacts the teaching and learning outcomes. Through an extensive analysis of existing studies, this SLR aims to reveal valuable insights regarding the impact of the usage of the metaverse in education, as well as its challenges, advancements and impact in the future of education. To address each research question more precisely and maintain the primary focus of this SLR, the findings were categorized and organized based on the subjects and themes they explore, as shown in Table 4:

Table 4: Article categorization by each research question

Research Question	Articles selected
Q1	Abraham et al. (2023)
	Rahman et al. (2023)
	Kshetri et al. (2022)
	Bhavana & Vijayalakshmi (2022)
	De Felice et al. (2023)
	Hwang et al. (2023)
	Hwang & Chien (2022)
	Moreira et al. (2023)
	Yue (2022)
	Al-Kfairy et al. (2022)
Q2	Soni & Kaur (2023).
	Onggirawan et al. (2022)
	Ahuja et al. (2023)
	Mitra (2023)
	Yu (2022)
	Ho et al. (2023)
	Nagao (2023)
	Zahedi et al. (2023)
	Duan et al. (2021)
	Wu et al. (2023)
Yuan et al. (2023)	
Q3	Raj et al. (2023)
	Hao & Lailin (2022)
	Tlili et al. (2022)
	Kaddoura & Al Husseiny (2023)
	Sá & Serpa (2023)
Q4	Zonaphan et al. (2022)
	Seddon et al. (2023)
	Ktoridou et al. (2023)
	Braguez et al. (2023)
	Zhong et al. (2022)

4. Research results and discussion

4.1. Impact and usage of metaverse in education

Several nations have employed online meeting software platforms to varying degrees for remote instruction amid the COVID-19 pandemic. However, the notable limitations of these programs pose challenges for students in terms of active participation in the learning process and hinder their ability to immerse themselves fully in the classroom setting. The metaverse assumes some of the responsibilities associated with these limitations. According to Abraham et al. (2023), learners are afforded the opportunity to participate in interactive and immersive exchanges with digital content and their peers within the educational environment of the metaverse. Students have the opportunity to engage in

collaborative projects, participate in role-playing games, and participate in various online activities with peers from diverse geographical locations.

The metaverse is a digital representation of the real world, connecting users through avatars, bridging the physical and digital realms by gathering real-time global data and enabling immersive experiences. By utilizing users' physical inputs, AI systems can be trained to offer personalized services to students and have the potential to revolutionize the educational field through the metaverse (Rahman et al., 2023). As Kshetri et al. (2022) stated, the metaverse is becoming an important part in the education market, bringing young students the advancements such as immersive learning and its benefits.

The potential of the metaverse as a means to connect people has enhanced its possibilities in various sectors and fields to a significant extent. Even though researchers are still studying these technologies and their impact on classroom motivation, higher attention spans, student satisfaction and other subjects (Bhavana & Vijayalakshmi, 2022), the academic community has largely overlooked the comprehensive examination of existing metaverse solutions and their impact on education (De Felice et al., 2023).

Hwang et al. (2023) indicate that the utilization of the metaverse provides students with the opportunity to participate in immersive experiential learning and engage in various modes of authentic human interaction. However, while the introduction of new technologies may initially create a sense of novelty, it is not sufficient to ensure sustained student learning as the effectiveness of the students' learning experiences still relies on their motivation to learn. In this sense, educators might still not recognize the features of the metaverse and its applications in education (Hwang & Chien, 2022). Nevertheless, students do have important considerations regarding the application of the metaverse in different learning scenarios, evaluating their acceptance in the usage of this technology as an educational information system (Moreira et al., 2023).

The metaverse's rapid growth can be attributed to its recognized potential for significant future business value. However, many fail to realize that education is the field with the largest potential for metaverse application as its usability aligns to the academic field. The shared virtual space of the metaverse offers enhanced opportunities for student engagement. Nevertheless, despite this potential, there are a significant number of sceptics who view the metaverse as a mere hoax (Yue, 2022). This is owing to the fact that, even though the metaverse is emerging as a technology that combines virtual worlds with immersive user experiences, many users are concerned regarding the potential security and privacy risks present for students (Al-Kfairy et al., 2022).

4.2. Applications of metaverse in education

In general terms, the purpose of the metaverse is to develop a fully immersive and integrated virtual experience in which users can learn and interact with their peers in a multitude of virtual scenarios (Soni & Kaur, 2023). Yet, as Onggirawan et al. (2022) established, virtual education has garnered significant attention as

technology continues to advance and permeate various aspects of society. The concept of the metaverse has been undergoing continuous updates, presenting the metaverse as a learning method and exhibiting better comprehension of various subjects compared to traditional face-to-face learning methodologies. It has significant potential in the education field, facilitating skills development through technology use and leading to notable improvements in student performance with the proper guidance from teachers and educators. Furthermore, Ahuja et al. (2023) indicate that this virtual environment can kickstart immersive technologies such as VR, AR and AI to offer life-like experiences to students across the world, blending these technologies in favour of an extended virtual experiences within the learning process. For instance, through simulation, medical students could acquire, extensive practical knowledge for their future professional life, gaining experience with the correct development of interactive tools that promote collaboration and accessibility.

Susanta (2023) asserts that the metaverse has recently emerged as a multifaceted platform with a wide range of applications. The academic community, specifically within the field of education, has shown significant interest in this matter. To exemplify, the integration of Digital Twins within an educational setting based on the metaverse can contribute to the improvement of authenticity and user experience. This integration enables the transfer of ideas and concepts from the physical realm into the virtual environment. Yu (2022) highlights the transformative impact of the metaverse on the realm of online education, encompassing e-learning as well. Ho et al. (2023) propose the integration of VR and AI technologies to incorporate the metaverse into computer science education. For example, VR headsets are employed to capture video content such as presentations and lectures within the metaverse. Subsequently, AI algorithms autonomously generate tailored class notes by analysing these video recordings.

Regarding the metaverse's role in VR for educational use, Nagao (2023) described a virtual university campus that conducted on-demand lectures in virtual halls, with automated evaluations, focusing on the learning process through machine learning. As a social network based on multiple software, the metaverse can help online education harness the newfound potential, paving the way for future advancements in accessibility and sustainability (Zahedi et al., 2023). In this sense, the application of the metaverse in an educational context should be a more direct and fully immersive experience, where the concepts of race or gender would not be an issue when assessing the learning process. However, the metaverse development is still at an early stage, needing further advancement and investment to exploit its great potential (Duan et al., 2021).

Finally, Wu et al. (2023) suggest that the metaverse's development involves the integration of metaverse technology into existing educational environments. In addition, Yuan et al. (2023) assert that the features of VR technology can compensate for the limitations of traditional classes. They further emphasize that these resources can aid students in grasping knowledge points and improving their skills within this smart learning methodology, as the authentic experiential aspect of VR enhances the teaching and learning outcomes.

4.3. Challenges and advancements

The term 'metaverse' has made a significant impact on various sectors, including education. More industries are expected to be influenced by the metaverse by 2026, as this digital ecosystem is believed to enhance collaboration, improve training processes and contribute to a more positive work environment (Raj et al., 2023). This coincides with the article by Kaddoura and Al Husseiny (2023), which states that the metaverse provides opportunities to develop new instructional approaches that cater to different learning models, including hybrid and mobile learning. The rise in interactive technology usage among students has led to the emergence of a new generation of learners enrolling in universities. The incorporation of teaching strategies has become simpler thanks to recent developments, while the scalability of the metaverse allows for the integration of multiple resources and interactive features, helping the development of more varied applications. Therefore, as in the case of physical training spaces, the design of virtual training spaces needs to comply with strict and high-quality requirements. Both students and teachers may get the most out of their educational opportunities in this way.

The emerging concept of the educational metaverse has garnered significant attention as a novel framework for online education. On the other hand, Hao and Lailin (2022) highlight that its practical implementation often encounters conflicts and inconsistencies among various parties involved. Stakeholders in this context encompass government agencies, science and technology enterprises, and educational institutions. The development of a high-quality and efficient educational metaverse environment, leveraging its state-of-the-art technological features, is a significant matter that necessitates attention and resolution.

Nevertheless, the educational community has been captivated by the potential of the metaverse for some time (Tlili et al., 2022). The notion of transforming universities into more interactive digital experiences by incorporating technologies such as this as the central component of the learning process is an uncertain and entirely new concept that requires the participation and collaboration of multiple stakeholders. The utilization of the metaverse in educational settings is still a relatively new development. According to Sá and Serpa (2023), there is a need to provide increased support and encouragement for its implementation in educational institutions. This can be achieved through platform training programs.

4.4. Metaverse and the future of education

According to Zonaphan et al. (2022), technology has made learning more exciting and engaging, with VR and AR being among the most promising technologies in the education field. Through the metaverse, students are offered advantages such as visualizing materials, thereby making learning interactive, easier, and more interesting. However, limitations such as the cost of the required devices need to be addressed. Furthermore, Seddon et al. (2023) highlight that, although the notion of the metaverse is currently in its nascent phase, there is a range of existing comparable technologies that facilitate user engagements within shared digital environments and 3D spatial audio. Nevertheless, the incorporation of the metaverse and similar technologies opens new avenues for knowledge sharing,

potentially enhancing how we operate, teach, learn, and transfer knowledge within the field of education.

The emergence of metaverse applications across various sectors has opened up possibilities for its utilization in education. While there is immense potential for its use in this field, educators face challenges due to the limitations of educational applications within the metaverse, such as risks regarding privacy and security. However, the metaverse's significant potential lies in providing immersive experiences for content and social interactions (Braguez et al., 2023). With the introduction of the metaverse into the educational domain, the future of education will witness increased intelligence, digitalization, and virtualization. This transformative technology is expected to bring profound changes to education and empower its future. However, amidst the technological boom, it is crucial to consider the challenges that the education metaverse may encounter in relation to public perception, technological concerns and ethical considerations regarding privacy and digital security (Zhong & Zheng, 2022).

On a different note, Ktoridou et al. (2023) state that the metaverse is expected to become a significant part of our lives, and while its utilization is already prevalent in areas such as the gaming industry, its use in education is still being debated. Furthermore, students and teachers generally possess a good understanding of the metaverse and foresee its integration into education in the coming years, however, there remains openness and division regarding the extent and fundamental nature of this potential implementation within the field.

5. Conclusion

The research demonstrates the considerable potential of the metaverse in revolutionizing education. Nevertheless, there is a discernible deficiency in comprehending tangible implementations that can effectively harness the vast capabilities of this technology. Although there have been extensive deliberations regarding the advantages of integrating educational systems into the metaverse, there remains a dearth of practical implementations. To maximize the educational potential of the metaverse, it is necessary to conduct extensive analysis on the practical uses of this technology. Through the implementation of comprehensive research and rigorous experimentation, scholars and educators have the potential to discover novel approaches for leveraging the metaverse as a powerful instrument for educational transformation. This may entail the development of immersive virtual learning environments, AR experiences and the facilitation of collaborative virtual classrooms through personalized AI-driven learning systems.

5.1. Recommendations

It is necessary to examine the possible obstacles, constraints, and ethical implications linked to education conducted in the metaverse. Comprehending these factors will facilitate the formulation of suitable guidelines and policies to ensure the responsible utilization of the metaverse within educational contexts. The utilization of the metaverse in the realm of education holds considerable promise. However, further investigation in this particular domain will enable the

opportunity to revolutionize the field of education, providing students with immersive, personalized, and interactive learning opportunities.

Key unresolved questions to kickstart further investigation on the subject include the long-term impact of immersive virtual environments on learning outcomes and the development of effective pedagogical methodologies within the metaverse, as well as the accessibility of this technology to students of diverse backgrounds. Additionally, more research is needed to understand the social and psychological implications of prolonged metaverse usage for students. Addressing these gaps will be paramount in advancing the understanding of this technology and maximizing the potential benefits of metaverse integration in education.

6. References

- Abraham, A., Suseelan, B., Mathew, J., Sabarinath, P., & Kumar, A. (2023). A study on metaverse in education. *7th International Conference on Computing Methodologies and Communication (ICCMC)*, 1570-1573. <https://doi.org/10.1109/ICCMC56507.2023.10083910>
- Ahuja, A., Polascik, B., Doddapaneni, D., Byrnes, E., & Sridhar, J. (2023). The digital metaverse: Applications in artificial intelligence, medical education, and integrative health. *Integrative Medicine Research*, 12(1). <https://doi.org/10.1016/j.imr.2022.100917>
- Al-Kfairy, M., Al-Fandi, O., Alema, M., & Altaee, M. (2022). Motivation and hurdles for the student adoption of metaverse-based classroom: A qualitative study. *International Conference on Computer and Applications (ICCA)*, 1-5. <https://doi.org/10.1109/ICCA56443.2022.10039672>
- Bhavana, S., & Vijayalakshmi, V. (2022). AI-based metaverse technologies advancement impact on higher education learners. *WSEAS Transactions on Systems*, 21, 178-184. <https://doi.org/10.37394/23202.2022.21.19>
- Braguez, J., Braguez, M., Moreira, S., & Filipe, C. (2023). The possibilities of changes in learning experiences with metaverse. *Procedia Computer Science*, 219, 504-511. <https://doi.org/10.1016/j.procs.2023.01.318>
- Chang, S., Chang, C., Chen, H., & Wu, M. (2023). Measuring the importance of smart E-learning education system. *Proceedings of the 6th International Conference on Digital Technology in Education (ICDTE '22)*, 421-428. <https://doi.org/10.1145/3568739.3568810>
- Chauhan, S. (2023, April 25). Explore the next in education – An opportunity to elevate the education to global standards. *Digital Learning*. <https://digitallearning.eletsonline.com/2023/04/explore-the-next-in-education-an-opportunity-to-elevate-the-education-to-global-standards>
- De Felice, F., Petrillo, A., Iovine, G., Salzano, C., & Baffo, I. (2023). How does the metaverse shape education? A systematic literature review. *Applied Sciences*, 13(9). <https://doi.org/10.3390/app13095682>
- Digital Learning Network. (2023, March 24). Metaverse meets education - Opens a new world of innovation. *Digital Learning*. <https://digitallearning.eletsonline.com/2023/03/metaverse-meets-education-opens-a-new-world-of-innovation>
- Duan, H., Li, J., Fan, S., Lin, Z., Wu, X., & Cai, W. (2021). Metaverse for social good: A university campus prototype. *Proceedings of the 29th ACM International Conference on Multimedia (MM '21)*, 153-161. <https://doi.org/10.1145/3474085.3479238>

- Durak, G., & Cankaya, S. (2022). Shaping the future of online learning: Education in the metaverse. *IGI Global*. <https://doi.org/10.4018/978-1-6684-6513-4>
- Garlinska, M., Osial, M., Proniewska, K., & Pregowska, A. (2023). The influence of emerging technologies on distance education. *Electronics*, 12(7), 1550. <http://dx.doi.org/10.3390/electronics12071550>
- Guyatt, G., Meade, M.O., Richardson, S., & Jaeschke, R. (2008). What is the question? In G. Guyatt, D. Renni, M.O. Meade & D.J. Cook (Eds.), *Users' guides to the medical literature: A manual for evidence-based clinical practice* (2nd ed.) (pp. 17-28). McGraw-Hill.
- Hao, T., & Lailin, H. (2022). Educational metaverse dilemmas and solutions: A stakeholder-based perspective. *12th International Conference on Information Technology in Medicine and Education (ITME)*, 714-718. <https://doi.org/10.1109/ITME56794.2022.00150>
- Ho, K., Hou, Y., Chu, C., Chan, C., Pan, H., & Chan, T. (2023) Work in progress: An AI-assisted metaverse for computer science education. *IEEE World Engineering Education Conference (EDUNINE)*, 1-4. <https://doi.org/10.1109/EDUNINE57531.2023.10102819>
- Hwang, G., & Chien, S. (2022). Definition, roles, and potential research issues of the metaverse in education: An artificial intelligence perspective. *Computers and Education: Artificial Intelligence*, 3. <https://doi.org/10.1016/j.caeai.2022.100082>
- Hwang, G., Tu, Y., & Chu, H. (2023). Conceptions of the metaverse in higher education: A draw-a-picture analysis and surveys to investigate the perceptions of students with different motivation levels. *Computers & Education*, 2023. <https://doi.org/10.1016/j.compedu.203.104868>
- Kaddoura, S., & Al Hussein, F. (2023). The rising trend of metaverse in education: Challenges, opportunities, and ethical considerations. *Computer Science*. <https://doi.org/10.7717/peerj-cs.1252>
- Kshetri, N., Rojas-Torres, D., & Grambo, M. (2022). The metaverse and higher education institutions. *IT Professional*, 24(6), 69-73. <https://doi.org/10.1109/MITP.2022.3222711>
- Ktoridou, D., Epaminonda E., & Efthymiou, L. (2023). Is education ready to embrace metaverse? *IEEE Global Engineering Education Conference (EDUCON)*, 1-5. <https://doi.org/10.1109/EDUCON54358.2023.10125182>
- Mitra, S. (2023). Metaverse: A potential virtual-physical ecosystem for innovative blended education and training. *Journal of Metaverse*, 3(1), 66-72. <https://doi.org/10.57019/jmv.1168056>
- Moreira, T., Moreira, R., & Prado, H. (2023). Evaluating students' technology acceptance of use of metaverse as an educational information system for hybrid education. *Proceedings of the XIX Brazilian Symposium on Information Systems (SBSI '23)*, 197-205. <https://doi.org/10.1145/3592813.3592906>
- Moreno, B., Muñoz, M., Cuellar, J., Domancic, S., & Villanueva, J. (2018). Revisión Sistemática: Definición y nociones básicas [Systematic reviews: Definition and basic notions]. *Revista Clínica de Periodoncia, Implantología y Rehabilitación Oral*, 11(3), 184-186. <https://dx.doi.org/10.4067/S0719-01072018000300184>
- Nagao, K. (2023). Virtual reality campuses as new educational metaverses. *IEICE Transactions on Information and Systems*, E106D(2), 93-100. <https://doi.org/10.1587/transinf.2022ETI0001>
- Nightingale, A. (2009). A guide to systematic literature reviews. *Surgery*, 27(9), 381-384. <https://doi.org/10.1016/j.mpsur.2009.07.005>
- Onggirawan, C., Kho, J., Kartiwa, A., Anderies, J.M., & Gunawan, A. (2022) Systematic literature review: The adaptation of distance learning process during the COVID-

- 19 pandemic using virtual educational spaces in metaverse. *Procedia Computer Science*, 216, 274-283. <https://doi.org/10.1016/j.procs.2022.12.137>
- Rahman, K., Shitol, S., Islam, M., Iftekhar, K., & Saha, P. (2023). Use of metaverse technology in education domain. *Journal of Metaverse*, 3(1), 79-86. <https://doi.org/10.57019/jmv.1223704>
- Raj, A., Sharma, V., Rani, S. Singh, T., Shanu, A., & Alkhayyat, A. (2023). Demystifying and analysing metaverse towards education 4.0. *3rd International Conference on Innovative Practices in Technology and Management (ICIPTM)*, 1-6. <https://doi.org/10.1109/ICIPTM57143.2023.10118054>
- Rusillo, A., Ruiz, A., Suárez, S., & Martínez, T. (2023). Artificial intelligence, augmented reality and education. In V.Geroimenko (Ed.), *Augmented reality and artificial intelligence*. Springer Series on Cultural Computing (93-121). https://doi.org/10.1007/978-3-031-27166-3_6
- Sá, M., & Serpa, S. (2023). Metaverse as a learning environment: Some considerations. *Sustainability*, 15(3). <https://doi.org/10.3390/su15032186>
- Seddon, I., Rosenberg, E., & Houston, S. (2023). Future of virtual education and telementoring. *Current Opinion in Ophthalmology*, 34(3), 255-260. <https://doi.org/10.1097/ICU.0000000000000945>
- Schreiber, L., & Valle, B. (2013). Social constructivist teaching strategies in the small group classroom. *Small Group Research*, 44(4), 395-411. <https://doi.org/10.1177/1046496413488422>
- Soni, L., & Kaur, A. (2023). Strategies for implementing metaverse in education. *2023 International Conference on Disruptive Technologies (ICDT)*, 390-394. <https://doi.org/10.1109/ICDT57929.2023.10150886>
- Shettar, R.M., Lathiwale, M.S. Z., & Kulhalli, M. (2021). The role of ICT in higher education in selected places during COVID-19. *Journal of Research in Social Sciences and Language*, 1(1), 42-54. <http://dx.doi.org/10.20375/0000-000D-FF90-1>
- Tlili, A., Huang, R., Shehata, B., Liu, D., Zhao, J., Metwally, A., & Burgos, D. (2022). Is metaverse in education a blessing or a curse: A combined content and bibliometric analysis. *Smart Learning Environments*, 9(1). <https://doi.org/10.1186/s40561-022-00205-x>
- Wu, X., Chen, Y., & Wu, Y. (2023). Exploration of mathematics education by metaverse technology. *IEEE 12th International Conference on Educational and Information Technology (ICEIT)*, 173-178. <https://doi.org/10.1109/ICEIT57125.2023.10107894>
- Yu, J. (2022). Exploration of educational possibilities by four metaverse types in physical education. *technologies*. *Basel*, 10(5), 104. <https://doi.org/10.3390/technologies10050104>
- Yuan, J., Liu, Y., Han, X., Li, A., & Zhao, L. (2023). Educational metaverse: An exploration and practice of VR wisdom teaching model in chinese open university english course. *Interactive Technology and Smart Education*. <https://doi.org/10.1108/ITSE-10-2022-0140>
- Yue, K. (2022). Breaking down the barrier between teachers and students by using metaverse technology in education: Based on a survey and analysis of Shenzhen City, China. *Proceedings of the 2022 13th International Conference on E-Education, E-Business, E-Management, and E-Learning (IC4E '22)*, 40-44. <https://doi.org/10.1145/3514262.3514345>
- Yuen, S. C., Yaoyuneyong, G., & Johnson, E. (2011). Augmented reality: An overview and five directions for AR in education. *Journal of Educational Technology Development and Exchange (JETDE)*, 4(1). <https://doi.org/10.18785/jetde.0401.10>

- Zahedi, M., Farahani, E., & Peymani, K. (2023). A virtual e-learning environment model based on metaverse. *10th International and the 16th National Conference on E-Learning and E-Teaching*. <https://doi.org/10.1109/ICeLeT58996.2023.10139894>
- Zhang, X., Chen, Y., Hu, L., & Wang, Y. (2022). The metaverse in education: Definition, framework, features, potential applications, challenges, and future research topics. *Frontiers in Psychology*, 13(11). <https://doi.org/10.3389/fpsyg.2022.1016300>
- Zhong, J., & Zheng, Y. (2022). Empowering future education: Learning in the edu-metaverse. *International Symposium on Educational Technology (ISET)*, 292-295. <https://doi.org/10.1109/ISET55194.2022.00068>
- Zonaphan, L., Northus, K., Wijaya, J., Achmad S., & Sutoyo, R. (2022). Metaverse as a future of education: A systematic review. *8th International HCI and UX Conference in Indonesia (CHIuXiD)*, 77-81. <https://doi.org/10.1109/CHIuXiD57244.2022.10009854>