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Shorouq F. Eletter, Ghaleb A. Elrefae, Amer Qasim, Tahira Yasmin

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Shorouq F. Eletter*, Ghaleb A. Elrefae, Amer Qasim and Tahira Yasmin

College of Business,
Al Ain University, UAE
Email: Shorouq.eletter@aau.ac.ae
Email: ghalebelrefae@aau.ac.ae
Email: amer.qasim@aau.ac.ae
Email: Tahira.Yasmin@aau.ac.ae
*Corresponding author

Abstract: The evolution of traditional education has always coincided with the advancement of information technology – a virtual environment known as the Metaverse mixes enhanced physical reality with persistent digital worlds. The emergence of big data and cyber-physical systems has recently brought it to the attention of a global audience. There is much opportunity for innovative education with this original notion. Our bibliometric study examines the scholarly discourse on integrating the Metaverse into education using academic literature from Scopus databases. The study identifies essential themes, trends, and future directions in this discipline. Preliminary data indicates a growing trend in linked articles and a growing curiosity about the potential applications of the Metaverse in educational settings, sparking excitement and intrigue about the possibilities. This research's inception highlights its interdisciplinary and collaborative nature, which is crucial in understanding the full potential of the Metaverse in education, reflecting its growing scholarly interest and highlighting inclusivity and diversity across various academic disciplines.

Keywords: Metaverse; virtual reality; education; augmented reality; bibliometric analysis.

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Biographical notes: Shorouq F. Eletter is an Associate Professor of Business Management at the College of Business at Al Ain University. Her diverse research interests include business intelligence, deep learning, big data, knowledge management, management, marketing research, sentiment analysis, data mining, text analysis, blockchain, and metaverse.

Ghaleb A. Elrefae is a Financial Economics and Accounting Professor in the College of Business at Al Ain University, UAE. He has published in various journals, books, and journal proceedings. He served as Associate Editor and Guest Editor and has recently become a Chief-Editor and an editorial member of several economics, business, and information technology journals. His research interests include university corporate governance, risk management, financial contract theory, theory of the firm, industrial organisation, business analytics and artificial intelligence, and drone technology in business environments.

Amer Qasim is a Professor of Accounting in the College of Business at Al Ain University. He received his PhD in Accounting from the University of Aberdeen-UK. He has published in *Accounting Analytics*, *Artificial Intelligence in Accounting*, *Robotic Process Automation in Accounting*, and *Accounting Education*. He is currently working on research papers calling for modernising the accounting curriculum to reflect the technological advancements implemented in the accounting profession.

Tahira Yasmin is an Associate Professor at the College of Business at Al Ain University. She received her PhD in Business Management and Input-output analysis from Universiti Tenaga Nasional, Malaysia 2017. Moreover, she obtained her MSc from the Lahore College for University and a BSc from the Punjab University, Pakistan. She has co-coined various input-output theories and concepts such as fiscal plan impact, tariff impact, structural changes, stimulus packages effect, energy efficiency, and economic development policies in her research work.

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1 Introduction

Cyberspace has developed constantly since the 1990s, when the Internet was introduced, and it has now become an essential component of contemporary civilisation (Manjikian, 2010). It is a vital component of our everyday existence, transforming communication, acting as a treasure trove of information, and providing many hours of amusement. Cyberspace is now an essential aspect of modern life, revolutionising how individuals communicate, study, and amuse themselves (Mbanaso and Dandaura, 2015).

Consequently, the swift development of digital technologies has significantly influenced several industries, including education. The idea of the Metaverse, a shared virtual space created by integrating augmented physical reality with ongoing virtual worlds, has become a powerful and transformative force (Lee et al., 2021). The Metaverse is a virtual environment that replicates the real world, with users linked as distinct avatars (Rahman et al., 2023). By smoothly extending the physical world into the virtual environment, the Metaverse creates a coherent and integrated ecosystem beyond simply merging the physical and virtual worlds. This views the Metaverse as a networked system that combines the two dimensions to create a unified world (Tlili et al., 2022). The Metaverse is a post-reality universe, a continuous multi-user environment that blends physical reality with digital virtuality. It relies on virtual reality (VR) and augmented reality (AR) to enable multi-sensory interactions with virtual environments, digital objects, and people. This interconnected web of immersive, networked environments allows real-time communication and dynamic interactions with digital artefacts. The Metaverse paradigm potentially revolutionises online education, business, remote work, and entertainment (Mystakidis, 2022).

Education is a cornerstone of civilisation and the basis for our future development. The technological innovations provided by the Metaverse are crucial in shaping and

advancing the future of education (Capatina et al., 2024). The Metaverse represents a significant shift in how education is delivered and experienced. It is a comprehensive fusion of human experiences, virtual environments, and real-world elements across time and space, such as cyber-physical spaces. The educational Metaverse emerges from the heart of conventional educational practices, such as knowledge transmission and learning, while also transforming numerous foundational aspects. These changes include redefining the teacher-student dynamic, overcoming time and physical space constraints, and more (Lin et al., 2022).

Exploring the Metaverse in education is significant because it can transform traditional teaching and learning methods (Capatina et al., 2024). The Metaverse enables students to take lessons electronically while retaining the characteristics of a traditional classroom. Students can engage with teachers and classmates via avatars, creating an immersive learning environment that boosts motivation (Tlili et al., 2022). The Metaverse offers dynamic, immersive learning experiences that stimulate students' curiosity. Its collaborative elements promote worldwide connections and knowledge sharing, whereas individualised learning caters to individual needs, increasing motivation and achievement. Gamification features make learning more engaging and motivational (Yakin and Seraj, 2023). The Metaverse can increase student engagement by delivering immersive and interactive learning settings (AlGerafi et al., 2023; Yakin and Seraj, 2023; Lee and Hwang, 2022). It can also create tailored learning experiences and facilitate global cooperation. Furthermore, it provides unique chances for experiential learning (Sinha, 2023), enabling students to participate in simulations and virtual labs that would otherwise be unavailable. According to Sinha (2023), learning and development methodologies in management education are expected to change due to the integration of virtual and real-world elements inside the Metaverse.

The Metaverse has the potential to be an innovative form of learning environment since it provides virtualised, highly immersive experiences, more freedom for creation and sharing, and social communication spaces. It also has drawbacks, including less solid social relationships, privacy issues, the possibility of virtual crimes because of anonymity, and the potential for students with immature identities to struggle in the real world. The Metaverse is predicted to change daily life and the economy in addition to gaming and entertainment (Kye et al., 2021). Additionally, according to Tlili et al. (2022), no research has particularly examined using the Metaverse in education for students with impairments. This disparity is significant because the immersive and configurable technologies of the Metaverse may offer inclusive and customised learning opportunities. Subsequent investigations in this field may improve accessibility and involvement for these students.

The Metaverse is still a promising tool for educational contexts despite its potential. A rising corpus of literature addresses many facets of this integration, but there is not a thorough grasp of the state of the field's research. By performing a bibliometric analysis of the body of research on the use of the Metaverse in education, this study seeks to close this gap. This study aims to uncover meaningful patterns, themes, and gaps in the current body of knowledge by methodically examining and synthesising the research, thereby offering insightful information to educators, researchers, and policymakers. The present study employs a mixed-methods approach, integrating bibliometric analysis and content analysis, to map the progress of research on the Metaverse in education and identify potential and difficulties related to its integration. The findings of this study will further our understanding of how the Metaverse can be used to improve teaching methods and

open up new avenues for investigation in this rapidly developing field. The study aims to address the following research questions:

RQ1 What are the key trends in the research on Metaverse implementation in education regarding publication year, country, and keywords?

RQ2 Who are the leading authors, institutions, and countries contributing to the research on the Metaverse in education?

RQ3 What are the primary themes and topics covered in the literature on Metaverse in education?

RQ4 What are the identified opportunities and challenges of integrating the Metaverse into educational practices?

2 Methods

This study employs quantitative and qualitative synthesis approaches to review existing literature on the Metaverse in education. Traditional systematic reviews, while essential, can introduce outcome reporting bias and subjectivity due to manual processes. To address these limitations, a mixed-methods systematic review that integrates bibliometric analysis and content analysis is necessary to accurately identify a topic's knowledge base and scientific evolution.

The study conducted a comprehensive investigation using the Scopus database to cover interdisciplinary research on using the Metaverse in education. The search query combined keywords related to 'Metaverse' and 'education', using TITLE-ABS-KEY to target relevant literature specifically. Only scholarly articles, conference papers, book chapters, and books published in English up to the current date were included, while lecture notes and unrelated articles were excluded. This process resulted in a dataset of 594 publications from 2008 to 2024.

Bibliometric analysis at a single point in time offers a static snapshot of the field, identifying current key authors, institutions, and themes. In addition, researchers can track the field's evolution, uncovering new trends, shifts in focus, and changes in collaboration patterns. This longitudinal approach provides a richer, more nuanced understanding of the field's development and future directions (Aria and Cuccurullo, 2017). Biblioshiny, a Java software developed by Massimo Aria within the Shiny package environment in R, was used for bibliometric analysis. The software facilitated various bibliographic tasks such as 'co-citation', 'coupling', 'scientific collaboration analysis', and 'co-word analysis' and generated a data matrix. The study also tracked the continuous emergence of new data intersecting structural and temporal advancements in areas such as 'network analysis', 'factorial analysis', and 'thematic mapping' (Sreenivasan and Suresh, 2022).

3 Results and discussion

3.1 Descriptive analysis

Research on the Metaverse and education began in 2008, resulting in 747 publications by 2,312 authors, including 122 single-authored works Figure 1. These studies, published across 465 sources, reflect a growing academic interest in this field. The average citation rate of 8.664 per document indicates the relevance and impact of this research. This data highlights the collaborative and expanding nature of Metaverse research in education, underscoring its significance in academic discourse.

Figure 1 Descriptive analysis (see online version for colours)

The data in Figure 1 shows a significant increase in research on the Metaverse in education. From 2008 to 2019, very few publications indicated limited interest or emerging exploration, peaking at four publications in 2009. In 2020 and 2021, this grew modestly to six and five publications, respectively. However, 2022 saw a dramatic rise to 135 publications, and 2023 peaked with 414 publications, likely due to technological advancements and the COVID-19 pandemic (Tlili et al., 2022), highlighting the need for remote learning solutions. By mid-2024, there are already 168 publications suggesting sustained high interest and that the Metaverse is becoming central to educational research, exploring diverse aspects and driving ongoing innovation.

Figure 2 Research trends of publications from 2009 to early 2024

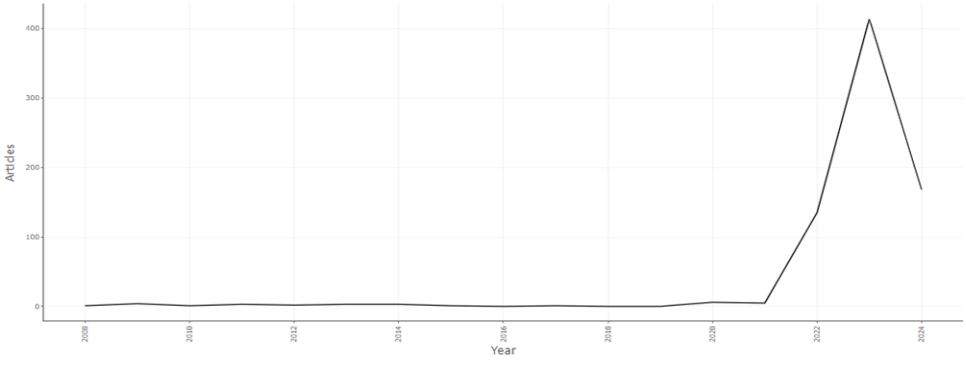


Table 1 highlights the top 10 sources for Metaverse research in education. *IEEE Access* and *IEEE Transactions on Learning Technologies* each have 17 articles – the *ACM International Conference Proceeding Series* and *Sustainability Journal* feature 16 and 15 publications, respectively. Studies in *Big Data* have 12, while *Education and Information*

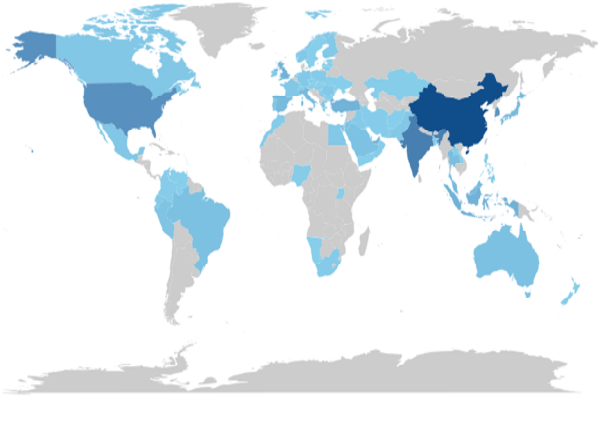
Technologies have 11. The other sources each have ten or fewer articles. Generally, the distribution of articles across these sources illustrates the interdisciplinary nature of Metaverse research in education, spanning technology, sustainability, and specialised Metaverse studies. This trend reflects increasing academic interest and investment in exploring and utilising the Metaverse for educational innovation and advancement.

Table 1 Top 10 relevant sources

Sources	*Articles*
IEEE Access	17
IEEE Transactions on Learning Technologies	17
ACM International Conference Proceeding Series	16
Sustainability (Switzerland)	15
Studies in Big Data	12
Education and Information Technologies	11
Communications In Computer And Information Science	10
Journal of Metaverse	10
Electronics (Switzerland)	9
2023 International Conference on Intelligent Metaverse Technologies and Applications, IMETA 2023	8

Figure 3 showcases the first author's country of affiliation. The map has three different colour shades: blue colour implies a different productivity rate, dark blue indicates high productivity, and grey means no publications (Peykani et al., 2021). Consequently, China is the most productive with 305 documents, trailed by India with 182, the USA with 139, and South Korea with 129. Additionally, the UAE, Indonesia, the UK, Turkey, Italy, and Malaysia have 73, 63, 62, 61, 45, and 45 documents in Scopus. These findings underline the global distribution of research efforts in the field, suggesting varying levels of academic engagement and national priorities in exploring the implications and applications of the Metaverse.

Figure 3 Top 10 countries with the most significant publications (see online version for colours)



Country	Freq.
China	305
India	182
USA	139
South Korea	129
United Arab Emirates	73
Indonesia	63
UK	62
Turkey	61
Italy	45
Malaysia	45

Figure 4 depicts the top 10 institutions with 18 or fewer documents on Metaverse in education. Notably, the University of Sharjah has 18 publications, City University Ajman and Bina Nusantara University each have 12, while the University of Salford and Nanyang Tech. The university has 11 publications. The University of Salamanca and the others have the lowest count at 9, reflecting diverse levels of scholarly activity in this emerging field among different universities. This variation may stem from differences in institutional priorities, research focus, or resource allocation towards Metaverse-related studies.

Figure 4 Top 10 institutions (see online version for colours)

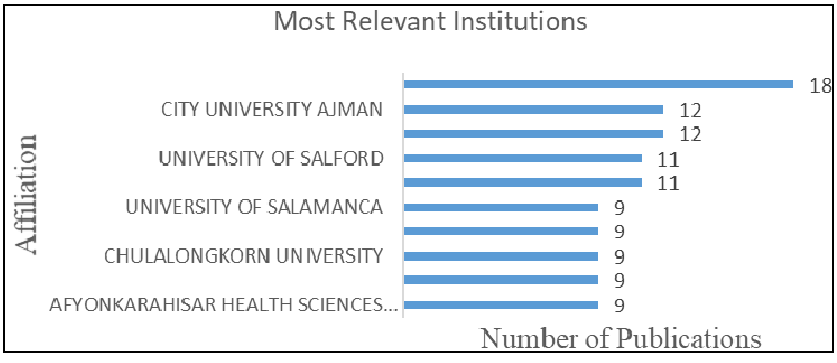


Table 2 displays the top 10 authors with publications on 'Metaverse' and 'education'. Li, Y. has ten documents. Chen, X., Liu, Y. and Salloum, S.A. each have eight documents. Wang, Y. and Zhang, Y. each have seven documents. AbuRayya, A., Lee, H., Liu, X. and Wei, Z. have six publications. This distribution highlights top prolific researchers driving the discourse in this niche field, indicating their significant influence and the collaborative nature of research at the intersection of Metaverse and educational studies. This can help identify leading trends and potential collaborators for future research initiatives.

Table 2 Top 10 authors

Authors	*Articles*
Li, Y.	10
Chen, X.	8
Liu, Y.	8
Salloum, S.A.	8
Wang, Y.	7
Zhang, Y.	7
AbuRayya, A.	6
Lee, H.	6
Liu, X.	6
Wei, Z.	6

3.2 Trending topics and themes in Metaverse research

A thematic map of four topological regions based on density and centrality was created, as shown in Figure 5. This thematic map provides insights into current trends and future directions in Metaverse-related educational research. This map was derived using a semi-automatic algorithm that reviewed the titles of publications used in this study on the topics of 'Metaverse' and 'education' to capture more profound variations (Rusydiana, 2021). The upper right quadrant, characterised by high density and centrality, 'motor or driving topics', includes significant topics such as 'Metaverse learning', 'Metaverse-based', 'educational Metaverse', and 'extended reality'. These topics are essential for future research and should be further developed. The top left quadrant (specific and rapidly developing topics) features high-density but low-centrality topics. This region indicates that they are specific, under-represented, yet rapidly evolving. Examples include 'deep reinforcement' and 'deep learning-based' approaches. Lower left quadrant (emerging topics): includes topics with low density and low centrality, suggesting they have been used but are now declining. These topics include 'immersive learning', 'bibliometric analysis', and 'virtual worlds'. Lower right quadrant (basic) is characterised by high centrality but low density: it covers fundamental topics crucial for general research, such as 'VR' and 'Metaverse environment'.

Figure 5 Thematic map (see online version for colours)

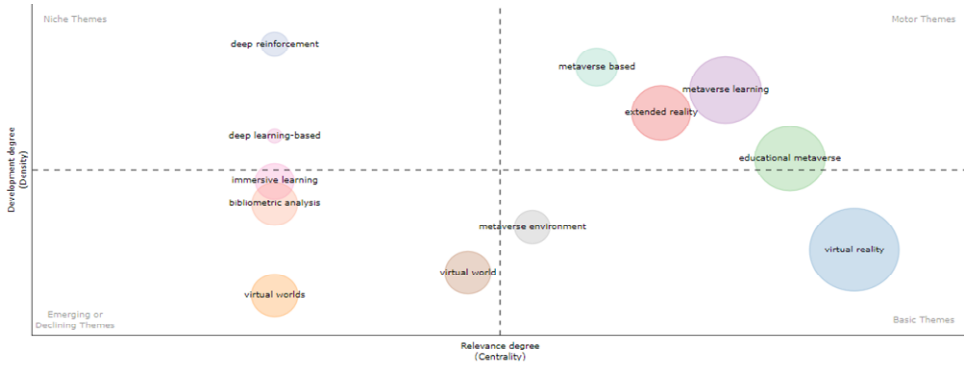
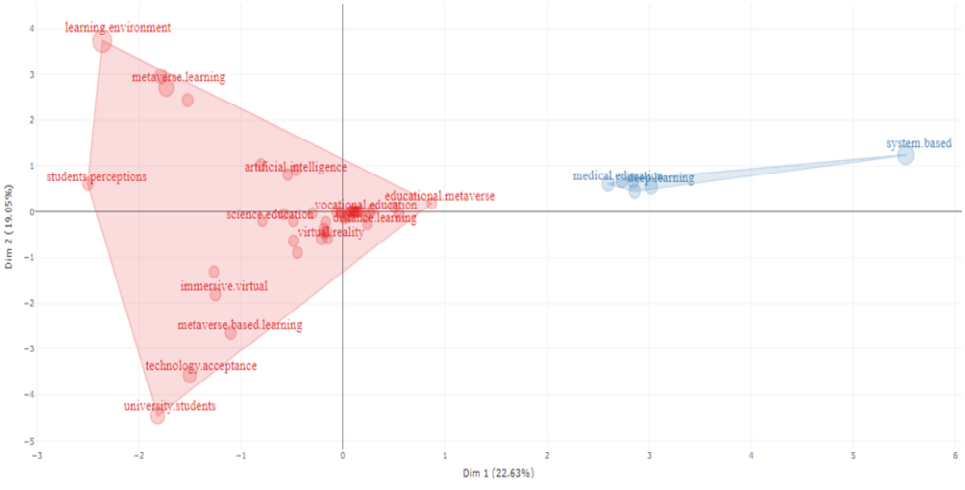


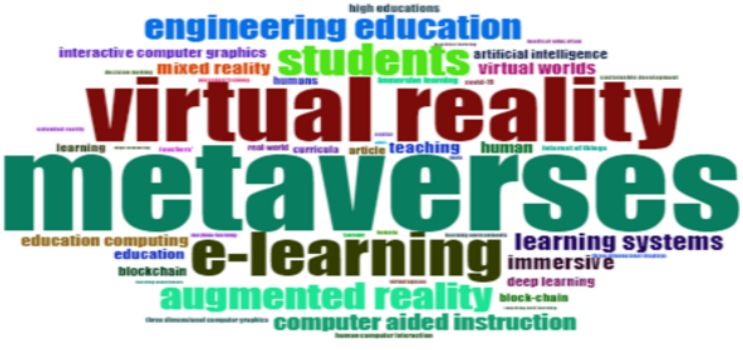
Figure 6 presents a conceptual structure map visualising the contextual structure of words from the titles of all publications analysed in this study on 'Metaverse' and 'education'. Dimensionality reduction techniques, such as multidimensional scaling (MDS) (Tayebi et al., 2019), were used for this analysis. Words are positioned based on their dims 1 and 2 values, with 'dim' referring to a diminutive particle, a specific term in bibliometric science (Rusydiana, 2021). This mapping illustrates the relationships between words with similar values. Two clusters are evident: a red cluster and a blue cluster. The red cluster contains a large and diverse set of words, indicating that many research papers explore connections between these terms. The top three words in the red cluster, 'Metaverse learning', 'educational Metaverse', and 'VR', appear close to one another. In the blue cluster, the words 'medical education', 'Metaverse system', 'education system', and 'deep learning' are prominently grouped. This visualisation underscores the contextual linkages and thematic concentrations in the studied publications.

Figure 6 Conceptual structure map: factorial analysis (see online version for colours)



The word cloud depicts a visualisation of the words illustrating the frequently employed terms in publications on 'Metaverse' and 'education' Figure 7. Words are shown in the word cloud in different sizes based on how frequently they appear. Although the word order is arbitrary, the main words are positioned in the centre to stand out more because of their size. The most common word was 'metaverse', the second most common word was 'virtual reality', the third most common word was e-learning', the fourth most common word was 'students', and the fifth most common word was 'augmented reality'.

Figure 7 The frequency of the words used in the titles in all publications of this study (see online version for colours)



4 Opportunities and challenges

4.1 Opportunities

The Metaverse offers enormous learning potential benefits, such as creating immersive and dynamic experiences while fostering student cooperation and social interaction. The Metaverse is a broad framework that encompasses several future digital advances. It

offers numerous advantages, including seamless portability, realistic experiences, and increased engagement. To ensure accessibility and sustainability, the educational system must be examined and modified in this evolving digital context (Lin et al., 2022). The Metaverse is a practical technique for increasing educational equality. Emerging technologies help to break down barriers such as distance, time, and money, resolving problems that are frequently impossible to overcome in the physical world (Kaddoura and Al Husseiny, 2023; Garlinska et al., 2023; Dwivedi et al., 2022).

The Metaverse's immersive nature can significantly boost student engagement and motivation. The Metaverse improves student learning outcomes by providing interactive and gamified learning environments (AlGerafi et al., 2023; Yakin and Seraj, 2023; Lee and Hwang, 2022). The Metaverse permits the creation of personalised learning routes. AI-powered Metaverse technology can tailor instructional content to students' specific needs and learning styles, resulting in better learning results (Kumar et al., 2023; Shu and Gu, 2023; George and Wooden, 2023; Yakin and Seraj, 2023).

Additionally, the Metaverse offers unparalleled opportunities for experiential learning, allowing students to participate in simulations and virtual labs that would otherwise be impossible or impractical in the actual world. This practical knowledge is invaluable for subjects such as science and engineering (Wang et al., 2021; Zhang et al., 2022; Qasim et al., 2023; Sinha, 2023; Yakin and Seraj, 2023; Capatina et al., 2024). It enables students and educators worldwide to collaborate in real-time, eliminating geographical barriers. This can result in richer educational experiences and a more global approach to learning (Garlinska et al., 2023; Kaddoura and Al Husseiny, 2023; Yakin and Seraj, 2023; Lee and Hwang, 2022; Li et al., 2024). Individuals with impairments can benefit from the Metaverse's personalised learning environments, promoting greater inclusion in educational settings (Song, 2023; Yenduri et al., 2023; Acharya and Mohbey, 2024; Othman et al., 2024).

4.2 Challenges

Technological barriers: the integration of the Metaverse in educational environments necessitates substantial technological infrastructure (Stanoevska-Slabeva, 2022; Chamola et al., 2023; Zaidi et al., 2024), Metaverse platforms based on cloud computing have increased demand for computing capacity, necessitating the use of high-performance devices and robust servers, as well as continuous advances in processing speed, complexity, and power consumption (Wang et al., 2023). Additionally, the Metaverse requires the purchase of pricey headsets and associated equipment, posing a financial barrier that might prevent widespread adoption, particularly among people who cannot afford this cutting-edge technology (Zaidi et al., 2024).

The development and maintenance of Metaverse platforms can be prohibitively expensive (Christopoulos et al., 2021; Mystakidis, 2022; Jung et al., 2023). Some schools and universities may struggle with the financial investment to integrate these technologies into their curricula. Both educators and students must have a certain level of digital literacy to effectively use Metaverse technologies (Chang et al., 2023). Training and professional development are necessary to equip users with the required skills, which can be time-consuming and costly

The Metaverse involves the collection of vast amounts of personal data. Ensuring the privacy and security of this data is a significant challenge, as educational institutions need

to protect against data breaches and cyberattacks; maintaining confidentiality, integrity, and availability is essential to improving the effects of education (Lin et al., 2022). Metaverse apps are still in their early phases. Businesses struggle to discover health issues and generate possibilities in the Metaverse since a regulated legal framework is absent. Legal aid is urgently needed, particularly in private data cases (Jung et al., 2023).

Integrating the Metaverse into education requires a shift in pedagogical approaches (Lin et al., 2022). To incorporate the Metaverse into education, a change in pedagogical strategies is required, emphasising immersive and interactive learning opportunities. Teachers need to change how they use virtual environments to promote student engagement, teamwork, and the development of valuable skills. New evaluation techniques will also be required to quantify student performance in these cutting-edge environments properly.

Social and cultural boundaries may challenge the Metaverse's inclusivity and accessibility. In order to foster a courteous, inclusive, and encouraging workplace that celebrates diversity, these issues must be resolved (Kaddoura and Al Husseiny, 2023). While the Metaverse allows for unparalleled virtual contact and participation, mental and physical health can suffer in this immersive environment. Scholars have begun to recognise the negative impacts of the Metaverse on social, emotional, and physical well-being (Jung et al., 2023). The Metaverse presents severe threats to one's physical and mental health despite its potential for virtual engagement. It can result in obesity, musculoskeletal diseases, cardiovascular issues, and inactive lifestyles. Depression, anxiety, and addiction are examples of mental health problems. The lack of authenticity in virtual connections puts social health at risk. The Metaverse may disrupt sleep habits and meaningful interactions, and the lines between the virtual and real worlds may blur. However, promoting balanced use, consistent physical activity, and mental health assistance are necessary to address and mitigate these hazards.

5 Conclusions

Education is the cornerstone of human civilisation, fostering societal growth and influencing future generations. The Metaverse is a watershed moment in educational technology, leveraging breakthroughs to create a seamless blend of human, virtual, and physical interactions that transcend time and space. This shift re-imagines traditional educational paradigms by leveraging the dynamic capabilities of cyber-physical environments.

The Metaverse represents a significant shift in how education is delivered and experienced. Traditional educational activities, such as lectures and hands-on learning, are enhanced with immersive digital environments that connect the real and virtual worlds. This relationship allows for more engaging and individualised learning experiences. Teachers and students can connect unimaginably in virtual classrooms that mimic real-world situations or historical events. Furthermore, physical space constraints are no longer a hindrance, allowing students from different regions to join in the same virtual learning environment. This paradigm shift creates new potential for collaboration, accessibility, and creativity in education.

This bibliometric analysis explains the current status of research and has implications for future scholarship and practice. As the Metaverse grows in popularity, educators, researchers, and policymakers are urged to look for new ways to incorporate this

emerging technology into teaching and learning practices. The Metaverse can potentially alter education and challenge traditional classroom boundaries by promoting collaboration, transdisciplinary dialogue, and evidence-based methodologies. In conclusion, this study contributes to the growing body of literature on the intersection of the Metaverse and education by examining research trends, thematic areas, and methodology. This analysis lays the groundwork for future research into harnessing the Metaverse's transformative power to improve educational experiences and empower learners in the digital age.

References

Acharya, M. and Mohbey, K.K. (2024) 'Virtual environment role in higher education students learning enhancement with intellectual disabilities', in *Applied Assistive Technologies and Informatics for Students with Disabilities*, pp.35–57, Springer Nature, Singapore.

AlGerafi, M.A., Zhou, Y., Oubibi, M. and Wijaya, T.T. (2023) 'Unlocking the potential: a comprehensive evaluation of augmented reality and virtual reality in education', *Electronics*, Vol. 12, No. 18, p.3953.

Aria, M. and Cuccurullo, C. (2017) 'Bibliometrix: an R-tool for comprehensive science mapping analysis', *Journal of Informetrics*, Vol. 11, No. 4, pp.959–975.

Capatina, A., Patel, N.J., Mitrov, K., Cristea, D.S., Micu, A. and Micu, A.E. (2024) 'Elevating students' lives through immersive learning experiences in a safe Metaverse', *International Journal of Information Management*, April, Vol. 75, p.102723.

Chamola, V., Hassija, V., Singh, A., Mittal, U., Pareek, R., Mangal, P. and Brown, D. (2023) *Metaverse for Education: Developments, Challenges and Future Direction*, p.2023081872, https://doi.org/10.20944/preprints202308.1872.v1.

Chang, C.Y., Kuo, H.C. and Du, Z. (2023) 'The role of digital literacy in augmented, virtual, and mixed reality in popular science education: a review study and an educational framework development', *Virtual Reality*, Vol. 27, No. 3, pp.2461–2479.

Christopoulos, A., Mystakidis, S., Pellas, N. and Laakso, M.J. (2021) 'ARLEAN: an augmented reality learning analytics ethical framework', *Computers*, Vol. 10, No. 8, p.92.

Dwivedi, Y.K., Hughes, L., Baabdullah, A.M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M.M. and Wamba, S.F. (2022) 'Metaverse beyond the hype: multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy', *International Journal of Information Management*, October, Vol. 66, p.102542.

Garlinska, M., Osial, M., Proniewska, K. and Pregowska, A. (2023) 'The influence of emerging technologies on distance education', *Electronics*, Vol. 12, No. 7, p.1550.

George, B. and Wooden, O. (2023) 'Managing the strategic transformation of higher education through artificial intelligence', *Administrative Sciences*, Vol. 13, No. 9, p.196.

Jung, T., Cho, J., Han, D.I.D., Ahn, S.J.G., Gupta, M., Gopal, D. and Tom Dieck, M.C. (2023) 'Metaverse for service industries: future applications, opportunities, challenges and research directions', *Computers in Human Behavior*, February, Vol. 151, p.108039.

Kaddoura, S. and Al Husseiny, F. (2023) 'The rising trend of Metaverse in education: challenges, opportunities, and ethical considerations', *PeerJ Computer Science*, Vol. 9, p.e1252, 13th February, https://doi.org/10.7717/peerj-cs.1252.

Kumar, D., Haque, A., Mishra, K., Islam, F., Mishra, B.K. and Ahmad, S. (2023) 'Exploring the transformative role of artificial intelligence and Metaverse in education: a comprehensive review', *Metaverse Basic and Applied Research*, Vol. 2, p.55, https://doi.org/10.56294/mr202355.

Kye, B., Han, N., Kim, E., Park, Y. and Jo, S. (2021) 'Educational applications of Metaverse: possibilities and limitations', *Journal of Educational Evaluation for Health Professions*, Vol. 18, DOI: https://doi.org/10.3352/jeehp.2021.18.32.

Lee, H. and Hwang, Y. (2022) 'Technology-enhanced education through VR-making and Metaverse-linking to foster teacher readiness and sustainable learning', *Sustainability*, Vol. 14, No. 8, p.4786.

Lee, L.H., Braud, T., Zhou, P., Wang, L., Xu, D., Lin, Z. and Hui, P. (2021) *All One Needs to Know About Metaverse: A Complete Survey on Technological Singularity, Virtual Ecosystem, and Research Agenda*, arXiv preprint arXiv:2110.05352.

Li, C., Jiang, Y., Ng, P.H., Dai, Y., Cheung, F., Chan, H.C. and Li, P. (2024) 'Collaborative learning in the edu-Metaverse era: an empirical study on the enabling technologies', *IEEE Transactions on Learning Technologies*, Vol. 17, pp.1107-1119, DOI: 10.1109/TLT .2024.3352743.

Lin, H., Wan, S., Gan, W., Chen, J. and Chao, H.C. (2022) 'Metaverse in education: vision, opportunities, and challenges', in *2022 IEEE International Conference on Big Data (Big Data)*, IEEE, December, pp.2857–2866.

Manjikian, M.M. (2010) 'From global village to virtual battlespace: the colonizing of the internet and the extension of realpolitik', *International Studies Quarterly*, Vol. 54, No. 2, pp.381–401.

Mbanaso, U.M. and Dandaura, E.S. (2015) 'The cyberspace: redefining a new world', *IOSR Journal of Computer Engineering (IOSR-JCE)*, Vol. 17, No. 3, pp.17–24.

Mystakidis, S. (2022) 'Metaverse', *Encyclopedia*, Vol. 2, No. 1, pp.486–497, https://doi.org/ 10.3390/encyclopedia2010031.

Othman, A., Chemnad, K., Hassanien, A.E., Tlili, A., Zhang, C.Y., Al-Thani, D. and Altınay, Z. (2024) 'Accessible Metaverse: a theoretical framework for accessibility and inclusion in the Metaverse', *Multimodal Technologies and Interaction*, Vol. 8, No. 3, p.21.

Peykani, P., Farzipoor Saen, R., Seyed Esmaeili, F.S. and Gheidar-Kheljani, J. (2021) 'Window data envelopment analysis approach: a review and bibliometric analysis', *Expert systems*, Vol. 38, No. 7, p.e12721, https://doi.org/10.1111/exsy.12721.

Qasim, A., El Refae, G.A. and Eletter, S. (2023) 'Metaverse and accounting education: potentials and opportunities in the accounting internship courses', in *2023 Tenth International Conference on Social Networks Analysis, Management and Security (SNAMS)*, IEEE, November, pp.1–6.

Rahman, K.R., Shitol, S.K., Islam, M.S., Iftekhar, K.T. and Saha, P. (2023) 'Use of Metaverse technology in education domain', *Journal of Metaverse*, Vol. 3, No. 1, pp.79–86.

Rusydiana, A.S. (2021) 'Bibliometric analysis of journals, authors, and topics related to COVID-19 and Islamic finance listed in the dimensions database by Biblioshiny', *Science Editing*, Vol. 8, No. 1, pp.72–78.

Shu, X. and Gu, X. (2023) 'An empirical study of a smart education model enabled by the edu-Metaverse to enhance better learning outcomes for students', *Systems*, Vol. 11, No. 2, p.75.

Sinha, E. (2023) 'Co-creating' experiential learning in the Metaverse-extending the Kolb's learning cycle and identifying potential challenges', *The International Journal of Management Education*, Vol. 21, No. 3, p.100875.

Song, J. (2023) 'Inclusive educational effectiveness through Metaverse for the disabled students and policy suggestions', *Journal of Intelligence and Information Systems*, Vol. 29, No. 1, pp.175–201.

Sreenivasan, A. and Suresh, M. (2022) 'Future of healthcare start-ups in the era of digitalization: bibliometric analysis', *International Journal of Industrial Engineering and Operations Management*, Vol. 4, Nos. 1/2, pp.1–18.

Stanoevska-Slabeva, K. (2022) 'Opportunities and challenges of Metaverse for education: a literature review', *Edulearn Proceedings*, Vol. 22, pp.10401–10410, DOI: 10.21125 /edulearn.2022.2527.

Tayebi, S., Manesh, S., Khalili, M. and Sadi-Nezhad, S. (2019) 'The role of information systems in communication through social media', *International Journal of Data and Network Science*, Vol. 3, No. 3, pp.245–268.

Tlili, A., Huang, R., Shehata, B., Liu, D., Zhao, J., Metwally, A.H.S. and Burgos, D. (2022) 'Is Metaverse in education a blessing or a curse: a combined content and bibliometric analysis?', *Smart Learning Environments*, Vol. 9, No. 1, pp.1–31.

Wang, H., Ning, H., Lin, Y., Wang, W., Dhelim, S., Farha, F. and Daneshmand, M. (2023) 'A survey on the Metaverse: the state-of-the-art, technologies, applications, and challenges', *IEEE Internet of Things Journal*, Vol. 10, No. 16, pp.14671–14688.

Wang, Y., Liu, J. and Carley, K. (2021) 'Experiential learning in virtual reality: a Metaverse-based approach', *Journal of STEM Education*, Vol. 14, No. 4, pp.22–34.

Yakin, A. and Seraj, P.M.I. (2023) 'Impact of Metaverse technology on student engagement and academic performance: the mediating role of learning motivation', *International Journal of Computations, Information and Manufacturing*, Vol. 3, No. 1, pp.10–18.

Yenduri, G., Kaluri, R., Rajput, D.S., Lakshmanna, K., Gadekallu, T.R., Mahmud, M. and Brown, D.J. (2023) 'From assistive technologies to Metaverse – technologies in inclusive higher education for students with specific learning difficulties: a review', *IEEE Access*, May, DOI: 10.48550/arXiv.2305.11057.

Zaidi, S.S.B., Adnan, U., Lewis, K.O. and Fatima, S.S. (2024) 'Metaverse-powered basic sciences medical education: bridging the gaps for lower-middle-income countries', *Annals of Medicine*, Vol. 56, No. 1, p.2356637.

Zhang, X., Chen, Y., Hu, L. and Wang, Y. (2022) 'The Metaverse in education: definition, framework, features, potential applications, challenges, and future research topics', *Frontiers in Psychology*, Vol. 13, p.1016300, https://doi.org/10.3389/fpsyg.2022.1016300.