IJITLS

International Journal of Information Technology and Language Studies (IJITLS)

A SWOT Analysis of the Metaverse in Education

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Article Information

Article type: Review

Keywords:

SWOT Analysis
Metaverse
Education

Abstract

The rapid expansion of Metaverse technologies is reshaping education, yet their educational value remains uncertain because potential benefits coexist with substantial pedagogical, technological, ethical, and security risks. This study addresses the lack of an integrated assessment of these competing implications by examining the influence of the Metaverse on education through a SWOT framework. Drawing on prior literature, the study qualitatively synthesizes evidence into strengths, weaknesses, opportunities, and threats. The findings show that the Metaverse can support immersive, flexible, collaborative, and simulation-based learning while reducing constraints related to time, location, cost, and physical risk. However, high technological requirements, reduced face-to-face interaction, accessibility inequalities, privacy breaches, cybersecurity vulnerabilities, health concerns, and ethical challenges may hinder effective adoption. The study provides a structured basis for educators, institutions, policymakers, and developers to guide strategic planning, risk mitigation, and responsible integration of Metaverse technologies into education.

1. Introduction

The term “Metaverse” traces its origins to Neal Stephenson's 1992 novel 'Snow Crash,' gaining wider recognition through the movie adaptation, Ready Player One (Cline, 2011). The term is a composite of the prefix "meta," signifying "virtuality," and the stem "verse," denoting "universe" (Wu & Ho, 2023). Despite its inception three decades ago, the advancement of the Metaverse has been constrained by technical challenges impinging on shared comprehension, coordination, and communication processes (Owens et al., 2011). Metaverses are considered collaborative three-dimensional, real-time virtual environments facilitating the simultaneous involvement of multiple users in social, cultural, and economic activities. Users interact within these realms through avatars, transcending physical constraints (Owens et al., 2011). Employing technologies such as Artificial Intelligence (AI), Blockchain, Non-Fungible Tokens (NFTs), Edge Computing, Digital Twins, Human-Computer Interaction, Immersion, Sense of Presence, Affordances, mixed reality, augmented reality, extended reality, virtual reality, and 3D graphics, the Metaverse facilitates real-time interactions unattainable in the physical world (Kemec, 2022).

Technological interest in the Metaverse has surged with recent advancements in virtual and augmented reality (Ahn et al., 2022). Augmented reality integrates digital elements into live images, while virtual reality involves complete immersion in a virtual environment (Filiz, 2022). The Metaverse has become a focal point in diverse fields such as engineering management (Ooi et al., 2023), software engineering (Fernandes & Werner, 2022), virtual commerce (Shen et al., 2021), emergency medicine (Wu & Ho, 2023), medicine (Kawarase IV et al., 2022), nursing practice (De Gagne et al., 2023; D. Zhang et al., 2021), sustainable learning (Park & Kim, 2022), and education (Hwang & Chien, 2022). There has been a growing body of literature in the field of education, encompassing various research methodologies such as bibliometric analysis (Tas

& Bolat, 2022; Tlili et al., 2022), content analysis (Narin, 2021), and systematic reviews (Chua & Yu, 2023; De Felice et al., 2023; López Belmonte et al., 2023; Ritterbusch & Teichmann, 2023). Despite the increasing interest in the application of the Metaverse in education, a notable research gap persists regarding its implementation and effectiveness (Jeon, 2021). Thus, this current review aims to address this gap by offering a structured and comprehensive understanding of the potential impact of the Metaverse on education.

The review intends to assess the influence of the Metaverse on the educational process through a SWOT analysis, evaluating strengths, weaknesses, opportunities, and threats. In this analysis, strengths pertain to capabilities facilitating institutions in efficiently achieving their goals, while weaknesses encompass limitations hindering institutional performance. These aspects are considered internal elements. On the other hand, opportunities are external factors that assist institutions in leveraging their advantages, while threats are negative external factors impeding goal attainment. These opportunities and threats are both considered external factors (Culp III et al., 2016). This SWOT analysis is designed to inform strategic planning, risk mitigation strategies, and policy development, ensuring a balanced and effective integration of the Metaverse into the education system. The structure of this study is as follows: it commences with an introduction section, followed by a detailed exploration of strengths, weaknesses, opportunities, and threats associated with the use of the Metaverse in education. The study concludes with a final section summarizing key findings and insights.

2. Strengths

The Metaverse evolves by integrating the physical world with the Internet of Things, virtual reality, and digital twins (Kang et al., 2023). Notable features of the Metaverse include the fusion of virtuality and reality, rapid advancements in internet communication techniques and hardware platforms, robust human-computer interaction, social interaction with peers, exploration of breakout spaces, access to libraries, and decentralization (Koohang et al., 2023). The growing interest in Metaverse applications can be attributed to their capacity to offer varied experiences comparable to those found in the real world. This increased focus spans multiple sectors, with education being a notable area of interest. Consequently, the Metaverse will facilitate educational activities within a virtual environment (Koohang et al., 2023). This suggests the creation of virtual institutions, the remote conduction of classes, education taking place within a virtual setting, and virtual management. Students will have the chance to attend classes virtually, experiencing aspects similar to a traditional classroom environment (Tlili et al., 2022).

The existence of the Metaverse has the potential to simplify the learning process by alleviating limitations associated with time, space, expenses, and risks, allowing learning to take place conveniently at any time and location through the utilization of VR headsets (Koohang et al., 2023). Metaverse education acts as a means to access learning materials, empowering students to improve their comprehension through a wide array of resources without being restricted by time or location. Furthermore, Metaverse education provides the benefit of cost-effectiveness and decreased resource usage, as experiments can be digitally simulated. Additionally, it minimizes learning risks associated with simulations involving dangerous materials or high-risk scenarios, such as air crashes (Fitria & Simbolon, 2022). Integrating the Metaverse into education enhances the concrete portrayal of abstract concepts, as demonstrated by the clarification of Einstein's theory of relativity (Georgiou, Y., Tsivitanidou, O., & Ioannou, 2021). Through immersive experiences, students can engage with concepts that were that were once limited to their imaginations, resulting in more entertaining and effective learning outcomes (Lin et al., 2022). Moreover, the positive development of problem-based learning is enhanced through its integration with the Metaverse, where problem-based learning acts as an educational tool within the overall educational process, and the Metaverse functions as the virtual classroom setting. In this integrated approach, teachers deliver concise lectures and present topic-related problems to students, fostering active collaboration and problem-solving through chat discussions within the Metaverse. This holistic integration not only captivates students' attention towards course material but also enhances overall classroom engagement and comprehension (Kanematsu et al., 2012).

The Metaverse finds its primary application in virtual learning scenarios, frequently intertwining with collaborative and cooperative learning methodologies to enhance the educational experience (Araya & Avila, 2018). Within this framework, teachers utilize the Metaverse to create virtual rooms for internal meetings, while learners have the capability to establish study rooms for collaborative work, studying, and socializing freely (Fitria & Simbolon, 2022). Simultaneously, students can interact with teachers and peers through avatars, facilitating the exchange of academic information within internal social networks and fostering collaborative learning (Díaz et al., 2020). In this educational context, teachers can upload teaching materials and assign learning topics within the Metaverse, providing students with access to these resources through their virtual devices. Moreover, students can establish connections and receive guidance and feedback through an autonomous tutoring system that relies on data mining of user interactions (Schaf et al., 2012). This comprehensive approach has a positive impact on enhancing students' motivation to learn (Tlili et al., 2022). Furthermore, the engaging characteristics of the Metaverse open up new opportunities for game-based learning, allowing educators to create flexible learning environments within its framework. This not only provides students with increased control over their learning experiences but also results in reduced associated costs (Getchell et al., 2010). In the context of game-based learning, the Metaverse functions as a valuable instrument, boosting students' motivation and refining their communication skills (Estudante & Dietrich, 2020).

3. Weaknesses

Despite the promise of the Metaverse, the incorporation of online learning in education reveals certain drawbacks that impact its effectiveness for both educators and learners. Although the construction of appealing virtual schools creates a comfortable atmosphere, it risks diminishing the real-world connection between teachers and students, limiting interactions to avatars and non-existent in-person meetings. This reduced interaction often results in students losing their sense of direct monitoring of their mental and learning progress. Another limitation of the Metaverse lies in its reliance on high technology consumption due to the development of intricate and high-quality graphics. Moreover, the tools supporting the Metaverse can be costly, posing a challenge, especially for individuals with varying incomes. Consequently, it becomes evident that no technological advancement can adequately substitute for the irreplaceable role played by a teacher (Fitria & Simbolon, 2022).

4. Opportunities

The Metaverse endeavors to establish a fully immersive, hyper-spatiotemporal, and self-sustaining virtual shared space to meet the diverse needs of students for learning, socializing, and exploration (Wang et al., 2022). It provides a platform for learners to navigate various virtual realms using storytelling and visualization. experiencing scenarios like residing in a smart green city or witnessing the transformation of a European street through the use of VR headsets. Moreover, the Metaverse facilitates bite-sized 360-degree storytelling and virtual tours, allowing students to delve into crucial global development topics such as education, public health, urban development, climate change, and international trade (Koohang et al., 2023).

The Metaverse has the potential to democratize education by enabling collaboration among students from various economic backgrounds and remote locations, making the learning process more effective, flexible, and time-efficient (Koohang et al., 2023). This democratization extends to scientific disciplines such as natural science, mathematics, and engineering, where the Metaverse serves as a tool for technical support. It provides 3D modeling computer programs that empower students to establish connections between experiments and virtual objects (Tlili et al., 2022). Furthermore, leveraging user interaction data mining, the Metaverse supports the development of autonomous tutoring systems (Schaf et al., 2012).

In biology classes, the Metaverse provides the option of using virtual animals, serving as substitutes for real animals in the study of animal organs. This includes virtual representations of rabbits, cats, frogs, and fish. Similarly, in astronomy classes, the Metaverse allows students to observe realistic planetary movements and witness phenomena like volcanic eruptions (Fitria & Simbolon, 2022). The Metaverse also offers support for a variety of educational programs, including professional accreditation, workplace training, and interactive learning environments. In the realm of professional accreditation, learners can leverage the Metaverse to acquire advanced certifications in fields like coding, accounting, or real estate. This is particularly advantageous in developing countries where access to coding classes for languages such as C#, Python, or JavaScript may be limited.

In the realm of arts and humanities, the potential to participate in a music concert featuring a singer is facilitated through Art lessons by installing a forthcoming application within the Metaverse (Fitria & Simbolon, 2022). Additionally, the Metaverse has become a prevalent tool in language learning, allowing students to engage with peers who speak different languages in virtual environments, thereby creating novel avenues for acquiring foreign languages (Cruz-Lara et al., 2011). Adding to its versatility, the Metaverse proves advantageous in history classes by offering a distinctive edge over the real world. This allows them to embark on virtual tours of historical sites, transcending the limitations of physical location, whether they are at home, abroad, or even in outer space. (Fitria & Simbolon, 2022). Through immersive visual experiences, students can explore museums and view historical objects, eliminating the necessity for physical visits. For example, they can virtually tour renowned Indonesian landmarks like Borobudur Temple, Prambanan Temple, and other natural tourist destinations, enhancing their comprehension of history. Consequently, lectures become more engaging and educational, fostering effective comprehension of the subjects (Koohang et al., 2023). This expanded functionality is particularly evident in subjects like Geography, where teachers can seamlessly integrate virtual experiences of volcanic eruptions into their lessons (Fitria & Simbolon, 2022).

Considerable attention has been directed toward the rise of virtual reality sports classrooms, where augmented reality sports games like screen golf, screen tennis, and others are utilized as instructional tools in physical education (Yu, 2022). The integration of Metaverse technology in physical education is evident through employing artificial intelligence in activities such as golf, table tennis, and e-sports. The use of virtual and augmented reality extends to various physical education activities like basketball, skiing, surfing, and rafting, along with cloud-based subjects such as F1, American football, baseball, and e-sports. Case studies explore the utilization of mobile devices, smart stadiums, and blockchain technology for living sports platforms, game prediction, and sports media (Egliston & Carter, 2021). Furthermore, successful applications of virtual reality technology, like VR boxing and VR tennis, are observed. Within Metaverse technologies, lifelogging is extensively applied in exercise physiology and training, allowing instructors to lead large groups of students in activities like cycling while providing lessons on proper exercise techniques through a shared screen (Yu, 2022).

The Metaverse plays a crucial role in advancing industrial activities within workplace training by allowing learners to use VR or AR equipment for hands-on instructions that require physical presence. This encompasses a broad range of activities, including surgical operations, aircraft maintenance, and various manufacturing processes. The immersive training capabilities of the Metaverse significantly enhance conventional training programs conducted in university training centers. The Metaverse also addresses the training needs for soft skills, such as communication, empathy, listening, and leadership, which are challenging to develop and assess. By immersing learners in authentic real-world scenarios, the Metaverse enables the safe and practical development of these soft skills, allowing learners to navigate sensitive or intricate relationships with peers and supervisors effectively (Koohang et al., 2023).

The Metaverse plays a positive role in promoting sustainability in education by enhancing learning productivity and eliminating the need for transportation and resource-intensive activities. Regarding transportation, the Metaverse has the potential to advance sustainable education by reducing carbon emissions associated with in-person meetings, training sessions, and sightseeing, achieved through the elimination of traditional modes of travel (Dwivedi et al., 2022). Simultaneously, in terms of resource-intensive activities, instructors can leverage the Metaverse to provide hands-on instruction and create learning opportunities that might be impractical in the physical world. For example, students can engage in simulations, such as experiencing the intricacies of flying an aircraft, offering them a more profound understanding of the pilot's role (Teng et al., 2022).

The integration of the Metaverse into education ensures remarkable accessibility and inclusivity for all students, including those with disabilities. It opens avenues for students with disabilities to more easily participate in education and social interactions, providing a user-friendly and immersive environment facilitated by specialized tools like glasses and headphones. This setup affords learners the flexibility to study without the constraints of specific locations and fixed schedules, even within larger student groups (Sghaier et al., 2022). By leveraging virtual reality (VR) and augmented reality (AR) visuals, students can actively engage with learning materials, interact with peers, and hone skills in a secure and controlled setting, fostering a sense of comfort without overwhelming anxiety. The immersive learning environments and interactions with instructors can particularly benefit students with autism, special needs, and challenges in social interaction, enhancing both interpersonal and learning abilities (Koohang et al., 2023).

5. Threats

The Metaverse is linked to various potential threats that have gained global recognition in research. These significant threats encompass mental health issues (Pellas et al., 2021), physical health concerns, and ethical concerns (Koohang et al., 2023). On the mental health level, the emergence of virtual reality addiction raises concerns about excessive time spent in the virtual world at the expense of the real world (Filiz, 2022). This issue can give rise to psychological risks, including information overload, weakened social connections, and the potential for traumatic experiences within virtual reality environments, all of which can adversely affect users' mental well-being (Slater et al., 2020). On the physical level, VR-based technologies have been associated with health issues such as dizziness, sickness, and nausea (Pellas et al., 2021). AR-based technologies within the Metaverse have the potential to distract users from the real world, thereby increasing the risk of accidents. Lastly, from a moral perspective, engaging in educational activities within the Metaverse can negatively impact students' sense of morality, potentially leading to the violation of cultural norms or even the commission of crimes (Kye et al., 2021).

Privacy is a major concern in the Metaverse due to potential threats stemming from the real-time monitoring and collection of user data by malicious actors, creating risks of user identification (Z. Zhang et al., 2022). In the social Metaverse, the inability of users to control virtual properties complicates the implementation of privacy-preserving measures (O'Brolcháin et al., 2016). Navigating a mall in the Metaverse poses a scenario where an avatar recording purchases and travel history could be exploited for social engineering attacks, jeopardizing real-world privacy. Ensuring privacy in virtual homes within the Metaverse is also challenging, as other avatars can freely access private spaces (Ning et al., 2023). Given the digital foundation of the Metaverse, addressing cybersecurity and privacy concerns is crucial for secure service provision. This necessitates comprehensive measures, including various strategies, methods, and solutions to protect users and systems from diverse threats and vulnerabilities (Z. Zhang et al., 2022).

The integration of the Metaverse raises significant concerns regarding data security, as avatars within this virtual realm generate various forms of data, including personal details like messages, voice recordings, and videos. Customizing digital identities and avatars in the Metaverse creates an additional risk of privacy breaches, exposing users to identity hijacking and scams (Koohang et al., 2023). Security threats persist with the generation of corporate secrets and personal information crucial for service continuity. For instance, unauthorized access, forgery, or leakage of personal information and content within the Metaverse platform can occur, with attackers manipulating avatar information for malicious purposes during user interactions (Dwivedi et al., 2022). Moreover, Geolocation tracking poses a threat to physical privacy (Christopoulos et al., 2021). Smart devices like virtual reality headsets and augmented reality glasses intensify privacy concerns by collecting additional private data, including recorded conversations, videos in private spaces, and tracking the user's gaze through eye-tracking technology (Koohang et al., 2023).

Navigating the dynamic and real-time nature of the Metaverse's complex services makes it challenging to accurately determine when to assess and implement security measures to protect personal information. Existing protection measures and management policies for conventional systems are deemed inadequate in safeguarding the Metaverse's virtual environment against cybercrime and cyber-attacks. Consequently, improvements tailored to the unique characteristics of the Metaverse are necessary. This includes the implementation of more sophisticated authentication and dynamic access control policies for data and personal information, as well as secure storage through encryption to mitigate the impact of unauthorized access (Dwivedi et al., 2022).

The integration of the Metaverse introduces potential risks in software security, similar to those encountered in existing software systems. Vulnerabilities such as insecure system architecture, unpatched software, malware, and ransomware are factors that the Metaverse shares with conventional software platforms. Additionally, there is a concern about minors being exposed to explicit content and violence within the Metaverse. An illustrative incident occurred in the case of Roblox, a representative Metaverse platform, where hackers targeted the system, infecting it with ransomware. These hackers demanded the virtual currency, Robux, as a ransom and engaged in disseminating shocking images, racist messages, and orchestrating lewd actions by manipulating game characters. Moreover, the incorporation of augmented reality (AR) in real-world applications, including fields such as medicine and industry, creates opportunities for malicious actors to compromise safety and well-being. This raises critical considerations about conducting sensitive activities, like high-security research, using Metaverse systems. To shield users from software threats, adopting a "security by design" approach in the early stages of software development becomes imperative (Dwivedi et al., 2022).

Hardware security encompasses the safeguarding of devices such as HMDs, VR headsets, and IoT devices, serving functions like authentication and access control (Rogers et al., 2015; Schneegass et al., 2016). These devices provide users with the potential to bypass authentication processes without the need for usernames and passwords. Additionally, they can be linked to biometric data, including the tracking of physical movements. Consequently, exploiting security vulnerabilities in Metaverse devices can grant malicious actors control over connected devices, enabling remote manipulation, extraction of specific device information (e.g., gaze data, Metaverse activities), or even infiltration of the central management server in Metaverse systems. Ensuring the security of each device within the Metaverse platform is paramount. This involves regularly updating devices with patches and implementing robust security measures. Furthermore, it is recommended to employ a dedicated secure chip for executing security functions on a device, supplementing the reliance on a software module to prevent potential performance degradation resulting from excessive CPU load (Dwivedi et al., 2022).

The Metaverse confronts network security threats attributed to the absence of encryption in network connections within the platform and between avatars. This vulnerability opens the door for attackers to potentially intercept messages and sensitive information, employing techniques like sniffing or spoofing attacks. To counteract this, it is crucial to implement encryption for network connections utilizing a secure and efficient cryptographic algorithm, taking into account the nature of the data and the Metaverse environment. Moreover, the concern of availability looms large, as network disconnections or security attacks, such as distributed denial of service (DDoS), can exert a more pronounced impact on Metaverse services compared to asynchronous online services. For pivotal business processes, it is recommended to establish a business continuity and disaster recovery plan to mitigate unforeseen repercussions resulting from a DDoS attack on the Metaverse system (Dwivedi et al., 2022).

6. CONCLUSION

The advent of the Metaverse signals a new phase of technological integration in the realm of education. It introduces an educational experience that is immersive, authentic, interactive, innovative, diverse, and collaborative, significantly enhancing the processes of teaching and learning. This plays a pivotal role in shaping the future landscape of education. Nevertheless, educators must cultivate their technological competencies and carefully weigh the advantages and disadvantages of the Metaverse to optimize its effectiveness while mitigating potential risks. It's essential to recognize that the virtual realm of the Metaverse differs from the physical reality we currently inhabit on Earth. Therefore, creators of the Metaverse need to address the safeguarding of user data and privacy, adhering to existing legislation and crafting new laws tailored to the distinct challenges posed by the Metaverse.

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