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OPTIMIZATION OF METAVERSE TECHNOLOGY FOR IMMERSIVE LEARNING USING THE SPATIAL.IO PLATFORM

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Abstract

This study examines the optimization of metaverse technology to support immersive learning, focusing on the use of the *Spatial.io* platform. The metaverse, as an interactive three-dimensional virtual environment, offers significant potential in education, such as collaboration, simulations, and in-depth material exploration. *Spatial.io*, as one of the metaverse platforms, provides virtual spaces that support interactive and collaborative learning across devices. This research uses a literature review method to analyze the implementation of metaverse technology through *Spatial.io*, the challenges of implementation, and opportunities for optimization. The study's results show that the integration of *Spatial.io* can increase student engagement, conceptual understanding, and digital literacy. However, challenges such as infrastructure limitations, device accessibility, and educator readiness remain major obstacles. The study recommends strategies for improving infrastructure, providing educator training, and developing digital-based curricula to maximize the potential of the metaverse in education.

Kata Kunci: Metaverse, *Spatial.io*, Immersive Technology, Society Era 5.

A. Introduction

Technological advancements in the field of education have become an undeniable phenomenon. These advancements are inseparable from innovations developed by experts in computers and the internet, which have created a new, more modern ecosystem. As we move toward the Society 5.0 era—a concept centered on human beings and technology—it is expected that society can utilize innovations from the Fourth Industrial Revolution to address social challenges and enhance quality of life.

Education plays a crucial role in the development of human resources in this Society 5.0 era. The role of schools and educators is vital in transforming learning practices. Currently, the development of learning media continues to innovate and renew. Schools and educators are required to develop themselves in order to adapt to technological advancements in education.

One of the latest technologies currently being developed is the metaverse. The concept of the metaverse was first introduced by Facebook founder Mark Zuckerberg, who announced on October 29, 2021, that Facebook would change its name to Meta and make significant investments in developing metaverse technology (Muhammet Damar, 2021).

The metaverse is defined as a three-dimensional virtual environment where users can interact with digital elements and other users in real time. In the context of education, this technology has shown great potential in creating experiential learning, where students can explore complex simulations such as virtual laboratories or historical tours.

The metaverse also represents a world where virtual and physical realities interact and evolve simultaneously through social, economic, and cultural activities to create entities and value. Metaverse technology has quickly entered our lives, and several of its applications have started to be used in education (Lee et al., 2022).

The metaverse is a virtual space that promises significant transformation in education. By combining Virtual Reality (VR) and Augmented Reality (AR) technologies, the metaverse creates an immersive and interactive learning environment where students can learn through direct experiences, collaborate with classmates from around the world, and access unlimited educational resources. Immersion, as defined by Alfarizi and Yugopuspito (2020), refers to user involvement in a virtual environment where they feel that the real world stops or disconnects, and thus they experience a sense of merging into the virtual world.

According to a study by Indarta et al. (2022), the metaverse is believed to overcome existing limitations in education, such as class capacity constraints during the pandemic, limitations of distance and time to access classrooms, and so on. With the concept of a virtual world, online learning can be conducted interactively without diminishing the student's learning experience. The concept of learning anytime and anywhere has become an appealing idea for many members of Generation Z.

Various metaverse-based platforms are now used to create flexible and engaging learning environments. One such platform is *Spatial.io*, which allows users to interact in a 3D virtual space through desktop devices, mobile phones, or VR headsets. *Spatial.io* offers collaboration features that support remote learning while providing an immersive learning experience. However, despite the promises of this technology, its use in education is still relatively new. The challenges of integrating this technology into learning remain considerable, even in developing countries like Indonesia, which face additional challenges such as limited infrastructure and unequal access to technology across regions (Siahaya, 2024).

Therefore, further analysis is required to delve deeper into the potential of metaverse technology in supporting learning, the challenges that educators and students may face in adopting it, and how to optimize metaverse technology to support immersive learning with *Spatial.io*.

This study focuses on a literature review of the integration of metaverse technology in learning. The study uses *Spatial.io* as a platform to support immersive or experiential learning

implementation. The scope of this research includes an analysis of relevant literature on metaverse technology, its application with the *Spatial.io* platform, and the challenges and opportunities in adopting this technology in the education field. Through this review, it is expected to provide insights for educators, technology developers, and policymakers on the best ways to leverage metaverse technology to support more collaborative and immersive learning

B. Literature Review and Hypothesis Development

Metaverse Concept

The term metaverse combines the word "meta" meaning virtual and transcendent, referring to a world and universe. The term first appeared in the 1992 novel Snow Crash (Aburbeian & Owda, 2022). The metaverse developed before the COVID-19 pandemic based on virtual reality, but it gained attention after addressing the limitations and unique needs of field operations, leading to rapid growth in its concept. According to Milgram et al. (in Mystakidis, 2022), immersive technologies and digital environments where data is represented and projected, such as Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), are referred to as Extended Reality or Cross Reality (XR). Kye et al. (2021) stated that avatars, which represent our projections in the digital world, are associated with social, economic, and cultural activities within the metaverse. Not only in daily life aspects, but several metaverse applications have also been used in education.

Metaverse technology has fundamental differences compared to AR or VR. Park, S. M., & Kim, Y.G. (2022) explained three key differences between Metaverse and the prior technologies, AR and VR. First, while VR-related studies focus on physical approaches and rendering, Metaverse has a stronger aspect as a service with more sustainable social content and meaning. Second, Metaverse does not necessarily require AR and VR technology. Therefore, even if a platform does not support VR or AR, it can still be considered a Metaverse application. Finally, the Metaverse has a scalable environment that can accommodate many people, which is crucial to strengthen the social meaning emphasized by this technology (Xi et al., 2022).

Characteristics of the Metaverse

Interactivity in the metaverse enables users to engage and converse with others using their avatars. Users can affect artificial objects and have an impact on the attitudes and behaviors of others. The avatars that users choose can represent their sense of presence and contribute to results in virtual teams. This relationship is reciprocal. Interactivity refers to the degree to which users can engage and participate, thus increasing the potential for individual or global interaction

(Díaz et al., 2020). Furthermore, persistence ensures the uninterrupted preservation of data, such as position, chats, and property objects. Additionally, data can be easily recovered whether users are reconnected or disconnected from the virtual environment (Abu-Salih, 2022). The metaverse platform remains operational and continues to evolve long after users have left the virtual space.

Immersive Learning in the Metaverse

Although many learning methods have been proposed in the education field, immersive learning has recently been recommended in educational settings. "Immersive" describes a profound learning experience. Students engage directly through touch, sight, hearing, or feeling, and are actively involved with objects, environments, or situations. An "immersive" learning experience in education refers to an experience where students are fully engaged in the learning process and feel deeply connected to the material being studied. Immersive learning does not always have to rely on technology but can involve direct experiences such as laboratory visits, museum tours, or visits to historical sites relevant to the learning material. If immersive learning is not feasible, a virtual environment that simulates the real world can be created using supporting technologies such as VR headsets. Immersive technology is used to create these deep learning experiences. Several digital technologies can facilitate immersive learning using metaverse technology, including Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). These technologies are categorized as immersive technologies and can be grouped under the umbrella term Extended Reality (XR) (Mystakidis and Lympouridis, 2023). Through immersive learning, students can experience realistic sensations and engage in deep learning experiences, which can enhance understanding and retention of the learning material (Tang et al., 2020).

Metaverse Learning with Spatial.io

Spatial.io is one of the metaverse platforms that offers high accessibility through modern devices such as smartphones, tablets, and VR headsets and can be accessed via web browsers using WebXR. Metaverse technology, particularly the Spatial.io platform, holds great potential in education by providing virtual classrooms, simulations, global access, social interaction, and educational content development. Pujasari et al. (2024) discuss the phenomenon of using the metaverse in higher education. There are two main benefits of implementing the metaverse concept in the English for Tourism course. The results of the study show that students have a positive perception of using the platform.

C. Research Method

This study uses a literature review method to analyze how metaverse technology is used in learning through the *Spatial.io* platform. To maintain relevance and up-to-date data, the selected studies were published in the last five years (2019-2024). The research focuses on various applications of *Spatial.io* in educational environments, including articles from journals, conference proceedings, and scholarly works such as theses and dissertations that have gone through peer review. The literature sources are taken from reputable platforms in the fields of technology and education.

The literature search was conducted through Google Scholar, as it offers wide access and ease of search. The keywords used included "metaverse technology in learning," "immersive learning with *Spatial.io*," "educational impact with *Spatial.io*," "interactive metaverse learning," and "metaverse technology in classrooms." This search was filtered by publication year (2019-2024) and language (articles in Indonesian and English) to ensure relevance.

The collected literature was then evaluated in several stages. The first stage was initial selection, where the titles and abstracts of each article were examined to ensure alignment with the research topic. Articles that were not relevant were discarded. Next, a deeper evaluation was conducted on the articles that passed the initial selection, assessing their methodology, research results, and contribution to the development of studies in the related field. Data from the selected literature was then analyzed to identify key themes, findings, and research gaps in the use of metaverse technology with *Spatial.io*. This synthesis aims to provide a comprehensive insight into the benefits and challenges of implementing this technology and provide recommendations for future research and practice.

D. Discussion

Previous research shows that metaverse technology has significant potential to improve learning quality. In the study by Pujasari et al. (2024), learning based on metaverse technology can enhance engagement by integrating virtual environments into the metaverse concept, offering opportunities for immersive and interactive learning, thereby increasing student involvement. Additionally, since students need the ability to use such platforms, their digital literacy also improves. This finding aligns with the study by Rasyida, Nurdin, and Rasyim (2023), which demonstrated increased interest and learning outcomes after implementing metaverse-based learning using *Spatial.io* in informatics subjects. This was indicated by a higher average score in students' cognitive domain learning outcomes.

However, despite the vast potential of this technology, challenges in its implementation remain. According to Fauzian (2022), the challenges in utilizing this technology in learning include accessibility and technological limitations. For students to fully experience the metaverse using the *Spatial.io* platform, they require compatible devices, such as VR headsets, which are relatively expensive and not widely distributed. Moreover, fast and stable internet connectivity is essential for access. These challenges limit the accessibility of the metaverse experience, especially for certain socioeconomic conditions (Fauzian, 2022). Furthermore, frequent use of this technology, as reported by Suparyati et al. (2024), can lead to physical fatigue and vision problems.

Optimizing the use of metaverse technology based on *Spatial.io* requires a more structured approach. The use of metaverse technology can open educational accessibility for students, overcome geographical and mobility barriers, and facilitate deeper collaborative and experiential learning in line with immersive learning principles. By leveraging the interactive features offered by the metaverse, educational institutions can create more engaging, captivating, and relevant learning environments, thereby increasing student motivation and involvement in the learning process (Chen & Wang, 2023). Additionally, a deeper understanding of the potential and limitations of metaverse technology is necessary so its application can be optimized according to learning needs. Despite these challenges, the long-term benefits are highly diverse (Brown & Taylor, 2023)

E. Conclusion

Metaverse technology offers significant transformations in the educational landscape by creating interactive, collaborative, and immersive learning environments. As a three-dimensional virtual space supporting real-time interaction, the metaverse enables students to learn through deep experiences that cannot be achieved with traditional learning methods. The implementation of this technology provides great opportunities to increase student engagement, deepen conceptual understanding, and support cross-location collaboration.

Spatial.io, as one of the metaverse-based platforms, has shown potential as an effective educational tool. With features such as collaborative virtual spaces, cross-device accessibility, and visual integration, this platform offers new opportunities for dynamic teaching and learning. However, this study highlights that optimizing metaverse technology with the *Spatial.io* platform does not solely depend on the software used but also on infrastructure readiness, educator training, and the development of relevant curricula.

Overall, this literature review confirms that metaverse technology could become an essential component of future education, with the ability to revolutionize learning into a more immersive and digitally relevant experience. Further research, especially empirical studies, is urgently needed to evaluate the impact of this technology on student learning outcomes and its implementation challenges in various educational contexts.

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