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UTILISATION OF VIRTUAL REALITY (VR) AND AUGMENTED REALITY (AR) IN EDUCATION: A COMPREHENSIVE REVIEW

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Abstract

This research explores the utilisation of Virtual Reality (VR) and Augmented Reality (AR) technologies in education through a comprehensive review. VR and AR technologies offer innovative ways to create immersive and interactive learning experiences, enabling students to better understand complex concepts. The study identifies key benefits of VR and AR in education, including increased student engagement and motivation, as well as the provision of practical, real-life learning environments that are difficult to achieve with traditional methods. However, the study also highlights significant challenges that need to be overcome, such as high costs, technical infrastructure needs, and specialised training requirements for educators. Thus, the conclusions of this study emphasise the importance of careful planning and proper support to maximise the potential of VR and AR as transformational tools in education.
Keywords: Virtual Reality (VR), Augmented Reality (AR), Education.

Introduction

Along with the rapid development of technology, the world of education is undergoing a significant transformation. One technological innovation that promises great potential in transforming learning methods is Virtual Reality (VR) and Augmented Reality (AR). VR technology allows the creation of interactive three-dimensional simulated environments, while AR combines digital objects with the real world through devices such as smartphones or smart glasses. (Mariska & Aslan, 2024).; (Ikhlas et al., 2024); (Firdausih & Aslan, 2024).

Virtual reality (VR) is a technology that allows users to enter and interact with computer-generated three-dimensional environments. These environments can simulate a variety of different experiences, from visiting distant places to experiencing situations that are not possible in the real world. (Satpathy et al., 2023).. By using devices such as VR headsets, users can feel the sensation of physically being in these environments. This technology provides an immersive experience, where users can see,

hear, and sometimes feel the virtual environment through input devices such as motion and sound controllers. (Kitaria & Mwadulo, 2022)..

Meanwhile, Augmented Reality (AR) is a technology that combines digital elements with the real world, enriching the user experience with additional information displayed through devices such as smartphones, tablets, or smart glasses. Unlike VR that fully immerses the user in a virtual world, AR maintains the user's view of the real world while adding visual elements such as graphics, sound, or text information that can interact with the surrounding environment. AR has been applied in various fields such as education, healthcare, and advertising, due to its ability to enhance the user's perception and interaction with the real world, without eliminating the existing physical elements (Wang & Wang, 2024).

The utilisation of VR and AR in education can provide a more immersive and interactive learning experience, which can increase student motivation and understanding. For example, in history subject matter, students can be invited to visit historical sites in the past through VR, or in biology lessons, students can see the anatomy of the human body in detail by utilising AR. (Cannavò et al., 2023)..

However, despite the promising potential of VR and AR in education, the adoption of these technologies still faces several challenges. These include the high cost, limited content available, and the need for specialised training for educators to operate these devices. In addition, there is still little comprehensive research on the long-term effectiveness of using VR and AR in learning. (Hernandez, 2020).

Therefore, there is a need for a comprehensive review that evaluates the various aspects of VR and AR utilisation in education. This review will not only cover the potential benefits and advantages of these technologies, but will also identify the challenges and barriers faced in their implementation. Thus, it is hoped that a clearer picture can be obtained of the steps that need to be taken to maximise the benefits of VR and AR in education.

The research and discussion in this background will provide insight into the extent to which VR and AR technologies can change the traditional learning paradigm, as well as provide practical recommendations for educational institutions interested in integrating these technologies in their curriculum.

Research Methods

The study in this research uses the literature method. The literature research method is an approach used to review and analyse various written sources relevant to a particular research topic. This process involves collecting, evaluating, and synthesising data from scientific journals, books, research reports, articles, and other written sources to build a theoretical foundation or understand recent developments in the field of study under study. (Setiowati, 2016); (Syahran, 2020). Literature research aims to identify gaps in knowledge, confirm previous findings, and enrich the conceptual

framework of the research being conducted. This method is very important in providing a comprehensive context and knowledge base for further research, as well as in formulating hypotheses and in-depth research questions. (Helaluddin, 2019).

Results and Discussion

Implementation of VR and AR in Education

Virtual reality (VR) is a technology that simulates a three-dimensional environment that users can explore and interact with as if they were inside it. This is typically achieved through the use of devices such as VR headsets that track the user's head and hand movements, allowing them to experience an immersive experience. (Broll, 2022). The term "Virtual Reality" first appeared in 1987, introduced by Jaron Lanier, founder of the VPL Research company that developed some of the early VR hardware and software. Since then, VR has undergone significant development, from use in flight simulators for pilot training to applications in entertainment, education and healthcare. (Negi, 2023).

Augmented Reality (AR) is a technology that adds digital elements to real-world environments, often through devices such as smartphones, tablets, or smart glasses. The idea of AR can be traced back to 1968 when Ivan Sutherland and his colleague Bob Sproull developed the first true display system known as "The Sword of Damocles". However, the term "Augmented Reality" itself was only popularised in 1990 by Tom Caudell, a scientist at Boeing. Since then, AR has grown rapidly and is found in a variety of applications including gaming (such as Pokémon GO), navigation, advertising, and education. The technology allows users to view and interact with the real world that has been blended with digital information, enhancing their perception and experience of the surrounding environment. (Kline & Ayer, 2024)..

The application of Virtual Reality (VR) in education has opened up new opportunities to optimise the teaching-learning process. With VR, students can enter fully immersive virtual environments, such as scientific laboratories, historical sites, or even space, without having to leave the classroom. For example, students learning about Egyptian history can virtually tour the pyramids and tombs of the pharaohs, providing a much more immersive and engaging experience than just reading about the topic in a textbook (Eswaran & Khang, 2014). (Eswaran & Khang, 2024).. This not only increases students' interest but also helps them understand complex concepts in a more interactive and fun way.

In addition, VR also provides a safe and controlled learning experience for topics that may be risky or costly if done in person. An example is medical training where aspiring doctors can perform surgical procedures in a virtual environment without risk to real patients. Likewise in engineering and aviation, where VR enables simulation of complex machines or devices, allowing students to learn and make mistakes without

real consequences. As such, VR facilitates practical learning which is especially important in fields that require high technical skills (Buehler & Kohne, 2020)..

Meanwhile, Augmented Reality (AR) changes the way students interact with learning materials in the real world, by adding layers of digital information that enrich the learning context. Through the use of AR applications on devices such as smartphones or tablets, students can see 3D models of human organs, chemical molecular structures, or even the planets in the solar system "live" in their classrooms. (Seol & Jeon, 2022). For example, a biology teacher can have students scan a picture of a liver in their textbook and see the organ in 3D that can be rotated and zoomed in, thus providing a better understanding of the complexity of its structure. (Lanman, 2020).

The implementation of AR in education also supports collaborative and interactive learning. With AR applications, students can work in groups to solve problems or complete projects together. For example, in maths lessons, students can use AR to visualise complex concepts such as spatial geometry by viewing and manipulating 3D shapes directly. In addition, AR can be used to add gamification elements to learning, such as using AR-based scavenger hunts where students have to find and identify virtual objects scattered around the classroom or campus. All of these help to create a more dynamic and engaging learning experience, increasing students' motivation to learn. (Hoffmann, 2021).

As VR and AR technology continues to advance, the world of education will hopefully continue to see new innovations that revolutionise the way we learn and teach. In addition to increasing the effectiveness of learning, these technologies also open up access to a wider range of educational resources, providing opportunities for students in different parts of the world to get a high-quality education that may have previously been out of reach.

Key benefits of using VR and AR in education

The use of Virtual Reality (VR) and Augmented Reality (AR) in education brings a number of significant key benefits. Firstly, these technologies are capable of increasing student engagement and motivation. Immersive and interactive learning environments make students feel more connected to the subject matter. VR allows students to be immersed in real and relevant scenarios, while AR adds virtual elements to the real world that make the learning process more interesting and enjoyable. (Holzapfel et al., 2023).

Secondly, VR and AR are very effective in helping to understand abstract and complex concepts. In many fields of study, such as science, technology, and maths, there are concepts that are difficult to explain with just text or two-dimensional images. Using VR, students can explore scientific phenomena, geometric structures, or biological processes in a more visual and practical way. AR, on the other hand, allows

students to view and interact with 3D models in a real-world context, providing a more in-depth understanding of the subject being studied. (Bagaria et al., 2022).

Third, VR and AR technologies can create safe and controlled learning experiences. For example, in medical training, aspiring doctors can practice surgical procedures in a risk-free virtual environment. Likewise in engineering or aviation, where human error can be extremely costly or dangerous, VR provides the opportunity to practice without real consequences. In addition to reducing risks and costs, it also prepares students for real-world situations in a more effective way (Vairamani, 2024).

Fourthly, VR and AR increase access and flexibility in education. With these technologies, students from different geographical locations can access educational resources that may not be available in their area. Distance learning becomes more effective when students can participate in virtual tours, simulations, and experiments that would be difficult to do physically. In addition, this technology also allows learning to be tailored to the pace and learning style of each student, providing a more personalised and adaptive experience, so that each student has the opportunity to reach his or her full potential. (Aurelia, 2024).

Furthermore, VR and AR also encourage collaboration and social skills among students. VR and AR-based learning platforms are often equipped with features that allow students to work together on projects, even if they are in different locations. Students can interact with each other's virtual avatars, share ideas and complete tasks collaboratively in a virtual environment that supports teamwork. This helps develop communication and teamwork skills that are essential in the modern world of work. (Kocasarac & Mlotshwa, 2024)..

In addition, VR and AR can improve teachers' ability to deliver material. Teachers can use these technologies to make presentations more dynamic and engaging, as well as provide clearer and more comprehensive demonstrations. For example, in history lessons, teachers can use VR to transport students to a specific era and see historical events as if they were happening around them. In engineering lessons, teachers can demonstrate the principles of mechanics in 3D models that students can see and understand from different angles. (Lee & Woo, 2023).

Overall, the integration of VR and AR in education opens up revolutionary new opportunities in the way we learn and teach. These technologies not only make learning more engaging and interactive, but also provide more effective tools for teachers to explain concepts and for students to understand and recall material. More importantly, VR and AR prepare generations of students to face future challenges with more comprehensive skills and knowledge.

As such, VR and AR bring many key benefits in education, from improving engagement and understanding, providing a safe environment for practice, to increasing collaboration and learning flexibility. With these technologies, education can

become more inclusive, effective, and adaptive to the needs of each student, allowing them to reach their full potential in an ever-evolving digital age.

Challenges and obstacles in integrating VR and AR into the education system

Despite its many benefits, integrating VR and AR in education also comes with challenges and obstacles. One of the main challenges is the high cost. VR and AR devices, as well as the software that supports them, often require significant investment. Many educational institutions, especially in less developed regions, may not have sufficient budgets to acquire and maintain these technologies. In addition, the cost of regular maintenance and upgrades is also an obstacle, given that these technologies are evolving rapidly. (Shaukat, 2023).

Besides cost, there are also technical and infrastructure issues that need to be addressed. The use of VR and AR requires a strong and stable network infrastructure, as well as high-performance hardware to run applications smoothly. Inadequate internet connectivity, especially in rural or remote areas, can hinder the implementation of these technologies. In addition, institutions require specialised technicians to install, maintain, and repair VR and AR devices, which adds to the complexity and cost of implementation. (Kashchenevsky, 2023).

Another issue that must be considered is the readiness and training of teaching staff. Teachers and lecturers need to receive adequate training to utilise VR and AR technologies effectively in their curriculum. Many teachers may not be familiar with these technologies and feel intimidated by their complexity. Without proper training, there is a risk that these technologies will not be utilised to their full potential or remain unused despite being available. (Charbaji, 2020).

Finally, there are also concerns about user safety and health. Prolonged use of VR may cause health problems such as eyestrain, dizziness, or motion sickness. There are also concerns about data protection and user privacy, given that VR and AR technologies require extensive recording of user data. A strong framework is needed to ensure that the use of these technologies is safe and does not negatively impact students' health and privacy. (Madison, 2020).

Integrating VR and AR into the education system offers a lot of potential, but it also requires careful planning and attention to the challenges and obstacles.

Conclusion

The utilisation of Virtual Reality (VR) and Augmented Reality (AR) in education offers significant opportunities to enhance the teaching and learning process. With the ability to create immersive and interactive learning environments, VR and AR can help students understand complex concepts in a more engaging and immersive way. These technologies also enable more practical and real-life learning experiences, such as conducting scientific laboratory simulations or deep historical explorations in ways that

are not possible with traditional methods. As such, VR and AR have great potential to increase student engagement and enrich their learning experience.

However, to achieve these benefits, a number of challenges and barriers need to be overcome. High costs, the need for adequate technical infrastructure, and the need for specialised training for teaching staff are some of the key constraints that must be addressed. In addition, attention to health and safety aspects is also crucial to ensure the technology is used effectively and safely. With careful planning and adequate support, VR and AR could become invaluable tools in education, bringing about a significant transformation in the way we teach and learn.

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