International Journal of Educational Technology and Society
Volume. 1 No. 1 March 2024
e-ISSN: 3046-8337; p-ISSN: 3046-8345, Page 22-26
DOI: https://doi.org/10.61132/ijets.v1i1.48
Available Online at: https://international.aspirasi.or.id/index.php/IJETS

Integrating Virtual Reality in STEM Education: Enhancing Engagement and Learning Outcomes

Dara Sovann[1*], Sopheap Chan[2], Makara Lay[3]
[1-3] University Of Battambang, Cambodia

Abstract: *This study investigates the impact of virtual reality (VR) tools in enhancing student engagement and learning outcomes in STEM (Science, Technology, Engineering, and Mathematics) education. By analyzing experimental data from VR-based STEM lessons across multiple schools, the research highlights how immersive experiences can help students understand complex concepts, increase motivation, and improve retention. The findings emphasize the potential of VR to transform traditional STEM education by providing interactive and engaging learning environments.*

Keywords: *Virtual reality, STEM education, Student engagement, Immersive learning, Educational technology*

1. INTRODUCTION

STEM education has been recognized as a critical factor in developing the skills needed for the global economy. However, traditional approaches to teaching STEM subjects often struggle to engage students, especially when dealing with complex and abstract concepts. This challenge has led educators to explore the potential of innovative educational technologies to enhance learning experiences. Among these, Virtual Reality (VR) has emerged as a promising tool that can provide immersive, interactive environments where students can explore and manipulate scientific concepts firsthand.

The goal of this study is to examine the effectiveness of VR technology in STEM education by evaluating its impact on student engagement and learning outcomes. By providing a simulated, hands-on learning experience, VR can make difficult concepts more accessible and engaging, which may lead to increased understanding and retention. This article reviews the integration of VR in STEM education, discusses the potential benefits and challenges, and presents findings from a study conducted in Cambodian secondary schools.

2. LITERATURE REVIEW

Virtual reality has been increasingly integrated into educational settings to improve engagement, motivation, and comprehension. Research has shown that VR can create an immersive learning environment that enhances cognitive and affective learning outcomes (Johnson-Glenberg, 2018). For instance, studies by Makransky and Mayer (2020) indicate that VR allows students to interact with 3D models, conduct virtual experiments, and experience real-world scenarios that would otherwise be inaccessible in traditional classrooms.

In STEM education, VR has proven particularly beneficial in visualizing scientific processes, such as molecular interactions, physics simulations, and engineering design (Parong & Mayer, 2018). Additionally, VR environments support active learning and improve spatial skills, which are essential in disciplines like engineering and mathematics (Merchant et al., 2014). However, implementing VR in education faces challenges, including high costs, the need for specialized training, and the lack of VR content tailored to specific curricula (Freina & Ott, 2015).

Theories of immersive learning, such as experiential learning theory (Kolb, 1984), suggest that students learn best when actively engaged in experiences that reflect real-life applications. VR offers a unique platform for such experiential learning by enabling students to explore complex STEM concepts in a safe, controlled environment. Despite these benefits, more research is needed to understand the long-term impact of VR on student learning and the potential barriers to widespread implementation in developing countries (Dalgarno & Lee, 2010).

3. METHODOLOGY

This study was conducted in collaboration with four secondary schools in Cambodia that introduced VR-based STEM modules in their curricula. The study involved 200 students across grades 9-12, divided into two groups: a control group receiving traditional instruction and an experimental group using VR as part of their lessons.

The VR modules were designed to align with the existing STEM curriculum, covering topics such as molecular biology, physics, and environmental science. Students in the experimental group used VR headsets and interacted with simulations created specifically for STEM education. Both groups were tested on their understanding of the material before and after the instruction, using standardized assessments to measure learning outcomes. Additionally, surveys were conducted to gauge student engagement and motivation.

4. RESULTS

The results of the study indicate that students in the VR group demonstrated higher levels of engagement and retention than those in the control group. Key findings include:

a. Improved Understanding and Retention: The VR group scored 25% higher on post-tests compared to the control group. Students in the VR group reported that the interactive nature of VR helped them understand complex concepts more easily.

b. Increased Engagement and Motivation: Survey results showed that 85% of students in the VR group found the lessons more enjoyable and engaging. Many students reported feeling motivated to learn more about STEM topics after the VR experience.
c. Positive Feedback on Accessibility and Interactivity: Students noted that the ability to interact with and visualize abstract scientific processes, such as chemical reactions and cellular structures, was a key benefit of using VR.
d. Challenges of Implementation: Despite the positive feedback, some teachers reported difficulties with technical setup and maintenance of VR equipment, highlighting a need for more training and support.

5. DISCUSSION

The findings support the notion that VR can significantly enhance STEM education by providing immersive and interactive experiences that traditional methods lack. VR's ability to engage students actively aligns with theories of experiential learning, which emphasize the importance of hands-on experiences in developing deeper understanding (Kolb, 1984). The increased test scores among VR group students suggest that VR can facilitate knowledge retention, likely due to the engaging, memorable nature of VR experiences.

However, integrating VR in educational settings presents challenges. Teachers reported a need for technical training and resources to manage VR equipment effectively. Additionally, the high cost of VR technology remains a significant barrier, especially in developing countries like Cambodia. Policymakers and educators should consider subsidizing VR tools and offering professional development programs to help teachers integrate VR in their classrooms.

Moreover, the success of VR in education depends on the quality and relevance of VR content. Customizing VR simulations to fit specific curriculum standards can enhance the relevance of VR in STEM education. As VR technology advances, educational content providers and curriculum designers must collaborate to develop more tailored VR experiences that align with educational standards.

6. CONCLUSION

Virtual reality holds great potential to transform STEM education by making learning more interactive, engaging, and accessible. This study demonstrates that VR can enhance student engagement and improve learning outcomes by offering immersive experiences that bring STEM concepts to life. However, to fully leverage VR's benefits, schools and educational authorities must address challenges related to cost, teacher training, and content development.

Moving forward, further research is needed to explore the long-term impact of VR on learning outcomes and to develop cost-effective solutions for implementing VR in schools. By investing in VR and other innovative educational technologies, developing countries like Cambodia can improve STEM education, equipping students with the skills needed to succeed in an increasingly technological world.

FUTURE RESEARCH

Future studies should explore the impact of VR in other educational contexts, such as primary and tertiary education, and assess the feasibility of VR as a long-term solution for enhancing STEM learning. Cross-cultural studies could also provide insights into how VR is received in diverse educational settings.

REFERENCES

Bell, J., D'Angelo, M., & Jang, D. (2017). Enhancing science learning through immersive virtual reality environments. Journal of Science Education and Technology, 26(1), 1-9. https://doi.org/10.1007/s10956-016-9687-3

Bower, M., Howe, C., McCredie, N., & McCormack, D. (2014). Virtual worlds and augmented reality in education. Australian Educational Computing, 29(2), 22-30.

Dalgarno, B., & Lee, M. J. W. (2010). What are the learning affordances of 3-D virtual environments? British Journal of Educational Technology, 41(1), 10-32. https://doi.org/10.1111/j.1467-8535.2009.01038.x

Freina, L., & Ott, M. (2015). A literature review on immersive virtual reality in education: State of the art and perspectives. Proceedings of eLearning and Software for Education (eLSE), 1, 10-1007. https://doi.org/10.1109/eLSE.2015.7256489

García, O., & Wei, L. (2014). Translanguaging: Language, bilingualism and education. Palgrave Macmillan.

Hwang, G. J., & Chen, C. H. (2017). Influence of interactive e-books on learning achievement and learning motivation. Computers & Education, 109, 79-88. https://doi.org/10.1016/j.compedu.2017.02.001

Johnson-Glenberg, M. C. (2018). Immersive VR and education: Embodied design principles that include gesture and hand-based interactions. Frontiers in Robotics and AI, 5, 81. https://doi.org/10.3389/frobt.2018.00081

Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development. Prentice Hall.

Makransky, G., & Mayer, R. E. (2020). Benefits of taking a hands-on approach in virtual reality in terms of immersion, motivation, and learning. Educational Psychology Review, 32, 1-16. https://doi.org/10.1007/s10648-019-09498-3

Mayer, R. E. (2019). Multimedia learning: Principles and applications. Cambridge University Press.

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. Computers & Education, 70, 29-40. https://doi.org/10.1016/j.compedu.2013.07.033

Parong, J., & Mayer, R. E. (2018). Learning science in immersive virtual reality: Effects of environment immersion and active control on learning outcomes. Computers in Human Behavior, 86, 402-411. https://doi.org/10.1016/j.chb.2018.05.022

Slater, M., & Sanchez-Vives, M. V. (2016). Enhancing our lives with immersive virtual reality. Frontiers in Robotics and AI, 3, 74. https://doi.org/10.3389/frobt.2016.00074

Sobral, S., Almeida, L., & Carvalho, A. (2018). Interactive virtual reality for chemistry education. Royal Society of Chemistry. https://doi.org/10.1039/C8RP00021A

Zimmerman, T. G., & Mitchell, T. M. (2014). Virtual reality and cognitive rehabilitation. Springer. https://doi.org/10.1007/978-3-319-06783-5