Journal of Engineering Science and Technology
Vol. 19, No. 4 (2024) 57 - 63

TRANSFORMING SOLIDS PHYSICS LEARNING: VR INTEGRATION ON THE MOOC PLATFORM

SUDI DUL AJI[1], AKHMAD ZAINI[1], SUJITO[2], NURUL AIN[1], AMELIA NURDEVIANTI PUTRI[2], MUHAMMAD NUR HUDHA[3*]

[1]Universitas PGRI Kanjuruhan Malang, Jl. S. Supriadi 48, Malang 65148, Indonesia
[2]Universitas Negeri Malang, Jl. Semarang 5, Malang 65145, Indonesia
[3]Universitas Sebelas Maret, Jl. Ir. Sutami 36, Surakarta, 57126, Indonesia
*Corresponding Author: hudha.m.nur@gmail.com

Abstract

Solid state physics, being an abstract subject, poses challenges for students in terms of conceptual understanding. The integration of advanced technology is essential to bridge this gap and enhance learning outcomes. This research focuses on designing a VR MOOC (Virtual Reality-Massive Open Online Course) learning technology specifically tailored for solid state physics. The study employs the Design-Based Research (DBR) methodology, which involves a systematic approach in four distinct phases: analyzing literacy gaps, developing a framework and design, testing and refining solutions, and reflection and identification. In the first phase, gaps in existing literature and educational practices are identified to inform the design. The second phase involves creating a robust framework and design for the VR MOOC platform. This is followed by the third phase, where the designed solutions are rigorously tested and refined based on feedback and observed effectiveness. The final phase includes reflection on the entire process and identification of key insights and improvements. The research findings demonstrate that the VR MOOC platform, characterized by its three main roles - platform manager, course creator, and regular user - can significantly enhance the learning experience. It provides an effective, interactive, and structured learning environment, which not only facilitates a deeper understanding of solid-state physics concepts but also boosts student engagement and interest through the immersive features of VR technology. This innovative approach highlights the potential of VR MOOC in transforming traditional learning paradigms and advancing educational practices in complex scientific domains.

Keywords: Online learning, Solid state physics, VR MOOC.

1. Introduction

Research in physics education has extensively explored various methods to improve conceptual understanding, highlighting its importance as the main focus in physics learning [1, 2]. Students are expected to develop critical thinking skills to understand and solve the complex problems and challenges inherent in physics subjects [3]. The ability of students to comprehend physics lessons is contingent upon their grasp of the concepts taught by educators. Moreover, meaningful learning processes are crucial for students to truly internalize physics concepts [4, 5].

The integration of Virtual Reality (VR) technology in education, particularly through Massive Open Online Courses (MOOCs), has gained significant attention in recent research. VR content delivery has been shown to markedly improve student performance and engagement by providing a sense of presence and enhancing interaction in online learning environments [6, 7]. VR's role in creating authentic learning activities and fostering increased student interaction within MOOCs is particularly noteworthy [8]. However, the implementation of VR in MOOCs is not without challenges, including the need for specialized equipment and managing usability issues.

The application of VR in education is widespread and has shown promising results in various scientific fields, including biology, chemistry, and astronomy physics [9-15]. In the context of solid-state physics, understanding these concepts is a critical aspect of science education. Nevertheless, traditional teaching methods often face challenges due to the high level of abstraction and lack of interactivity, which can impede deep conceptual understanding. The use of VR in MOOCs offers an innovative solution by presenting material in a more visual, interactive, and comprehensive manner. This research aims to design VR MOOC learning technology to enhance the conceptual understanding of solid-state physics, addressing the core question of how to effectively develop and implement such a platform.

2. Design Procedure

This research employs the Design-Based Research (DBR) methodology [16], structured programmatically with a systematic sequence of activities aimed at developing and characterizing VR MOOCs. DBR is an innovative methodology in educational research that bridges the gap between theory and practice by iteratively developing and testing educational interventions in real-world settings. It is specifically designed by and for educators who seek to leverage the impact of educational research into practice [17].

The design-based research approach is ideal for this study, considering the practitioners' experience and expertise, and combining this with a comprehensive literature review. This will result in a detailed and relevant analysis of both literature and practitioners' perspectives, culminating in the development of formalized research questions. The methodological framework is depicted in Fig. 1.

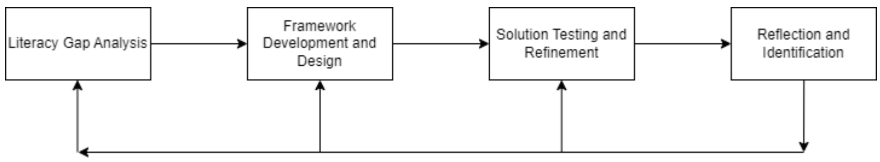

Fig. 1. Design-based research approach.

2.1. Phase 1: Analyzing literacy gaps

In the initial phase, the research identifies common themes of VR MOOCs in the context of solid state physics as documented in existing literature. This review includes examining various applications of VR MOOCs and the current state of solid state physics education. Identifying these themes will help establish the principles underlying potential solutions.

2.2. Phase 2: Framework development and design

The second phase involves developing the framework and perspectives that will guide the analysis and discussion of the research. This phase is grounded in existing design principles and technological innovations, allowing researchers to create a VR MOOC design tailored to solid state physics education.

2.3. Phase 3: Solution testing and refinement

In the third phase, the research will conduct interviews with lecturers teaching solid state physics and those specializing in physics learning media. Additionally, technology experts will be consulted regarding the use of VR and MOOC platforms. This phase aims to gather insights on literacy definitions, the specifics of learning solid state physics, and how student needs can be met through the MOOC platform.

2.4. Phase 4: Reflection and identification

The final phase involves reflecting on the analysis and discussions from phase 3, establishing links between these results, the literature review, and practitioner data collected in phase 1. This reflection will help identify guiding principles for designing an effective VR MOOC platform for solid state physics. Following this, repeated testing and refinement of the solution will be conducted to ensure the robustness and impact of the results on future research.

3. Results and Discussion

Virtual-based learning environments can now accommodate large amounts of learning resources, with large user communities available through social networks [18]. One such platform is the VR MOOC. The design of the VR MOOC software is conducted through UML modeling, which is intended to provide explicit references for the system's implementation in the field [19]. This modeling approach ensures that the software design is clear and functional.

There are several roles involved in this platform, detailed in Fig. 2. The first role is the platform manager. Many believe that using technology to personalize learning, giving students more control over their process, is crucial [20]. Analogous to a marketplace, the platform manager acts as the service provider, facilitating interactions between course creators and users. The platform manager's responsibilities include confirming the registration of all platform users, publishing eligible courses, and enrolling users as course participants. The second role is the course creator. Course creators develop learning content accessible to participants, requiring a range of skills and knowledge to effectively utilize Virtual Reality features [21]. Finally, the regular user is a member of the MOOC platform who selects courses they wish to take, applying to be included as a course participant.

Ensuring content accessibility and collaboration among stakeholders is essential for a fully accessible online learning environment [22].

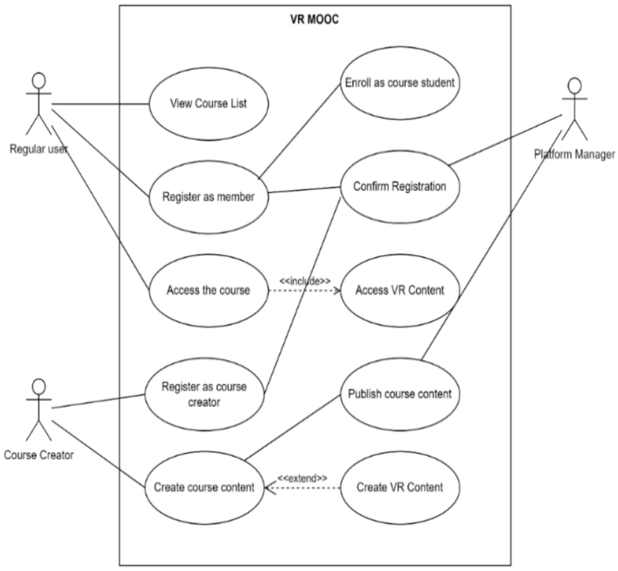

Fig. 2. Diagram use case VR MOOC.

The use case diagram in Fig. 2 outlines the authority and responsibilities of each system actor but does not detail the processes and procedures for each role. To address this, we use Business Process Modelling and Notation (BPMN) diagrams to clarify the processes within the VR MOOC system. BPMN enhances process understanding and facilitates conversion to a RESTful API architecture, enabling broader development opportunities [23].

The course creation process starts with platform membership registration (Fig. 3). Once accepted, a course creator submits learning content for curation by the platform manager. This curation ensures that courses meet the MOOC platform's standards and terms. Approved content leads to the creation of a course space, where course creators can input content and embed VR features to make learning more interactive.

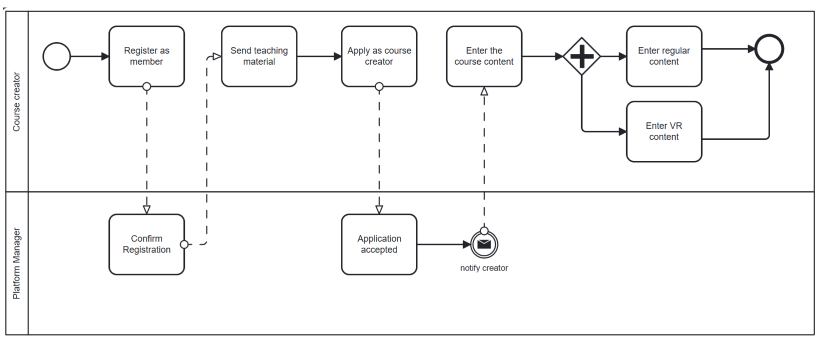

Fig. 3. Diagram of business process model and notation of course creation.

Courses on the MOOC platform are accessible only to registered members (Fig. 4). Once registered, members can view available courses and apply to participate in their desired courses. Enrolment ensures that participant numbers align with the system's capacity, maintaining course effectiveness. The VR MOOC platform's design supports learning solid state physics by creating an effective, interactive, and structured environment, enhancing students' conceptual understanding.

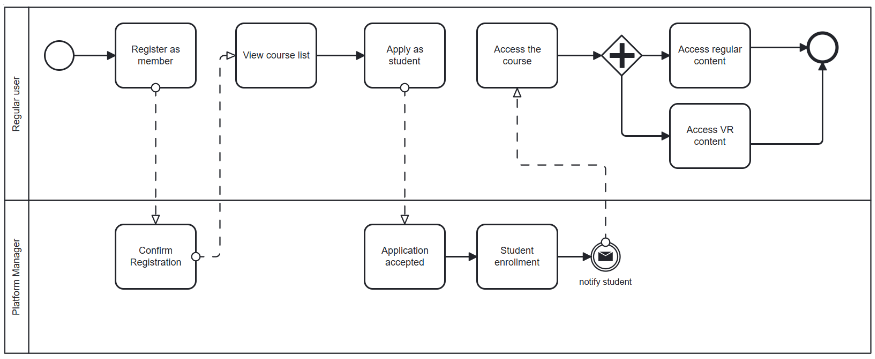

Fig. 4. Business process model and notation diagram for student registration.

4. Conclusion

As the world becomes increasingly dependent on technology, the integration of virtual reality (VR) into education has become an area of increasing interest. This research paper defines a conceptual design for a MOOC-based VR platform designed for solid state physics learning. In managing a VR-based MOOC platform, there are three main roles that play an important role in the learning ecosystem, namely: platform manager, course creator, and regular users.

The platform manager is tasked with ensuring good interaction between course creators and users, confirming registrations, publishing eligible courses, and managing participants. Course creators create learning content, including VR features to increase interactivity. After registration and curation by the platform manager, the content that makes the cut is assigned a dedicated course space. Regular users, who are already registered on the platform, have to submit a request to take a particular course. This process ensures that participant capacity in each course is maintained according to the established system.

The available courses can only be accessed by registered users, and they must go through an enrolment process to ensure a balanced distribution of participants, which contributes to an optimal learning experience. With good coordination between platform managers, course creators, and users, MOOC-based VR platforms create effective, interactive, and structured learning environments, increasing student engagement and interest in learning through the use of VR MOOC features.

Acknowledgements

The author would like to thank the Ministry of Education, Culture, Research and Technology for sponsoring this research with research contract

074/SP2H/PT/ LL7/2024; 080/C2/I.4/DP3M-UK/VI.2024 in the Regular Fundamental Research scheme.

References

1. Aji, S.D.; Hendrayana, A.D.; and Hudha, M.N. (2019). Problem Based Learning (PBL) as a learning device integrated with Computer Assisted Instruction (CAI) to enhance junior high school students comprehension on the concept of sound. *Journal of Physics: Conference Series,* 1375(1), 012034.
2. Ayu, H.D.; Chusniyah, D.A.; Kurniawati, M.P.; Purwanti, P.F.; Lukitawanti, S.D.; and Putri, A.N. (2024). Problem-based learning (PBL) as an effective solution to enhance understanding of physics concepts: A systematic literature review. *Journal of Environment and Sustainability Education*, 2(2), 86-105.
3. Wahyuni, B.; Zainuddin, Z.; Misbah, M.; and Murshed, M.B. (2024). Character-based physics learning module through generative learning model: Student conceptual understanding. *Journal of Environment and Sustainability Education*, 2(1), 31-39.
4. Mariana, A.; and Aji, S.D. (2020). Penerapan model pembelajaran conceptual understanding procedures untuk meningkatkan motivasi belajar dan penguasaan konsep siswa kelas VIII SMP. *RAINSTEK: Jurnal Terapan Sains & Teknologi*, 2(3), 221-227.
5. Huda, C.; Aji, S.; Hudha, M.; Wartono, M.; and Gamat, F. (2018). Inquiry/Discovery-based instruction to improve critical thinking skills and mastery of physics concepts. *Proceedings of the 1st International Conference on Education Innovation (ICEI 2017),* Surabaya, Indonesia, 66-68.
6. Hewawalpita, S.; Herath, S.; Perera, I.; and Meedeniya, D. (2018). Effective learning content offering in MOOCs with virtual reality-an exploratory study on learner experience. *Journal of Universal Computer Science*, 24(2), 129-148.
7. Cortiz, D.; and Silva, J.O. (2017). Web and virtual reality as platforms to improve online education experiences. *Proceedings of the 2017 10th international conference on human system interactions (HSI),* Ulsan, Korea (South), 83-87.
8. Reis, R.; and Escudeiro, P. (2016). *The role of virtual worlds for enhancing student-student interaction in MOOCs.* In Mendoza-Gonzalez, R. (Eds.) *User-centered design strategies for massive open online courses* (*MOOCs*). IGI Global, 208-221.
9. Aji, S.D.; Setyowati, T.; Jumina, S.; and Hudha, M.N. (2021, April). Augmented reality: Physics on wave and vibration. *Journal of Physics: Conference Series,* 1869(1), 012090.
10. Yulianti, Y.; Wardhani, L.K.; Hakim, A. R.; Aji, S.D.; and Hudha, M.N. (2021). Augmented Reality (AR) subject Natural Science media for human framework topics. *IOP Conference Series: Materials Science and Engineering,* 1098(3), 032032.
11. Morimoto, J.; Ponton, F.; Aberdeen, A.; and Morimoto, J. (2019). Virtual reality in biology: Can we become virtual naturalists. Retrieved March 5, 2024, from https://pdfs.semanticscholar.org/e7e1/eab5fedff0afbe14681f59100df91edb8a9e.pdf

12. Williams, N.D.; Gallardo-Williams, M.T.; Griffith, E.H.; and Bretz, S.L. (2021). Investigating meaningful learning in virtual reality organic chemistry laboratories. *Journal of Chemical Education*, 99(2), 1100-1105.
13. Kounlaxay, K.; Yao, D.; Ha, M.W.; and Kim, S.K. (2022). Design of Virtual Reality System for Organic Chemistry. *Intelligent Automation & Soft Computing*, 31(2), 1119-1130.
14. Orlando, S.; Pillitteri, I. F.; Bocchino, F.; Daricello, L.; and Leonardi, L. (2019). 3DMAP-VR, a project to visualize three-dimensional models of astrophysical phenomena in virtual reality. *Research Notes of the AAS,* 3, 1-8.
15. Herfana, P.; Nasir, M.; and Prastowo, R. (2019). Augmented reality applied in astronomy Subject. *Journal of Physics: Conference Series.* 1351(1), 012058.
16. Eady, M.J. (2008). Using design-based research to produce strategies for synchronous literacy for Indigenous learners. *Proceedings of the Emerging Technologies Conference Supporting a Learning Community*, Wollongong, Australia, 56-63.
17. Parmaxi, A.; and Zaphiris, P. (2020). Lessons learned from a design-based research implementation: a researcher's methodological account. *International Journal of Research & Method in Education*, 43(3), 257-270.
18. Wautelet, Y.; Heng, S.; Kolp, M.; Penserini, L.; and Poelmans, S. (2016). Designing an MOOC as an agent-platform aggregating heterogeneous virtual learning environments. *Behaviour & Information Technology*, 35(11), 980-997.
19. Purwaningsih, M.; Purwandari, B.; and Hidayanto, A.N. (2024). A Conceptual Model e-Collaboration for Rural Tourism-Combining Soft System Methodology and UML. *Procedia Computer Science*, 234, 1119-1127.
20. Zhang, M.; Yin, S.; Luo, M.; and Yan, W. (2017). Learner control, user characteristics, platform difference, and their role in adoption intention for MOOC learning in China. *Australasian Journal of Educational Technology*, 33(1), 114-133.
21. Favario, L. (2018, September). A comprehensive MOOC creation approach. *Proceedings of the* 2018 *Learning with MOOCS (LWMOOCS)*, Madrid, Spain, 120-123.
22. Francis, J.; Adamson, S.R.; Meiser, D.; Boettcher, N.; McLean, A.; and Callahan, R. C. (2021). Developing new online course accessibility services for faculty through collaboration between librarians and campus departments: A case study. *Medical Reference Services Quarterly*, 40(3), 261-273.
23. Jacob, G. (2023). Business process modeling notation as a tool for translating SOGC guidelines to provide clinical decision support for prenatal care within EMRs. *Journal of Obstetrics and Gynaecology Canada*, 45(5), 358-359.