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AN EVALUATION OF FLIPPED CLASSROOM PEDAGOGY IN NATURAL SCIENCES LEARNING USING MOBILE VIRTUAL REALITY

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Abstract

Integrating advanced learning technologies (ALT) like virtual reality in science classrooms has become an imperative goal in preparing learners for future ways of learning and careers. This ideal, therefore, has implications for teacher training and development. This paper evaluates flipped classroom pedagogy in Natural Sciences (NS) learning with mobile virtual reality (VR) applications. One of the main setbacks of introducing mobile virtual reality (MVR)-enhanced learning in educational settings is the need for more knowledge of sound instructional/pedagogic strategies for facilitating their adoption. The study therefore aimed at exploring techniques within a flipped classroom model that saw the integration of MVR technology in NS learning. 95 Natural Sciences students (in a teacher training program) were conveniently sampled to participate in the study. Data were collected from the qualitative analysis of student pre-lesson plans, video analysis of flipped classroom interactions and quantitative analysis of post-flipped learning quiz scores. Students worked in groups of five to interact asynchronously with MVR applications using cellphones and cardboard VR headgear to generate their own pre-lesson plans and concept maps for the actual contact class session. The analysis of these high-end lesson sequences showed that students' awareness of flipped roles compelled them to collaborate more, be creative, and change their approach to problem-solving. Aspects like knowledge sharing and pre-planning of questions for the instructor were also prompted by the experience. Higher-order thinking skills (HOTS) were developed holistically from the flipped learning experiences. Students also showed that more time spent engaging with MVR technology and the content led to deeper learning and better achievements in learning tasks. Challenges of the flipped pedagogy included more planning time, incompatibility of some mobile phones to MVR applications, fear of presentation and peer criticism. From the findings, some recommendations and implications related to autonomous learning and the development of HOTS in relation to flipped classrooms for science students' learning are also discussed in this paper.

Keywords: *Flipped classroom, Higher order thinking skills (HOTS), Interactive learning, Mobile virtual reality (MVR).*

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1. Introduction and background

The versatility required by thriving organisations in the 21st century suggests that students must be trained to be self-propelling, creative and adaptable to a fast-changing world. In educational settings, flipped classroom pedagogical strategies empower students to learn concepts outside of the classroom through watching pre-recorded lectures, engaging in virtual laboratories, videos or reading materials and then using the allocated classroom time to apply that knowledge through collaborative, hands-on activities (Bishop & Verleger, 2013; Halili & Zainuddin, 2015). Using mobile virtual reality (MVR) in natural sciences learning can enhance this approach by providing students with immersive, interactive experiences that deepen their understanding of abstract or complex concepts when they autonomously study course materials. This research explores the gap in strategies that could be used to enact flipped classroom pedagogy and their efficacy in transforming Natural sciences learning. The main aim of the study is to investigate possible ways through which mobile virtual reality (MVR) could be adopted in educational settings using sound instructional/pedagogic strategies such as flipped learning. On the other hand, because flipped pedagogy is also usually burdensome to enact in science subjects which require practical work, MVR applications provide a worthy tool to engage students in a flipped classroom.

Advances in technology have had a significant impact on teaching and learning in educational settings from K-16 internationally. The flipped classroom pedagogy is one of the most popular teaching models that have emerged due to technological advancements. The flipped classroom model has been widely adopted by educators as it offers students the flexibility to learn in their own spaces and at their own pace and facilitates an interactive and engaging learning experience. Mobile virtual reality (MVR) technology has created opportunities for educators to enhance the flipped classroom model further.

While the traditional classroom model is characterized by instructors providing lectures in class and students taking notes and asking questions, a flipped pedagogy involves the inversion of the traditional classroom roles. In this model, the instructor creates video lectures and provides slides, virtual laboratories, applications, or any other instructional materials for students to study at home (Lin et al., 2023). This enables students to study the materials at their own pace and convenience. During class, students become the focus and propel interactive activities, reinforcing the knowledge gained. This means peer-peer and peer-teacher interactions are at the fore of the model.

Benefits of the flipped classroom model include convenience and flexibility for students, autonomy in the learning process, access to learning resources, active learning, and peer-to-peer learning (Jong, 2023; Law et al., 2020)

Despite the numerous benefits of the flipped classroom model, its implementation can be challenging, especially for science subjects that require multi-representational tools and a practical approach. For instance, Subjects within the Natural sciences, such as physics, chemistry, space science and biology, require dealing with abstract ideas and engaging in practical activities to comprehend the content. In such subjects, learning is not only about understanding theories but also about developing practical skills. Consequently, the flipped classroom model must be modified to fit the needs of science subjects which is where MVR comes into play. This study there answers the following research questions:

- What is the role of MVR in flipped classroom experiences?
- How effective is MVR-based flipped classroom learning?

1.1. Mobile Virtual reality (MVR)

Virtual reality (VR) technology offers an immersive and interactive learning experience in virtuality that allows students to explore complex concepts and theories in a practical way. The technology provides a simulated environment that engages students' senses, enhances visualization and presence, and reinforces learned concepts (Jong, 2023, Lin et al., 2023). Mobile virtual reality (MVR) is a more affordable option for VR integration, combining mobile phones with low-cost VR headsets like Google Cardboard for immersive experiences. MVR technology is easy to use, portable, and affordable. Furthermore, the technology provides an opportunity for students to learn in a personalized and engaging way.

The integration of mobile VR technology in the flipped classroom model presents opportunities for science educators to deliver an interactive and practical learning experience to their students. The use of mobile VR technology can enhance the flipped classroom model by providing students with practical learning experiences that reinforce concepts as well as other learning materials provided. Moreover, mobile VR technology can be used to explore virtual laboratories and simulations that could complement traditional lab work and foster remote experiential learning.

1.2. Flipped classroom pedagogy in Natural Science learning using mobile VR

Fostering remote practical work in Natural sciences subjects could be complex and challenging. Using an MVR-based flipped experience, however, provides an opportunity for students to incorporate some exploratory practical work, for example, instead of completing a traditional dissection of a pig or frog in order to study the internal organs of living things, a VR application like Victory XR's frog dissection (https://sidequestvr.com/user/102517) for mastery of the same concepts, without harming any real frogs. Similarly, an application like the VR chemistry lab (https://sidequestvr.com/app/11063/the-vr-chemistry-lab) could provide chemistry students with a seamless experience in learning about laboratory safety and chemical reactions in a safe and controlled environment.

Studies have shown that the use of VR in natural sciences education can lead to improved academic performance, increased engagement, and enhanced critical thinking skills (Law et al., 2020; Lin et al., 2023). The integration of flipped classroom pedagogy and mobile VR can build on these benefits, allowing students to engage with course content in a more dynamic and interactive manner (Lu et al., 2021).

2. Theoretical underpinnings

Theoretically speaking, social learning theory, emphasizes the importance of social interactions in the learning process. In a flipped classroom setting, students can interact with their peers and instructor during in-class activities, allowing them to engage in collaborative learning and receive feedback on their understanding of instructional material. This approach has been found to promote deeper learning and enhance student engagement and motivation (Bishop & Verleger, 2013). Closely related to constructivism, the social learning theory promotes interactivity among peers through collaborative work. This research taps into these affordances of social learning in designing the MVR flipped classroom experiences for 95 students in the third year of a science teacher education program.

3. Methods

95 Natural Sciences students (in a teacher training program) were conveniently sampled to participate in the study. Data were collected from the qualitative analysis of student pre-lesson plans, video analysis of flipped classroom interactions and quantitative analysis of post-flipped learning quiz scores. Participants were divided into 19 groups, with each group having five students of varying abilities. All learning materials for preparing the flipped experience were uploaded to the institutional learning management system (LMS) Blackboard. To interact asynchronously, students had to download the MVR applications ARloopa and SolarsystemAR and, using cellphones and cardboard VR headgear, generate their own pre-lesson plans and concept maps for the actual contact class session. An embedded mixed-method approach was followed. Data were then gathered through artefacts, video recordings for observational purposes, classroom conversations, and quizzes. A content analysis of gathered data using Open and axial codes was used to generate baseline data to answer the research questions posed at the beginning of the inquiry.

4. Results

RQ1: What is the role of MVR in flipped classroom experiences?

The analysis of high-end lesson plans and sequence maps of what was done showed that students' use of MVR increased their awareness of the flipped roles. MVR compelled participants to collaborate more, visualize more, be creative, and change their approaches to problem-solving. Findings from the qualitative analysis of the interactive video lesson indicated that all 19 groups of participants followed a unique sequence of engagement in the selected content, as outlined in Table 1 below.

Table 1. A Highlight of flipped MVR-based lesson sequence.

Engagement with pre-provided content	**Engagement with MVR Applications**	**Collaborative Discussion**	**Engagement with learning Objectives**	**Plan lesson**
-The topic introduction Slides, diagrams, and videos. -Evidence of collaborative work in group conversations of the pre-text. -First-level display of HOTS by looking at ways of simplifying the content.	-Peer support in installing the mvr application and trying it out. -Self-talk moments when immersed in cardboard devices. -Relating MVR applications to the learning objectives. -Noting gaps in the application in relation to the learning objectives.	-Groups discussing the content again in line with the MVR application. -Peer-to-peer discussion on possible assessments and questions to pose during the class session. -Analysing the benefits of the MVR apps.	-Drafting lesson objectives against the learning outcomes with the use of the MVR application. -Highlighting gaps in understanding concepts.	-Planning lesson presentation for the contact session. -Delegating presentation roles. -Writing down possible misconceptions that could be addressed by the main instructor in class.

From Table 1, it is clear that adding MVR applications to flipped classroom learning resources, added a layer of group interactivity to the content. The collaborative learning experience became more engaging and participatory. MVR also provided another layer of visualisation of NS concepts besides the notes and pre-recorded lecture slides.

An analysis of video-recorded lessons showed three key higher-order thinking skills (HOTS) that were developed, including critical thinking in the task created to engage peers, creativity in showcasing the MVR application selected for the flipped lesson and communication, in the quality of questions posed as well as the misconceptions brought to the fore.

RQ2: How effective is MVR-based flipped classroom learning?

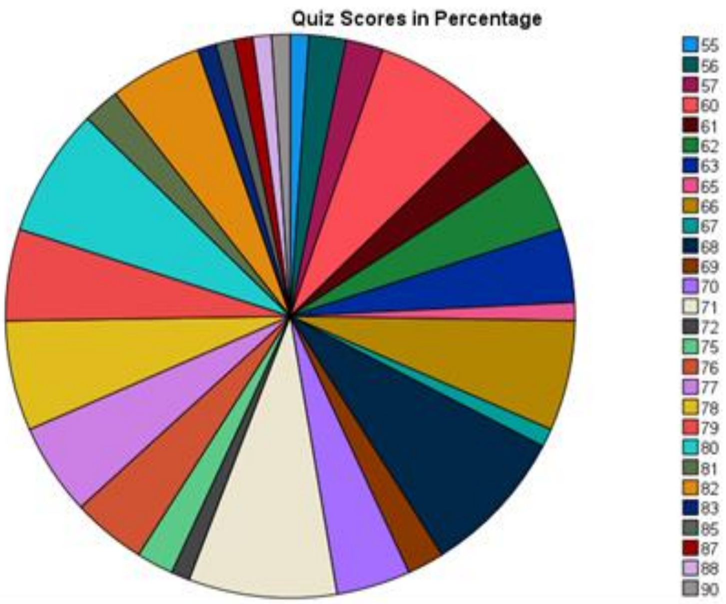
The results from the post-lesson quiz are shown in the descriptive statistics Table 2 below. These results showed that the lowest-performing student attained a score of 55%, and the highest-performing student obtained a score of 90%. This would typically not be the case for this group of participants, where a previous quiz on similar concepts showed a minimum score of 35% and a maximum score of 82%.

Table 2. Descriptive statistic of post-flipped class quiz scores.

	N	Range (%)	Min (%)	Max (%)	Mean (%)	S.D (%)
Quiz Scores in Percentage	95	35	55	90	71.38	8.406
Valid N (listwise)	95					

From Table 2, the mean score (M) of the quiz was 71.38%, with a standard deviation (SD) of 8.4%. The maximum quiz score was 90%, while the minimum score was 55%. The pie chart in Figure 1 below represents the mark distribution in percentiles for all the participants indicating a relatively good achievement in the given task.

Figure 1. Pie distribution of Quiz marks.



Following the distribution of marks from Figure 1, MVR-based flipped learning has a positive effect on the average achievement score of participant students. The added layer of engagement that MVR applications provide foster deep learning and interactivity.

5. Discussion and conclusion

Based on the findings of this research, the use of MVR in flipped classroom pedagogy within natural sciences learning has the potential to transform the way students engage with and understand scientific concepts. By providing an immersive, interactive learning experience, students can better understand the material and be better prepared for real-world applications of scientific knowledge. This study’s findings concur with recent studies, which show a positive outcome when VR and augmented reality (AR) are integrated in flipped learning models (Chang & Hwang, 2018; Jong, 2023, Lin et al., 2023). However, the study provides a unique contribution to the added group work dimensions that take place in a flipped classroom setting.

From the findings of this study, it is recommended that MVR learning resources be considered in facilitating remote and flipped learning experiences within educational settings, especially in NS. A group work approach has the potential to foster an added level of interactivity. Hence it should be considered as a sound pedagogical approach for implementing flipped MVR-based learning. For researchers, larger-scale studies using different pedagogical approaches like inquiry, argumentation, and problem-solving could be investigated using the MVR-based flipped learning model.

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