BRING YOUR OWN DEVICE: INTEGRATING MOBILE LEARNING TECHNOLOGY FOR ENGAGEMENT AND BASELINE ASSESSMENTS IN SCIENCE LEARNING

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Abstract

Integrating mobile technological tools into educational settings has been a game-changer in the way people teach, learn and engage with content. In science education, where engagements could sometimes be flooded with misconceptions and abstractions, the "bring your own device" (BYOD) strategy has proven to be helpful in creating meaningful engagements through applications like Mentimeter, Quizzes, Gimkit and Nearpod. This study investigates the potential of leveraging mobile devices brought to class by students for real-time engagements and formative assessments with the main aim of enhancing students' participation and attainment of learning outcomes in science classrooms. The study aims to provide insights into the effectiveness of the BYOD concept in creating an interactive and responsive learning environment for students. The study employed a sequential mixed methods design in capturing natural sciences students' engagements using the user engagement scale (UES) to measure engagement and semi-structured focus group interviews to capture students' experiences. A sample of 114 natural sciences students was purposefully selected to participate in a semester-long intervention where mobile devices were used for baseline assessments and interactive engagements during lectures. The researcher used the mentioned mobile learning platforms for questioning, instant feedback, and interactive engagements that were aligned with the topics being covered in the targeted semester. Pre- and post-UES data were analysed using statistical methods to measure changes in engagement before and after mobile learning interventions, while qualitative data were thematically analysed to identify patterns in student experiences during the semester-long intervention. Findings revealed significant improvements in student engagement and learning outcomes. Mobile-based formative baseline assessments through Quizzes and Mentimeter were noted for facilitating the connection between prior knowledge and new knowledge, thus increasing students' attainment of the learning outcomes during lectures. There were also significant positive changes in the user engagement score from pre- to post-UES. Additionally, 85% of students reported higher levels of motivation and interest in science topics, citing the immediacy of feedback and the interactive nature of the mobile assessments as key factors. Several advantages of the BYOD methods were also revealed as students generally felt confident using their own devices, which they already had a mastery of. Based on the findings, it is recommended that mobile learning tools be integrated into learning, especially to stimulate the recall of prior knowledge, experiences and engagement. Some setbacks of mobile formative assessment applications and the actual devices may always arise with technical issues and low internet connectivity. Nevertheless, the benefits of integrating engagement tools nested within the BYOD strategy outweigh the challenges. Trends in the data also highlight the importance of user-friendly interfaces and seamless integration of mobile learning tools into existing teaching plans for science students. Some further implications of the findings are captured in the manuscript.

Keywords: BYOD, engagement, formative assessment, mobile learning technologies, user engagement scale (UES).

1. Introduction and background

With the many technological advances in the 21st century, contemporary education is undergoing a paradigm shift, driven mainly by the pervasive influence of digital technologies (Ally & Tsinakos, 2014; Tlili et al., 2023). Among these technologies, mobile learning (ML)technologies have emerged with the potential to affect how teaching, learning and assessments take place. The "bring your own device" (BYOD) strategy, wherein students use their personal smartphones, tablets, or laptops for educational purposes, has gained considerable traction across various educational levels and disciplines (Song, 2014) since the

COVID-19 pandemic. This approach not only leverages resources already available to students but also capitalises on their familiarity and proficiency that people tend to have with their own devices.

In the context of science education, the integration of mobile technology through BYOD holds particular promise for increasing the amount of interactivity in the classroom, especially in the facilitation of baseline and formative assessment tasks (Burden & Kearney, 2016). Science, as a discipline, often grapples with abstract concepts and misconceptions that can hinder student understanding and engagement (Osborne & Freyberg, 1985). Traditional pedagogical approaches, including the use of pen and paper tests, may fall short in advancing the active participation and deep conceptual understanding required in science learning. Mobile applications such as Mentimeter, Quizzes, Gimkit, and Nearpod offer interactive and engaging platforms that can transform passive lectures into dynamic learning experiences for students in diverse educational settings. These tools facilitate real-time formative assessment, immediate feedback, collaborative activities, and access to a vast array of digital resources, thereby addressing some of the inherent challenges in science pedagogy as it relates to assessment (Hwang et al., 2018).

1.1. Problem statement

As highlighted by Burden and Kearney (2016), mobile learning (ML) formative assessments offer transformative potential for science education by enabling real-time feedback and personalised learning. However, a significant gap exists in their effective integration into science teaching, particularly in fostering sustained user engagement. Some of the current ML platforms lack interactive, context-specific features that align with science curricula, leading to low student and teacher adoption rates. Additionally, there is limited evidence on how these tools enhance engagement and learning outcomes in diverse classroom settings. Addressing this gap requires developing engaging, science-focused mobile assessment tools and evaluating their impact.

Research Questions:
- How do interactive mobile formative assessments affect students' engagement in science lessons when used as a baseline tool?
- How do mobile learning formative assessments (with their own devices) enhance the attainment of learning outcomes and participation in science learning from students' experiences?

Research objectives:
- To assess the influence of mobile formative assessments on students' engagement in science lessons.
- To establish how mobile learning methods of formative assessments (with their own devices) enhance the attainment of learning outcomes and participation in science learning from students' experiences.

2. Theoretical framework

The Framework for the Rational Analysis of Mobile Education (FRAME) model suggested by Koole (2009) is well suited for this research as it is crucial in studying mobile learning formative assessments in science teaching, particularly when the user engagement scale is the analytical framework for engagement. Figure 1 below shows components of the FRAME model.

Figure 1. Components of the FRAME-Model (Koole, 2009, p. 27).
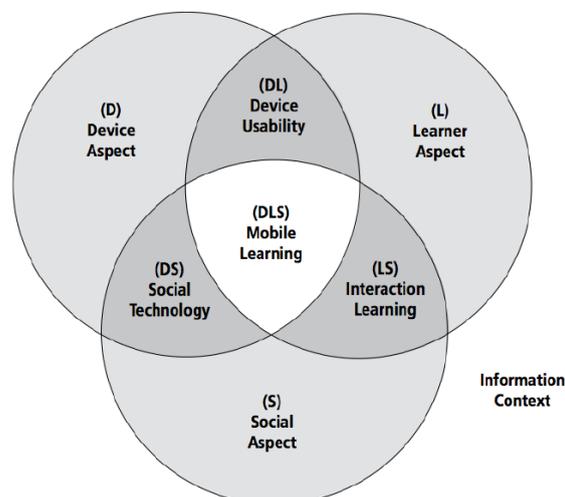
As seen in Figure 1, the FRAME model integrates three main aspects: device (usability, accessibility), learner (prior knowledge, motivation), and social (interaction, collaboration). It emphasises how mobile tools can be used to facilitate personalised, context-sensitive learning, aligning learning objectives set by the teacher. By focusing on the intersection of these aspects, the framework supports analysing how mobile assessments enhance engagement through usability, learner autonomy, and collaborative features in diverse classroom settings (Koole, 2009). The User Engagement Scale (UES) (O'Brien et al, 2018), a validated instrument that includes four main constructs, namely *"focused attention, perceived usability, aesthetic appeal, and reward factor"* associated with user engagements of technological tools and applications. This scale correlates with the FRAME model for mobile learning, which makes assessing student devices and the actual ML applications used for formative assessment easier.

3. Research methods

A sequential explanatory mixed-methods research design was employed in this study to provide a comprehensive description of the impact of BYOD and mobile learning formative assessments on engagement in science classes. The approach involves collecting and analysing quantitative data first, followed by the collection and analysis of qualitative data, where the qualitative findings help to provide explanations for quantitative results (Creswell & Plano Clark, 2023).

A sample of 114 natural sciences students from a teacher education program at a South African university was purposefully selected to participate in the intervention as part of research in the scholarship of teaching and learning (SOTL). Purposive sampling was deemed appropriate for collecting in-depth information from students directly involved in the semester-long mobile learning intervention within their natural sciences module. The selection criteria included willingness to participate, having a good working mobile device (laptop, tablet or cellphone) and being enrolled in the selected NS module. All ethical considerations, informed consent and assurance of anonymity and confidentiality were strictly adhered to.

During the semester-long intervention, natural sciences students used their own mobile devices (BYOD) to engage with various mobile learning platforms, including Mentimeter, Quizzes, Gimkit, and Nearpod. These platforms were integrated to facilitate formative assessments with the aim of assessing prior knowledge at the beginning of lectures, fueling engagement in the middle of content delivery, participation, discussions and providing instant feedback. The researcher served as the instructor to design and facilitate ML activities, ensuring alignment with the learning objectives for the targeted semester.

Data collection occurred in two phases. In phase one, the adapted User Engagement Scale (UES) was piloted with non-participating students from another module, then, after preliminary validation and reliability checks, it was administered to participants, pre- and post-ML interventions. The UES is a standardised questionnaire designed to measure various facets of user engagement with technology, with constructs focused on attention, perceived usability, aesthetic appeal, and reward (O'Brien et al, 2018), and respondents responded on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). In phase two, semi-structured focus group interviews were conducted with a subset of the participating students (N=60). The selection of students for focus groups aimed to capture a range of experiences and perspectives as reflected in the quantitative findings. The interviews were designed to explore students' experiences with the BYOD strategy, their perceptions of the mobile learning applications used, the impact on their learning and motivation, and any challenges encountered.

The quantitative data from the pre- and post-UES administrations were analysed using SPSS 30. Descriptive statistics (e.g., means, standard deviations) were calculated for both pre- and post-UES scores. Inferential statistical tests, such as a paired-samples t-test, were employed to determine if there were statistically significant changes in student engagement scores from before to after the ML intervention at a 95% confidence interval (p-value of <0.05). Braun and Clarke's (2006) six steps of thematic analysis guided the analysis of qualitative data to obtain themes.

4. Findings / results

The study yielded significant findings regarding the impact of integrating mobile learning tools within a BYOD strategy on natural sciences students' engagement and learning outcomes. The results are presented in a way that answers the research questions.

4.1. Quantitative findings: Interactive mobile formative assessments affect students' engagement in science learning

Results from the paired sample T-test of pre- and post-intervention UES data revealed a significant positive change in student engagement scores. The analysis revealed a highly statistically significant increase in the total UES score after the semester-long mobile learning intervention ($t(113)=−82.21$,

p<0.001). Significant improvements were also observed across all UES subscales: Perceived Usability (t(113)=−38.48,p<0.001), Aesthetics (t(113)= −25.71, p<0.001), Focused Attention (t(113)=−46.14, p<0.001), and Reward/Involvement (t(113)=−40.08,p<0.001). From thematic analysis of qualitative data, students reported higher levels of engagement after the semester-long intervention involving the use of mobile devices and applications like Mentimeter, Quizzes, Gimkit, and Nearpod. This suggests that the interactive and real-time nature of these tools, delivered through a familiar BYOD approach, effectively captured and maintained students' focused attention and involvement in the learning process.

4.2. Qualitative findings: Mobile learning tools enhance learning outcomes and student participation

The thematic analysis of the focus group interview data provided rich insights into students' experiences and corroborated the quantitative findings related to engagement. The findings also explicated several key themes that emerged from data analysis.

Immediate Feedback: Students found that the feedback provided by the formative assessment tools Quizzes and Mentimeter allowed for immediate assessment of their understanding of different concepts and provided them the opportunity to ask questions and clarify their misconceptions. This attribute of the ML apps helped in the identification of knowledge gaps and provided opportunities to adjust in a non-graded experience, unlike traditional assessments, where feedback may be delayed.

Enhanced Motivation and Interest: Students reported experiencing higher levels of motivation and interest in science topics during the intervention, especially in the mid-lecture quizzes, which checked for understanding. The content-focused nature of some of the assessments made the learning process very interesting, to learn the concepts and pay attention in class.

Interactive Nature of ML Assessments: The game-like features of platforms such as Gimkit and Quizzes, along with the polling and interactive presentation capabilities of Mentimeter and Nearpod, transformed learning from a passive activity into an engaging and enjoyable experience. Students found these methods more stimulating than the traditional lecture format, which consisted of just asking and answering questions.

ML facilitates prior knowledge connection to new knowledge: A significant finding was the perceived effectiveness of mobile-based formative baseline assessments in connecting prior knowledge with new scientific concepts. Students noted that using tools like Quizzes and Mentimeter at the beginning of topics helped them recall relevant information and identify what they already knew, making it easier to integrate new material. This bridging of past and present learning was seen as crucial for improving their attainment of learning outcomes during lectures.

Advantages of the BYOD Strategy: Students generally expressed confidence and comfort in using their own mobile devices for learning. Key advantages identified included: Familiarity and mastery, as students indicated that they were already proficient in using their own devices, and this minimised the learning curve associated with new technological devices and allowed them to focus on the content rather than grappling with unfamiliar hardware. Also, the accessibility of ML learning tools readily available on students' personal devices was perceived as convenient, allowing flexible access to learning materials and activities.

Challenges of the BYOD strategy: While the overall response was positive, students also acknowledged some setbacks associated with mobile formative assessment applications: Occasional technical glitches with the applications or with device connectivity were reported as potential sources of frustration for students. Reliance on stable internet access was a concern in some sessions, particularly if the institutional Wi-Fi was shaky, then students depended on their own limited mobile data.

Despite these challenges, participant students indicated that the benefits of integrating these mobile engagement tools within a BYOD strategy significantly outweighed the challenges for learning Natural Sciences concepts. The findings underscore the potential of these technologies to create a more interactive, responsive, and student-centred learning environment in science education.

5. Discussion

The findings of this study provide compelling evidence for the positive impact of integrating ML applications through a BYOD strategy on student engagement and learning in Natural Sciences. The statistically significant increase in UES scores shows that using students' devices for classroom interactions increases their involvement and interactivity in the learning process. These findings concur with findings from other studies, which reveal that ML motivates for more active participation compared to traditional didactic interactions (Burden & Kearney; Hwang et al., 2018). The qualitative results offered more evidence for why students felt their engagement was better with ML formative assessment integration. Students' increase in motivation and interest, attributed to the immediacy of feedback and the interactive nature of tools like Mentimeter, Quizzes, Gimkit, and Nearpod, resonates with the FRAME model of ML (Koole, 2009). Immediate feedback allows students to self-assess and co-construct meaning through active interactions and gamification in the learning environment (Dicheva et al., 2015). A particularly noteworthy

finding is the role of mobile-based formative baseline assessments in connecting prior knowledge to new information. The use of Quizzes and Mentimeter for this purpose directly addresses Ausubel's (1968) theory of meaningful learning, which emphasises the importance of anchoring new concepts to existing cognitive structures. By activating prior knowledge and identifying misconceptions at the outset, educators can tailor their instruction more effectively to address students' concerns, leading to improved attainment of learning outcomes, as reported by the students. This highlights the strong relationship between mobile technology and sound pedagogical principles of formative assessment.

The benefits of the BYOD approach (students' confidence and mastery of their own devices) cannot be overlooked in this research. This familiarity reduces cognitive load associated with learning the manipulation of a new or given device, allowing students to focus their mental resources on the scientific content instead of the technology. This practical benefit simplifies the implementation of ML for instructors and tutors. Although equity issues regarding device access and quality could hinder some ML experiences, this was not the case in this study, as all participants had either a tablet or a smartphone.

6. Conclusions and recommendations

This study successfully investigated the potential of leveraging students' mobile devices within a BYOD approach to enhance engagement and learning outcomes through baseline assessments in natural sciences classrooms. The mixed-methods approach provided both quantitative evidence of increased engagement and rich qualitative insights, supported by these findings from students' reported experiences.

Based on the findings and conclusions of this study, the researcher recommends that Natural Sciences instructors integrate ML applications like Mentimeter, Quizzes, Gimkit, and Nearpod into their teaching, particularly for stimulating recall of prior knowledge, conducting formative assessments and the active participation of students. Lecturers can also consider using the BYOD strategy, ensuring clear guidelines and instructions for use while being mindful of the potential digital divides that this might promote in a context where not all learners have smart devices. For researchers, a longer-term study could be conducted to examine the sustained impact of BYOD and mobile learning on student engagement, learning outcomes, and interest towards the learning of Natural Sciences.

Overall, the thoughtful integration of mobile technology through a BYOD strategy, using ML applications for formative assessment and interactive learning, holds good promise for classroom interactions in science education. By creating more responsive, participatory, and motivating learning environments, students feel more confident in their knowledge of the subject.

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