Exploring the Impact of Mobile Learning on STEM Education in K-8 Settings:

A Systematic Literature Review on the Implementation and Evaluation of Mobile Learning

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Abstract

Mobile learning, or m-learning is becoming increasingly popular in the classroom as technology advances and more affordable options hit the market. This systematic literature review examines m-learning in relation to STEM settings for K-8 classrooms. Seven studies published after 2010 were reviewed, focusing on m-learning curriculum and instruction as well as assessment and evaluation. The results reveal that mobile learning has the potential to enhance student engagement, promote collaboration, and encourage creativity. Challenges such as potential distractions and the need for effective content also came up frequently. Successful implementation of mobile learning depends on factors such as teacher training, technical knowledge, and the availability of one-on-one support.

I. Introduction

From online math games to virtual field trips and more, mobile devices such as tablets and smartphones are rapidly transforming education as we know it. As the classroom adapts to this new age, many wonder how mobile learning impacts students. Mobile learning, or m-learning, is a form of learning that utilizes technology such as tablets or smartphones in the classroom. This learning method has become increasingly popular since 2009 and 2010 as the first Android and Apple tablets were launched, respectively [1]. This type of learning is often used in traditional classroom settings to aid in student engagement and knowledge. M-learning exists in various forms including apps developed for the classroom, learning modules, games, etc. M-learning can also be utilized in home school programs, increasing students' ability to access online textbooks, virtual field trips, and collaborate with other students. M-learning is becoming increasingly popular as mobile devices are at a comparatively low price compared to desktop computers [1]. In addition, m-learning is extremely flexible and personalized, allowing students to work at their own pace, review materials at any time, and access a wide variety of resources.

While m-learning has the potential to benefit all subjects, it can be especially valuable when teaching STEM (science, technology, education, and mathematics) subjects. One study published in 2019 found that students who played STEM-based mobile games in the classroom had greater improvement in learning than students who did not play mobile games [2]. Topics where skills tend to see the most improvement include environmental science and economics [1]. However, it is worth noting that the natural sciences have dominated current studies focused on m-learning applications [3]. Current research is constrained, and although some studies have found m-learning can motivate students, overall the research on the impact of tablet and smartphone use on learning is limited [1].

This systematic literature review seeks to comprehensively examine m-learning within STEM education from the beginning to the end. It will explore the development of m-learning, how they are implemented by teachers in the classroom, and how students perceive and use them. While many existing systematic literature reviews have focused solely on student engagement and participation based on survey results, this review aims to provide a holistic perspective on m-learning in K-8 STEM education.

II. Methodology

There are three research questions that will be addressed in this review including

RQ1: What are the key benefits and challenges of implementing mobile learning in K-8 STEM education?
RQ2: How does the use of mobile technology impact student learning outcomes in K-8 STEM education?

RQ3: What factors influence the successful implementation of mobile learning in K-8 STEM education and how can educators integrate these technologies into their teaching methods?

Based on these research questions, a list of search terms was created to help facilitate gathering papers. This list included "mobile learning", "learning outcomes", "K-8", "mobile games", "STEM education", "STEM", "science education", "mobile devices", "elementary" and "middle school". This set of terms was used in Google Scholar to come up with an initial list of studies. Searches used included "mobile learning" AND "K-8", "mobile learning" AND "STEM education", "science education" AND "mobile learning", and finally "mobile devices" AND "K-8" AND "STEM".

In addition to creating search terms, exclusion criteria were also developed. The following exclusion criteria were created:

- Papers published before 2010
- Papers primarily focused on high school students or post-secondary education
- Papers that were unrelated to STEM topics
- Papers that were not written in English
- Papers that were literature reviews

The year 2010 was chosen as a cut-off based on the timeline of when tablets first hit the market. This paper focuses on elementary and middle school education as opposed to higher level education not due to a lack of research on higher level education, but instead due to a personal interest in how young kids learn and comprehend new topics. A broader range of K-8 was selected rather than only elementary school students due to the availability of the current research.

The initial search came upon eleven papers. This was then narrowed down to seven studies after reviewing the introduction and methods section to ensure each paper would fit the research topic. The final list of studies has been divided into two categories:

1. Mobile learning curriculum and instruction for K-8 STEM education (3 studies)
2. Assessment and evaluation of mobile learning in K-8 STEM education (4 studies)

III. Results

Mobile Learning Curriculum and Instruction of K-8 STEM Education

Among the seven studies gathered, three were focused on m-learning curriculum and instruction. These studies centered around developing a science-based curriculum to be used on mobile devices.

A study conducted in 2010 worked on transforming three science lessons into a mobilized curriculum. They collaborated with a primary school classroom consisting of 24 boys and 15

girls where they reconstructed current lessons to turn them into m-learning lessons [4]. After bringing the new and improved mobile lesson back into the classroom, researchers initially found that students demonstrated better engagement [4]. Furthermore, their results showed a significant difference in the end-of-year exam grades when comparing classrooms exposed to m-learning versus those who experienced traditional learning [4].

Although the previous study took an already-established lesson plan and mobilized it, many researchers are developing entirely new lesson plans, ones that could not be possible without the help of technology. A study conducted in 2012 worked on developing a concept map design to help students with learning topics in ecology. The researchers found that the concept map design was effective in improving students' understanding of ecological topics and observation skills. In particular, they noted how this lesson helped students better visualize concepts and make connections. [5]. Below is an example of the interactive mobilized module they developed.

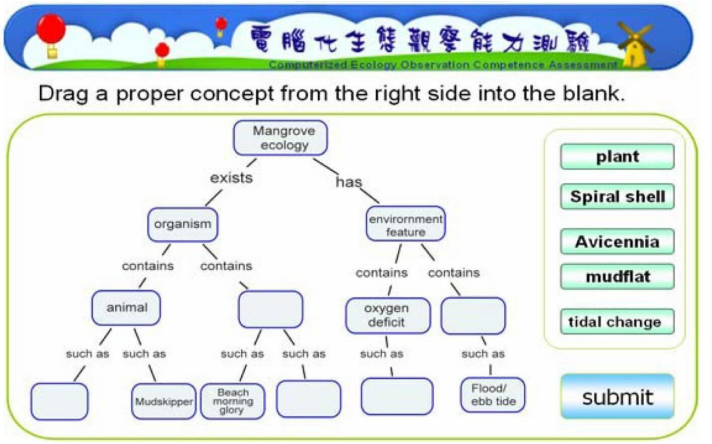

Figure 1: An illustration of a concept map (Taken from [5])

The last study focused on curriculum and instruction was also published in 2012. This study not only looked at m-learning but also personalized learning and how both can be beneficial to students. For this study, students went on a field trip and were then asked to create presentations on butterfly life cycles or spinach plants. The students were able to add drawings, pictures, and captions to their presentations to make them their own. The biggest benefit observed by researchers was the ability for students to choose when, where, and how to complete the tasks assigned to them [6].

Assessment and evaluation of mobile learning in K-8 STEM Education

The next four papers were concerned with evaluating m-learning in the classroom. While these studies may also have developed their own curriculum or lesson plans, their main focus is on how m-learning impacts students, not the development of m-learning itself. Two of these

studies cover the perspective of educators and how they can best integrate this new technology into the classroom.

A study published in 2013 observed a sixth-grade classroom in Hong Kong to see how well a BYOD (bring your own device) system would work in the classroom. Student outcomes were examined using pre- and post-tests, revealing that after an m-learning lesson, student knowledge was more structured and represented a deeper understanding of the material [7]. In addition, students participated in questionnaires that showed a positive perception of their m-learning experience [7]. Another study, published in 2017 did not create a new m-learning curriculum, but instead mailed questionnaires to participating elementary schools already utilizing m-learning in their classrooms. 86 responses were collected and the results indicated that m-learning enhanced students' ability to engage in the lesson plan with their peers [8]. In addition, they found m-learning to have a significant impact on student satisfaction with their teacher's teaching [8].

The following two papers focus on pre-service elementary teachers and how they can implement m-learning into their classrooms. The first paper, published in 2019 focuses on training teachers to use mobile technology during their teacher education programs. Overall, teachers agreed that mobile learning has the potential to improve student achievement, become more inquisitive, and encourage students to become more active in their learning process [9]. However, teachers also noted m-learning could distract students, cause anxiety, or start disciplinary problems [9]. The final paper, published in 2020 had preservice teachers complete a physics curriculum using tablets or paper. They compared the two methods of teaching through interviews and classroom observations. Interviews conducted post-learning experience compared to pre-experience indicated a positive view toward m-learning and increased confidence in using technology, especially in the classroom [10].

Table 1. Summary of Findings on M-Learning in STEM Education			
Study	Published	Methods	Results
BaoHui Zhang et al. [4]	2010	Learning assessments	Pre-service teachers have a positive preception of m-learning
Pi-Hsia Hung et al. [5]	2012	Pre- and post- tests	M-learning promoted substantial improvement in test results
Yanjie Song et al. [6]	2012	Mixed-methods (questionnaire, interviews)	Differentiated learning goals for students
Yanjie Song [7]	2014	Mixed-methods (pre- and post- tests, questionnaire, artifacts, observations)	Increase in student knowledge
Hsiu-Ju Chen [8]	2017	Questionnaire	M-learning significantly associated with particpiation
Hau Bai [9]	2019	Mixed-methods (analysis of online posts, suveys, artifacts)	Pre-service teachers have a positive preception of m-learning
Deepika Menon et al. [10]	2020	Mixed-methods (surveys, interviews, observations)	Significant increase in technology confidence

Figure 2: Summary of Results

IV. Discussion

The three research questions posed earlier can be answered based on the results section.

RQ1: What are the key benefits and challenges of implementing mobile learning in K-8 STEM education?

Most studies agreed that m-learning can be beneficial by promoting student engagement [4]-[8]. However, papers [9] and [10] discuss m-learning as a possible distraction, [9] went as far as to say that m-learning could promote cheating, cyberbullying, and access to inappropriate content within the classroom. This can be especially a concern for classrooms that have BYOD systems in place, as these devices may not have parental controls. Another benefit of mobile learning is the ability for students to receive feedback in real-time [4][9]. Unlike traditional classroom learning where papers must be submitted, graded by hand, and returned, tablets allow for auto-grading that gives students the ability to instantly assess their own progress. Another challenge, for both researchers and teachers, is ensuring the m-learning content is truly beneficial and engaging, and not just something new and exciting [9].

RQ2: How does the use of mobile technology impact student learning outcomes in K-8 STEM education?

Learning outcomes in relation to STEM education vary based on grade but most commonly include content knowledge, creativity, collaboration, and problem-solving skills. According to [7] which administered pre and post-m-learning tests, learning outcomes in the advancement of content knowledge were observed in their middle school students. Several papers discussed learning outcomes in relation to personalized learning [6]-[7], [10], reflecting that students learn best with a personalized curriculum, whether that be because of their ability to pick the work back up later [6]-[7] or due to teacher-student interactions [10]. Several papers identified m-learning as a way to promote collaboration among students [4][6][9], and encourage creativity [6]. Only one study addressed learning outcomes as it relates to problem-solving, paper [10] discusses how tablets can be used for more than just the lesson plan. Tablets have the ability to switch between apps, allowing students to access the calculator, YouTube to look up tutorial videos, and Google to ask questions [10].

RQ3: What factors influence the successful implementation of mobile learning in K-8 STEM education and how can educators integrate these technologies into their teaching methods?

Papers [9] and [10] focus more heavily on how pre-service teachers can successfully implement m-learning in their classrooms. One of the biggest factors affecting successful implementation is teacher technology training courses [10], if teachers are not confident with the technology they are using then they are less likely to be able to successfully teach their students how to use the technology. Time spent one-on-one with technology is one of the best ways to train teachers on how to use technology [10]. Teachers taking technology training courses reported an increase in confidence in being able to implement m-learning in the classroom [9]. In addition, some teachers have discussed using m-learning to not only teach in the classroom but to assess learning by utilizing technology to ask quiz questions [9].

These results help solidify that m-learning can be a useful tool in the classroom when teaching STEM education. While many previous literature reviews have focused solely on student engagement or m-learning development, this review took a holistic approach by considering both aspects. Through encompassing a broader range of studies, this review offers a more comprehensive understanding of the benefits, challenges, and impacts of m-learning in K-8 STEM education as a whole. However, the selected studies did have their own limitations. These included how each study was conducted, primarily via questionnaires and interviews. Only three of the selected studies [4]-[5] and [7] used pre- and post-m-learning tests to identify actual knowledge learned. While qualitative research does provide valuable insights into the experiences of students, there is an additional need to conduct more quantitative research to strengthen the evidence base.

In terms of implementing m-learning in classrooms, not all pedagogies are created the same. Identifying the most effective lesson plans is crucial for maximizing the benefit of m-learning for students. Out of the seven papers read for this literature review, the most effective lesson plans seem to be those that allow for student personalization and creativity such as in study [6]. This lesson plan allowed students to create drawings, upload pictures, and add captions to make their presentation unique. The use of multimedia elements encourages student creativity and allows them to make personal connections to the material being presented, catering to different learning styles.

Future research is needed on this topic. First and foremost, there is a need for longitudinal studies that examine the long-term effects of m-learning on students. How does long-term m-learning affect retention of knowledge, for example? Additionally, the natural sciences are currently dominating the m-learning field and additional studies should be conducted on mathematics, chemistry, engineering, and other subjects to identify subject-specific benefits and challenges to m-learning. Furthermore, as technology continues to evolve it is important to look at other aspects of m-learning such as virtual reality (VR) and augmented reality (AR) to see how these technologies may be beneficial to the classroom. Exploring the integration of VR and AR in the classroom has the potential to open up new possibilities for immersive and interactive STEM learning experiences. Lastly, research needs to be conducted on understanding the impact of m-learning on underrepresented student populations and addressing equity issues involved in technology use.

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