Student engagement in mobile learning activities: breakdowns and breakthroughs

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Abstract *The ubiquity of mobile devices together with the potential to bridge classroom learning to real-world has added a new angle to contextualising mathematics learning. The goal of this research was to evaluate student engagement in a series of mobile learning activities. The study uses critical incident analysis to evaluate the breakdowns and breakthroughs of mobile learning. Twenty-four Primary 7 students participated in the study. The mobile learning activities were found to have facilitated visualisation, encouraged reflection and promoted active learning. However, some issues regarding mobile use affected student engagement with the activity. The challenges identified highlighted the role teachers play in designing and carrying out novel technology use.*

Keywords: Mobile learning, Mathematics education, Technology enhanced learning, Student engagement, Issues of mobile learning

Introduction

The challenge to connect mathematics learning to real-world is not new, but the mobility and connectivity afforded by mobile technologies has renewed interest on this challenge. Potential benefits of using mobile technologies include facilitating learning across context and personalised learning (Cochrane, 2010). Previous mobile learning studies have shown various approaches to bridge the gap between school mathematics and the real-world. For example, Spikol and Eliasson (2010) utilised the built-in sensors of mobile devices to facilitate distance measurement while Crompton (2015) used the mobile camera and an interactive geometry application to facilitate investigation of angle properties. These examples illustrate how mobile technologies seem to be a good fit for contextualising school mathematics.

Sawaya and Putnam (2015) proposed an integrated framework to help teachers design mobile learning activities for maths. The framework consisted of three issues to consider when designing learning tasks: (a) learning goals, (b) activity types and lastly (c) affordances of the technology in reference to what mobile devices offer to support mathematics learning. These technology affordances are not unique to mobile devices but it is the combination of these affordances in a single device that highlights the potential of mobile technologies in supporting various learning activities. A representation of the framework is shown in Figure 1.

Systematic reviews of mobile learning in mathematics have shown an increasing interest in the use of tablet devices in schools (Crompton & Burke, 2016; Fabian, Topping, & Barron, 2016). These studies reported that the majority of mobile learning studies found positive results, typically in the form of evaluation surveys or through an experimental pre-test post-test evaluation of student achievement. A meta-analysis of studies that looked into student achievement have found that using mobile devices for mathematics had a medium effect (Fabian et al., 2016). However, while these results evidence the learning that occurred, these numbers do not communicate the sort of engagement that happens in the classroom.
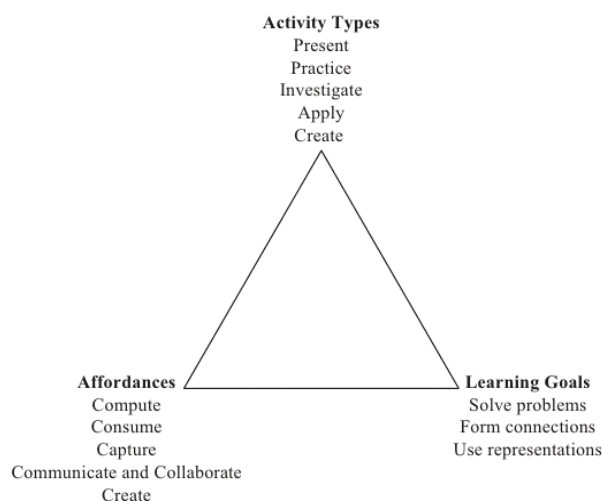
Figure 1: **Framework for the design of mlearning activities for mathematics (Sawaya & Putnam, 2015)**

Other positive outcomes reported in systematic reviews refer to positive student attitudes towards the use of mobile devices in maths, typically measured using a Likert-type survey (*ie* Did you find the activity fun?). Studies that focus on how the mobile technologies have engaged students are few and mostly short-term evaluations (Baya'a & Daher, 2010; Shih, Kuo & Liu, 2012). In response to this gap, the current study focuses on the evaluation of student engagement in mobile learning activities, drawing a focus on the breakdowns and breakthroughs of using mobile devices for learning mathematics.

The field of mobile learning is relatively new and its potentials and issues related to school use are still being mapped out. Sharples (2009) argued that "there is a need to understand what distinguishes mobile learning from classroom learning or learning with desktop computers (p.18)." Some examples of the distinctive aspects of mobile learning include mobility, portability and its capacity to support both formal and informal learning environments. Adopting new technologies in the classroom provides an array of possibilities but the practice of introducing new technology in the classroom is not without challenge. It was the goal of this study to identify issues in using mobile technologies for maths learning as well as identify advantages afforded by mobile technology use.

Methodology

Twenty-four Primary 7 students participated in mobile-supported constructivist learning activities that covered topics on geometry and information handling. Participation was voluntary. The teacher participant for this study is a female teacher with five years of teaching experience. The student participants (12 boys, 12girls), aged between 10-11 years old were the Primary 7 students assigned to the teacher participant of this study.

The programme consisted of eight mobile learning sessions conducted over a period of 3 months. The activities included topics on geometry and information handling and were all conducted in paired or group settings. Table 1 provides an indication of the mobile learning activities carried out. The activities were recorded and later analysed using critical incident analysis to identify the breakdowns and breakthroughs of the learning activities. Breakthroughs refer to the "observable critical incidents which appear to be initiating productive new forms of learning or important

conceptual change" and breakdowns are "observable critical incidents where a learner is struggling with the technology, is asking for help, or appears to be labouring under a clear misunderstanding (Vavoula & Sharples, 2009, p. 56)."

Table 1: Activities carried out

Session	Mobile Learning Activity	Activity Type
Session 1 - Symmetry (Phase 1)	Students took pictures of symmetrical objects and annotated it with its line of symmetry. Using an application, they also created symmetrical pictures of non-symmetrical objects in their environment.	Practicing math skills; Investigating; Creating content
Session 2 - Area and Perimeter (Phase 1)	Students investigated area and perimeter of surrounding environment using an application. They also investigated properties of area and perimeter of objects using a manipulative.	Practicing math skills; Investigating; Applying mathematical problems
Session 3 - Information Handling (Phase 1)	Students administered surveys on the mobile device. After which they interpreted the data collected and shared these findings with the class.	Investigating; Applying mathematical problems; Creating content
Session 4 - Angles (Phase 1)	Tasks were encoded in QR codes. Students took pictures of objects that corresponds to certain types of angles. They annotated the pictures to show the angle and its' estimated angle measurement.	Practicing math skills; Investigating; Applying mathematical problems; Creating content
Session 5 - Angles (Phase 2)	Using a scavenger hunt theme, students took picture of objects which were man-made and natural angles.	Practicing math skills; Investigating; Applying mathematical problems; Creating content
Session 6 - Symmetry (Phase 2)	Following a scavenger hunt theme, students looked for specific symmetrical objects from their environment.	Practicing math skills; Investigating; Creating content
Session 7 - Area and Perimeter (Phase 2)	Students took pictures of objects and annotated them with their area and perimeter. They then tagged the actual object with this information to create augmented realities.	Practicing math skills; Investigating; Applying mathematical problems
Session 8 - Information Handling (Phase 2)	Students used the phone sensors to gather data from their environment. Data were encoded and analysed collectively.	Investigating; Applying mathematical problems Creating content

Results

Using critical incident analysis, a total of eight breakthroughs (23 occurrences) and 21 different breakdowns (53 occurrences) were identified. Admittedly, there were fewer breakthroughs identified because the focus of the incident analysis was to identify issues within this pilot study. In addition, the wearable camera was worn by the researcher who was also providing the technical support and as such, capturing more of the technical issues that happened as opposed to capturing how the rest of the class was engaging with the activities.

Breakdowns of mobile learning

The breakdowns were categorised into three headings: technical, social and activity design issues. Technical issues refer to problems with the use of the tablet like application stability, responsiveness and network connectivity. Activity design issues refer to problems caused by the learning activity (for example, students not being clear about what to do next or students not having a good grasp of the topic covered). Social issues relate to problems that are related to the social layer of the activity (like collaboration and participation in the activity). There were 10 distinct technical issues, nine activity design issues and two social issues identified. For a list of the breakdowns identified, refer to Table 2.

Table 2: List of breakdowns

Breakdowns	No. of Occurrences	Category
Tablets were not charged	3	Technical
It was not possible to check on students' work remotely	1	Technical
Stability of the applications being used	5	Technical
Access to applications	3	Technical
Difficulty in handling the tablets with the cases	1	Technical
Network connectivity issues	3	Technical
Visibility of the screen in outdoor conditions	2	Technical
The measurement given by the tablet was not accurate	2	Technical
There was no way to verify the app measurement	1	Technical
In a collaborative worksheet, it was not possible to track student input	1	Technical
Too many handouts confuse the students	1	Activity design
Students were not clear about what to do	7	Activity design
Students were not clear about the meaning of some words used and the symbols used in the application	2	Activity design
Some students did not have a good grasp of the topic.	5	Activity design
Students were not sure how to use the application	3	Activity design
Students used the tablets for non-activity related tasks	1	Activity design
Weather conditions were not suitable for the activity	3	Activity design
Students did not finish on time	2	Activity design
Students get tired of repetitively switching between applications	1	Activity design
Students did not participate in the activity.	3	Social
Students did not collaborate.	3	Social

There were far more technical issues identified in the first activity than in the succeeding activities which shows that although students were already familiar with the use of the tablets, the transition to using these devices for learning activities still required some training. It is also possible that fewer issues were identified in the succeeding sessions because students have learned to troubleshoot the issues themselves, as was seen in some footages where more tech-savvy students helped other students encountering technical problems. This observation was also noted by the teacher in the interview---that students were initially worried about all the technical glitches but have adapted over time.

The most common technical issue is the stability of applications being used and this problem has impacted students work. When the tablets or the application malfunctions, students work were not always recovered and would require students to re-do the work. As one student phrased it:

> "If it doesn't work then all that you've done is gone unlike when you're working with paper. If you've got sheets there will always be spares but with tablets, you don't… so you do it again, then you get bored of it."

This issue is problematic particularly for activities that require data gathering as the instability of the tablet could make students lose a significant amount of work. For activities that are chunked into several steps, while this is still an issue, its effect is not as much as that only require going back a few steps.

The most common activity design issue is that students were not clear what to do next (n=7). There were several instances where the students started working on the tablet but end up not being clear about the task and this required an intervention from the teacher to get the class's attention and pause for a while so that the teacher could walk them through the task that they needed to do. This problem typically occurred when students used several applications in one session. For example, in session 1, there were two activities and two different applications used. Students were given an orientation on what they needed to do at the start of the session. They went on to do the first task with one application but got confused with what they had to do next because it required a different application.

Another common issue refers to students' grasp of the topic (n=5). In some instances, students appeared to lack the foundation to be able to work on the activity. For example, in the symmetry activity, although the concepts were covered before the activity, some students were not clear what symmetry was. Although this is a breakdown, because the teacher could observe what the students were doing, this breakdown was resolved by a brief explanation from the teacher, clarifying what is symmetrical and what isn't.

In the outdoor setup, the weather was a contributing factor in the implementation of the activity (n=3). For example, during the area and perimeter session outdoors (Session 7), the weather condition started satisfactory but towards the middle of the lesson, it started to drizzle and thus affected the screen sensitivity of the tablet. This illustrated the need for contingency plans should the weather not be permitting.

There were two issues in the social layer: students not participating in the activity and students not collaborating. Both categories related to student disengagement. In the first issue, students were not participating because of difficulties they encountered in the activity. For example, one student did not complete the activity because the technical difficulty she encountered required that she had to do the activity again. In the second issue, there were cases where students were observed not to be collaborating probably because they were not the ones operating the tablet. Both categories can be argued to be a result of failings of the technology and a shortcoming in the design of the activity.

Breakthroughs of mobile learning

Several breakthroughs were also observed throughout the mobile learning activities. One of the observed advantages of using mobile technologies is that they facilitate contextual learning. For example, in Session 3, the students designed a survey using an application which they later administered in class. Afterwards, they analysed the results using the generated bar graphs from the survey. The process of data collection can be said to add depth to the usual textbook exercise of

analysing presented bar graphs. In this exercise, they were not just presented with the data but as they administered the survey, they were also seeing how the survey was being populated.

Another advantage is that it facilitates visualisation of abstract math concepts, thus facilitating the link between abstract math concepts and its concrete representation in the environment. For example, in the angles learning activity, students adjusted the object in their environment to fit the properties that they needed.

The activities were set up as paired or group activities and this allowed students the chance to work collaboratively using the tablets. Collaboration is not limited to the learning activity but also evident in students working together to overcome a technical difficulty. Some students have acted as technical helpers and helped other groups without being asked to do so.

Another advantage of these activities is their capacities to promote active learning environments. The activities provided in the session are all hands-on activities which have been mostly received positively, technical breakdowns aside. The breakthroughs discussed in this section match the potential benefits of mobile learning. The mobile learning activities facilitated active networked learning, but also facilitated visualisation of math concepts as students matched the abstract math concepts with their concrete representations.

Discussion

A critical incident analysis identified technical, social and activity design issues in the mobile learning activities. The technical difficulties of the mobile learning sessions included issues with the battery, stability of the application, accuracy of the measures given by application, and network connectivity. The activity design issues included problems with the content and student background knowledge. The social issues included problems with collaboration and students' adaptability. These problems are not new and has been covered by previous math and mobile learning literature (Kalloo & Mohan, 2011; Wijers, Jonker, & Drijvers, 2010).

The effects of the technical problems in the activity varied. When only a portion of the activity was lost due to the unresponsiveness of the application, students quickly recovered from the problem. When it happened towards the end, with the majority of work being lost, this left some students frustrated. Students tolerated the technical issues up to a point. Students who had encountered several technical issues had mixed views about the use of mobile technologies and these views consequently affected their behavioural engagement. Some students persisted while there were those who became disengaged from the activity. This links back to the technology acceptance model that suggests that there should be a balance of usability and utility (Davis, 1989).

The non-technical issues related to the activity were more difficult to troubleshoot because these were mostly issues related to students' skills and the design of the activities. For example, when students did not have a good grasp of the topic, this meant that the teacher had to quickly go over the maths lesson with the whole class. In this case, it occupied some of the time for the activity. The other option was for the teacher to support the struggling student, and in that case, the teacher became temporarily unavailable to support the rest of the class. Both situations called for a re-think of the design of the learning activity.

The problem was partly caused by bringing in the technology without fully considering the learners and partly by not having fully considered the different scenarios that could go wrong in the classroom. The lesson plans were linear, restrictive and time-bound and did not allow much flexibility in terms of carrying out the lesson. Other mobile learning studies, particularly those carried out outside the classroom environment identified the need for careful planning of scenarios and flow of activities (Spikol & Eliasson, 2010). This then leads to the concept of classroom orchestration, "the methods and strategies empowered by a technology equipped classroom that an educator may adopt carefully to engage students in activities conducive to learning" (Chan, 2013, p. 515). This highlights the important role of the teacher, their flexibility and adaptability to carry out novel use of technology.

One of the advantages of using mobile devices is the range of activities they are able to support in a single device. While the activities could have been delivered in the same way without a mobile device, the mobile device in these instances allowed students to create artefacts which they shared with the rest of the class at the end of the activity. The artefacts also served as records of how abstract maths was situated in the environment. In addition, the mobile devices facilitated the activities as students moved in and out of the different learning spaces, from gathering artefacts "in the wild" and creating new content as they annotated the artefacts they had gathered, to sharing these new artefacts with other members of the class.

These observed breakthroughs tally with the students' perceived advantages of mobile learning for math: facilitate visualisation of abstract math concepts as well as engagement in fun and active learning activities that use technology. There was also the benefit of allowing personalisation, ownership of learning and improved student engagement, as the teacher suggested. These tangible benefits map well into Cochrane's (2010) potential benefits of mobile learning: facilitating learning across contexts, facilitating contextual learning, and providing personalisation in both personal and collaborative environments.

The mobility offered by the technology facilitated learning as students moved in and out of different learning spaces, investigating math properties within their environment. The process of finding concrete representations of abstract math within the environment facilitated a personal learning environment as the students worked on their own devices.

Conclusion

This study evaluated the breakdowns and breakthroughs of using mobile devices for learning mathematics in learning activities that transitioned between the indoor and outdoor environment. It has identified technical, activity design and social issues involved in implementing tablet use in a primary school setting. Some of the issues identified could have been avoided through a more careful orchestration of the learning activity. This points back to the important role that teachers play in designing and carrying out novel technology use. In the activities carried out, there was a shift in the teacher's role and responsibility, from the person guiding and stimulating discussion to that of a "curator—a collector, organiser and guarantor of educational opportunities (Crompton & Traxler, 2015, p. 230)". As such, it would be worthwhile addressing how teachers are being trained to target issues surrounding orchestration in addition to training on the use of new technologies..

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