Mobile Technologies in the Primary Mathematics Classroom: Engaging or Not?

Catherine Attard

Abstract Many schools invest in mobile technologies or actively promote their use through Bring Your Own Device (BYOD) programs with the expectation that the use of such devices will improve student engagement and, as a result, improve student learning outcomes. However, there is little research to date that explores teacher and student perceptions of whether and how the use of mobile technologies within mathematics classrooms does indeed improve engagement with mathematics. This chapter draws on data from a small range of research projects investigating the use of mobile technologies and associated applications in the primary mathematics classroom. It uses a multidimensional view of engagement and the Framework for Engagement with Mathematics as a lens to re-analyse existing and new data. Issues relating to engagement and the use of mobile technologies will be explored within the context of classrooms where students and many of their teachers are now considered to be 'digital natives', and Information and Communication Technologies are an integral and ubiquitous part of their daily lives.

Keywords Student engagement · Mobile devices · iPads · Mathematics Primary

Introduction

Over the past decade, the range of mobile devices in contemporary classrooms have fast become the standard learning tools, replacing the once prominent desktop computer (Meletiou-Mavrotheris, Mavrou, & Paparistodemou, 2015). Mobile technologies are "ubiquitous in nature, highly portable and endowed with multimedia capabilities offering a new dimension to curriculum, making learning

C. Attard (✉)
Centre for Educational Research, Western Sydney University, Sydney, Australia
e-mail: C.Attard@westernsydney.edu.au

N. Calder et al. (eds.), *Using Mobile Technologies in the Teaching and Learning of Mathematics*, Mathematics Education in the Digital Era 12,
https://doi.org/10.1007/978-3-319-90179-4_4

accessible ‘anywhere, anytime’” (Handal, Campbell, Cavanagh, & Petocz 2016, p. 200). An illustration of this phenomenon is evidenced in the increase in popularity of computer tablets. The Apple iPad, for example, quickly became one of the most popular devices in schools when it was released in 2011 alongside smartphones and other mobile devices.

The relatively low cost and the vast range of affordances offered by mobile devices has made them attractive to schools. Devices are often purchased in the hope of improving student engagement, leading to improved learning outcomes. This is based upon the assumption that when students are deeply engaged with tasks, they are more likely to develop positive attitudes. Positive attitudes are more likely to promote learning. Expectations that students would be more engaged when using such technologies, and eventually resulting in improved learning outcomes are reflected widely in literature (e.g., Beavis, Muspratt, & Thompson, 2015; Bray & Tangney, 2015; Ke, 2008, as cited in Chang, Evans, Kim, Norton, & Samur, 2015; Pierce & Ball, 2009). There is also an emerging body of literature from studies that have shown students are, in fact, more engaged with mathematics as a result of experiencing the use of mobile technologies in their mathematics lessons (Attard & Curry, 2012; Bray & Tangney 2015; Hilton, 2016; Ingram, Williamson-Leadley, & Pratt, 2016: Muir & Geiger, 2016).

Although we have emerging evidence that students are more engaged, there is a gap in the literature that explores student engagement on a deeper level to investigate what specific aspects and uses of mobile devices do, in fact, improve student engagement. Is it the device itself, the use of specific types of applications (apps), or is it the pedagogical practices of the teacher? Are students engaged simply because of the novelty of devices or activities that are introduced?

This chapter explores more deeply what it is to be engaged with technology within the primary mathematics classroom using the Framework for Engagement with Mathematics (FEM) (Attard, 2014), as a theoretical lens. First, a definition of engagement will be provided before the FEM is introduced. Next, to contextualise the discussion a brief exploration of literature pertaining to how mobile technology is being used in mathematics classrooms is provided. Examples of mobile technology use from three studies conducted in Australian primary classrooms will then be aligned to the FEM using voices from the classroom to explore how mobile technologies may or may not lead to engagement with mathematics.

Theorising Engagement

Within an educational context, the construct of engagement can be characterised as meaningful participation in a context where knowledge and learning are valued and used. An important element of this level of engagement is the maintenance of interpersonal relationships and identities within the classroom community, in addition to positive interactions within the environments in which the individual has significant personal investment (Hickey, 2003). Consistent with this socio-cultural view of engagement is the definition provided by Fredricks, Blumenfeld and Paris (2004), who define engagement as a deeper student relationship with classroom work, multi-faceted and operating at cognitive, affective and behavioural levels. It is argued that viewing engagement as the combination of behaviour, emotion and cognition provides a characterisation of children that is much more valuable than researching individual components. It is this view that informs the multidimensional view of engagement for this chapter. Engagement is the coming together of cognitive, operative, and affective facets (Fair Go Team NSW Department of Education and Training, 2006; Munns & Martins, 2005), leading to students valuing and enjoying school mathematics, and seeing connections between school mathematics and their own lives.

In this definition, engagement includes individual thoughts that are projected outwards in terms of a person's investment and effort towards learning, as well as those relational behaviours that occur within the mathematics classroom (Attard, 2014). This definition forms the theoretical foundation for the FEM (Fig. 1), introduced by Attard (2014) as a tool devised to assist teachers in planning engaging learning experiences in mathematics. The FEM is used in this chapter as a

FRAMEWORK FOR ENGAGEMENT WITH MATHEMATICS

In an engaging mathematics classroom, positive pedagogical relationships exist where:

- students' **backgrounds** and pre-existing knowledge are acknowledged and contribute to the learning of others;
- the teacher is **aware** of each student's mathematical abilities and learning needs;
- **interaction** amongst students and between teacher and students is continuous;
- the teacher models **enthusiasm** and an enjoyment of mathematics and has a strong **pedagogical content knowledge; and**
- **feedback** to students is constructive, purposeful and timely.

In an engaging mathematics classroom, engaging pedagogical repertoires mean:

- there is **substantive conversation** about mathematical concepts and their applications to life;
- tasks are positive, provide opportunity for all students to achieve a level of **success** and are **challenging** for all;
- students are provided an element of **choice;**
- technology is embedded and used to enhance mathematical understanding through a **student-centred** approach to learning;
- the **relevance** of the mathematics curriculum is explicitly linked to students' lives outside the classroom and empowers students with the capacity to transform and reform their lives; and
- mathematics lessons regularly include a **variety** of tasks that cater to the diverse needs of learners.

Students are engaged with mathematics when:

- mathematics is a subject they enjoy learning,
- they value mathematics learning and see its relevance in their current and future lives, and
- they see connections between the mathematics learnt at school and the mathematics used beyond the classroom.

Fig. 1 The Framework for engagement with mathematics (Attard, 2014) lens to assist in determining how the use of mobile technologies assists in increasing (or decreasing) students' engagement with mathematics.

The framework was derived as part of a qualitative, longitudinal study of the influences on student engagement during the middle years of schooling (Grades 5–8 in Australia) (Attard, 2014). The FEM emerged as an outcome of the research and an ongoing review of literature. Importantly, the framework takes student voice seriously in its consideration of what engages learners in mathematics classrooms, hence student voice features in this chapter. Although this study overwhelmingly indicated the teacher was the strongest influence on these students' engagement, this influence is complex, consisting of two separate, yet inter-related elements: pedagogical relationships and pedagogical repertoires. For the purpose of the FEM, pedagogical relationships refer to the interpersonal teaching and learning relationships between teachers and students that optimise the learning of and engagement with mathematics. Pedagogical repertoires refer to the day-to-day teaching practices employed by the teacher.

Pedagogical repertoires, as referred to in the FEM, assume aspects of more traditionally recognised frameworks and constructs such as Shulman's pedagogical content knowledge (1986), technological pedagogical content knowledge (Koehler & Mishra, 2009) and mathematical knowledge for teaching as described by Hill, Ball and Schilling (2008). However, they also encompass non-content specific practices that have been found to directly influence student engagement with mathematics such as opportunities for substantive conversation, provision of choice, and task variety.

It is suggested that it is difficult for students to engage with mathematics without a foundation of strong pedagogical relationships. It can also be argued that it is through engaging pedagogies such as the effective use of mobile technologies, that positive pedagogical relationships are developed, highlighting the connections between pedagogical relationships and engaging pedagogical repertoires. Although technology is specifically mentioned in only one statement within the FEM, in this chapter the framework is applied to the way technology is embedded in teaching and learning: the pedagogical relationships that inform the use of technology, and the pedagogical repertoires that embed technology.

Just as there are a range of influences on student engagement with mathematics through the use of mobile technologies, there are also a range of influences on how teachers use or envisage the use of these technologies.

How Are Teachers Using Mobile Technologies in Primary Mathematics Classrooms?

One of the biggest benefits of mobile technologies is the wide range of affordances available to teachers and students. One mobile device can give a student a tool to access all the processes and contents from the mathematics curriculum, through tasks that range from low level, fluency building activities to tasks that require the student to analyse, evaluate and create. Unlike a traditional text book, mobile devices provide opportunities for interaction in many different formats such as individual or collaborative gamification of activities. They also allow for various software applications to be used simultaneously. One example of this is the ability to capture audio and written work, allowing students to show and explain the solution to a mathematical problem. Another example, is the dynamic and instantaneous response to input the mobile technologies afford (Calder & Campbell, 2016). The range of affordances has resulted in a wide variety of ways that these technologies are being implemented in primary mathematics classrooms.

Arguably a one device per student (1:1) program is the ultimate resourcing goal of many schools. However, this is not the reality in many classrooms. Although mobile devices are more cost effective than the traditional desktop computers, few schools can afford to purchase one device per student, and many are reluctant to enforce a mandate that all students purchase a specific device. To combat the financial burden, schools are beginning to change direction in relation to the purchase of devices, and rather than providing or prescribing a specific device for students, 'Bring Your Own Device' (BYOD) programs, where a range of devices and platforms are used and students provide their own devices, are gaining momentum (Cristol & Gimbert, 2014; Hu & Garimella, 2014).

This change brings about further significant challenges for teachers, particularly in the area of mathematics. Many teachers find it challenging to design technology integrated tasks that move beyond requiring students to act as consumers, through the use of drill and practice (apps) that build fluency, to producing, authoring and problem solving through the use of more generic productivity apps (Attard, 2013; Zhang, Trussell, Gallegos, & Asam, 2015). Issues beginning to emerge in classrooms relate to the range of devices and operating platforms being used at any one time, and often, the disparity that develops when the number of devices brought to school is inconsistent from one day to the next. However, allowing students to bring their own devices to school does have the potential to promote engagement by enhancing the links between students' home lives and school.

Regardless of whether students bring their own devices or have devices supplied by schools, their incorporation into mathematics learning varies widely from, for example, teachers using one device per group of students, one per student within a group, or whole class, 1:1 use. These variations alone can influence student engagement, particularly if the devices are shared. Even more influential on student engagement is the software, or apps, and the way they are used in mathematics lessons. Tasks can use targeted, mathematics-based apps, or they can use productivity apps such as *Explain Everything* or perhaps the generic inbuilt apps such as a still or video camera. Other options include accessing subscription-based apps or programs that include a wide range of activities and allow the teacher to track student achievement such as *Mathletics, Maths Online* or *Matific*.

Mobile technologies lend themselves well to game playing and often this is the default pedagogy. Given that almost all young people are actively involved in game playing in either a concrete or digital form, it makes sense to expect that some use of digital games in education could assist in increasing student engagement with content such as mathematics, that may otherwise feel irrelevant to students' everyday lives. The use of digital games could also assist in bridging the digital divide between how ICT is used at home and at school, as described by Selwyn, Potter and Cranmer (2009).

The terms 'game based learning' (GBL) and 'gamification' have begun to appear regularly in academic literature. GBL, defined as the use of video games for educational purposes (Kingsley & Grabner-Hagen, 2015), has been shown in some research to enhance motivation towards learning and academic performance. One concept stemming from GBL is gamification, which as Goehle and Wagaman (2016) suggest, is a natural fit for education. Interestingly, there are several interpretations of the definition of gamification, which is generally suggested to be the use of game design elements within a non-game context (Brigham, 2015). A teacher might gamify an activity or the teaching of a particular concept by adding achievement badges, rewards and levels in an attempt to increase student engagement (Goehle & Wagaman, 2016; Kingsley & Grabner-Hagen, 2015). The purpose of gamification within education is the use of game elements such as rewards and game-like activities to promote learning and engage and motivate students.

Regardless of what affordances are being utilised, if we consider the FEM, student engagement is tied closely to the pedagogical relationships and pedagogical practices within the classroom. However, the OECD claim that "we have not yet become good enough at the kind of pedagogies that make the most of technology … adding 21st century technology to 20th-century teaching practices will just dilute the effectiveness of teaching" (2015, p. 3). So how do teachers use emerging mobile technologies and adapt their pedagogies effectively in the teaching of primary mathematics? The following provides a brief description of the three studies used in this chapter to illustrate engaging (or disengaging) practices.

The Studies

This chapter draws from data derived from three separate studies. Data from the first two studies have been presented elsewhere, but are re-purposed in this chapter for analysis against the FEM.

Study 1

This study was an exploratory case study that took place in the early days of iPad integration in schools. The study explored one primary mathematics classroom and sought to understand how iPads were introduced into teaching and learning in a Grade 3 context. Further detail of the methodology involved have been reported in Attard and Curry (2012) and Attard (2015).

Study 2

Study 2 was a multiple case study that investigated the pedagogies of four classroom teachers within their first six months of iPad integration. The teachers were situated at the same school and data was gathered from students and teachers in Kindergarten, Grade 2, Grade 4 and Grade 6. Further detail of this methodology has been reported in Attard (2013).

Study 3

Study 3 was a multiple case study involving 16 teachers and their students from eight schools across New South Wales. This study investigated whether the use of a subscription based program, *Matific*, would improve student engagement with mathematics. *Matific* is a range of digital mathematics resources that are game-based applications, available to students on any device or operating platform. Participants in this study used a range of devices that included desktop computers, laptops and iPads. A more detailed methodology is found in Attard (2016).

All three studies used qualitative methods that included student focus group discussions and individual teacher interviews. Studies 1 and 2 also incorporated classroom observations. Study 3 included data from pre- and post-tests. Some data from Studies 1 and 2 have been presented elsewhere. However, for the purpose of this chapter they have been re-analysed for alignment with the FEM which is now presented. Each element of the FEM is presented and aligned with data derived from the three studies and existing literature as an alternate way of considering how the use of mobile technologies can contribute towards improving student engagement with mathematics.

Mobile Technology to Enhance Pedagogical Relationships

Pedagogical relationships form the foundation for deep student engagement with mathematics. The following is a brief discussion of how each of the elements of the FEM have been evidenced in the three studies.

Students' Backgrounds and Pre-existing Knowledge Are Acknowledged and Contribute to the Learning of Others

Technology enhanced tasks that are open-ended and provide opportunities for students to apply pre-existing knowledge for the benefit of other students have been evidenced. An example of one such task was observed in Study 2, in a Grade 5 classroom. The task required students to plan an itinerary and budget for a 'big day out' in the city. The students were to include the use of public transport and a trip to the cinema in their plans. Each group of three students were provided with an iPad that was used to access a range of apps relating to public transport timetables, trip planners and movie timetables. Although this task could have been conducted using standard computers and the Internet, the mobility and ubiquitous access provided by the iPads allowed the students to focus more on the mathematics embedded within the task and it promoted collaboration and discussion. The open-ended nature of the task and the real-life context allowed students to draw on personal experience and resulted in high cognitive, affective and operative engagement. This comment was typical of what was heard amongst the groups of students: "I thought about it and showed them and Luke said I should get this train because I'll have more time" (Grade 5 student, Study 2).

The Teacher Is Aware of Each Student's Mathematical Abilities and Learning Needs

One of the affordances in the Matific suite of resources was the ability to allocate specific episodes for lesson time and homework to each student according to the identified need. Students were then able to access these tasks from any device at any time, using their login details. Although only seven out of the 16 teachers in this study utilised this affordance, it made a significant difference to their students' engagement with mathematics. One teacher who did differentiate the tasks talked about how she planned its use and how her strategy engaged her students in the following comment:

> *…we started off with the pre-test and I gave them feedback immediately afterwards and I had explained to them that I had grouped them so they knew they were grouped based on the pre-test. The kids were really aware of their goal for (the topic of) 'time' so because they were aware of their goal for time and because they knew that it was linked with Matific and the activities there they were conscious of their learning more…They loved having those goals and they knew that it was related to the Matific game that I had assigned to them (Grade 3/4 teacher, Study 3).*

The teachers felt that the ability to differentiate the tasks allowed their students to build confidence and ability with appropriately levelled episodes, while not appearing to be different from their more advanced peers:

> *It was perfect in a sense that we made it a point that we started at the middle and we went down for those who needed extra support, which was fabulous because they were still doing it visually, they were doing the exact same thing, and then we also gave the option that they could go up if they felt confident enough but at the same time visually, it was exactly the same for those kids that don't want to be different, that maybe do need that little bit of extra support (Grade 6 teacher, Study 3).*

Being able to experience success is an important element of student engagement, and plays a significant role in building confidence and developing a positive attitude towards mathematics.

Interaction Amongst Students and Between Teacher and Students Is Continuous

A common argument against the use of 1:1 device programs is the perception that opportunities for interaction are diminished. However, there is evidence that when embedded in strong pedagogical practices, the use of mobile devices can promote important mathematical discussion. This was evident in all three studies where there was a mixture of 1:1 implementation and shared devices.

In Studies 1 and 2, students were provided with opportunities to share the work they had completed either individually or in pairs (predominantly using productivity apps such as *Show Me* or *Explain Everything*) with their peers through the use of an interactive whiteboard (IWB). The purpose of this was to reflect on learning as well as to receive constructive feedback from peers. In Study 3, there were several instances where the structure of the software in relation to the rewards system (to be discussed later) promoted discussion and collaboration despite students working on individual devices. The teachers believed the resources promoted mathematical discussion, perseverance, and 'collective encouragement', saying: "They would challenge themselves but also challenge each other, it was very good" (Grade 6 teacher, Study 3).

The Teacher Models Enthusiasm and an Enjoyment of Mathematics and Has a Strong Pedagogical Content Knowledge

This section will focus on the second part of the above statement, the teachers' pedagogical content knowledge (PCK). In all three studies, PCK significantly influenced the success of mobile technology use. In Study 1, the teacher (with less than one year of experience), openly admitted his current depth of PCK limited his ability to incorporate iPads into mathematics lessons. "I could teach other things so well but my maths is always—like I have had to learn two things" (Grade 3 teacher, Study 1). In Study 2, there were several examples where PCK influenced students' learning. In a lesson on area using the *Doodle Buddy* app, students' questions took an unanticipated direction, and the teacher was unable to explain how to multiply decimal fractions even though this was a concept that appears within the primary mathematics curriculum. Conversely, in a Grade 4 classroom, the teacher used her

PCK to craft an effective lesson that used a drill and practice app to analyse student errors 'in the moment' and provide timely intervention (see Attard 2013 for a full description).

Feedback to Students Is Constructive, Purposeful and Timely

Although it is feedback from teachers that is an important foundation for the development of positive pedagogical relationships, feedback derived from the use of technology can contribute to engagement. One of the most significant affordances of using mobile technologies is the provision of immediate feedback when using consumable apps such as mathematics games. Not surprisingly, this affordance featured heavily in all three studies and is considered a major contributor to the increase in student engagement when using these devices. The following are representative quotes from all three studies: "… it makes me happy because if you touch it and you make a mistake it just like takes it away … if it's on the iPad you can just go oh, that's wrong and you can take it away" (Grade 3 Student, Study 1). "… it's a lot quicker instead of just asking to go to the teacher and look at the answers" (Grade 4 student, Study 2). In Study 3, the immediate feedback was more than just an indication of a correct or incorrect answer: "Well it would like tell me it's wrong, and then it would like give an example and stuff like that, and I would try again on a different one." (Grade 6 student, Study 3).

The teachers also recognised the power of immediate feedback in terms of improving engagement: "It was very, very engaging for the kids. They found it—and I found it as well—they were learning from their mistakes based on the feedback that they were getting instantly from the program itself which was really good" (Grade 6 teacher, Study 3).

Pedagogical Repertoires that Include Mobile Technologies

It is when strong pedagogical relationships are developed that a teacher's pedagogical repertoire becomes more influential in improving and maintaining engagement. There are strong connections between and amongst the elements of the FEM, and many of the affordances described above and below address several elements of the framework. There are also some elements that relate entirely to the teacher's pedagogical decisions rather than the technology use, so to retain the focus of this chapter and to avoid repetition, select elements that pertain directly to the use of mobile technologies are presented below.

There Is Substantive Conversation About Mathematical Concepts and Their Applications to Life

The first element of pedagogical repertoires is one such example that links closely to the need for continuous interaction. As discussed already, creative use of mobile technology promotes mathematical discussion. Tasks that required students to investigate real-life contexts such as the ‘big day out’ task in Study 2 allowed students to see the application of mathematics to day-to-day living. Substantive conversations about mathematics were also promoted in Study 2 when the Grade 4 teacher used iPads to photograph mathematics outside the classroom. The students photographed each other as they measured various items around the school. The teacher then used the photographs they had taken in their next mathematics lesson as a focus for discussions on measurement. Another example was a Grade 5 lesson where students conducted a comparison of virtual dice and real dice. This provided a foundation for discussions of probability in real-life situations.

Tasks Are Positive, Provide Opportunity for All Students to Achieve a Level of Success and Are Challenging for All

The *Matific* resources used in Study 3 were particularly effective in providing all students with the opportunity to achieve success while being challenged. Along with the ability to assign different tasks to different students, each episode, consisting of five questions, was carefully structured. The level of difficulty of each question increased gradually to ensure students were appropriately challenged. In addition, students were provided with scaffolding when answers were incorrect. This was a major benefit of the software that the students were very aware of and which, according to them, helped them learn. Students as young as Grade 2 noticed this:

> *...pretty much the best thing about Matific is because the last ones are pretty hard and it can teach you things. Like the first one gets you started with it the second one can make you like, can be a tiny bit tricky, and then the middle one is easy and hard, and then it goes quite hard. So the good thing is it is quite hard and they can teach you more (Grade 2 student, Study 3).*

All students appeared to have been challenged as a result of the structure of the resources, as evidenced in this quote: “the degree of difficulty challenged even some of my top kids” (Grade 6 teacher, Study 3). In this case, the high operative and cognitive engagement led to high affective engagement—students enjoyed and valued mathematics because they felt they were learning.

Technology Is Embedded and Used to Enhance Mathematical Understanding Through a Student-Centred Approach to Learning

The very nature of mobile devices has resulted in a more student-centred approach when compared to traditional devices such as desktop computers or interactive whiteboards, that are typically positioned at the front of the classroom and often perpetuate teacher-centred practices. The significant uptake of gamification caused by the use of mobile devices within mathematics lessons has resulted in improved student engagement when the games provide appropriate challenge and are accompanied by mathematical discussion, promoting high affective, cognitive and operative engagement.

Students in all three studies confirmed the use of games enhanced their engagement and made mathematics lessons fun, and the following quotes provide an example of how powerful this was: "Because they have games but all the games are educational, most of the time, and you can use games to help with different maths skills" (Grade 3 student, Study 1). The use of games promoted discussion when students in Kindergarten compared their progress, making comments like "look how far I've gone", and "I've gone further" and encouraging them to work harder. Likewise, in Study 3, the game element made learning fun and the associated rewards were a powerful motivator to work hard and understand the mathematical concepts: "I keep on practicing. I keep on doing it again" (Grade 6 student, Study 3).

The most significant benefit of the reward system within the *Matific* resources was that it provided motivation for students to continue working hard. The simple 'super awesome' statement that appeared for five correct answers promoted perseverance amongst almost all of the students in Study 3. They spoke about how they wanted to try harder when they got answers incorrect, in order to achieve a 'super awesome' status, with comments like this one being typical: "I kept on going back and back and I finally got five stars" (Grade 6 student, Study 3).

Although the use of games does generally engage students, caution should also be taken. In some instances, during Studies 1 and 2, games did not always improve engagement due to a mismatch between student ability and the content of the game; a mismatch between the content of the game and the purpose or mathematical goal of the lesson; or a lack of reflection or discussion following interaction with the game.

Mobile Technologies in the Primary Mathematics Classroom: Engaging or Not?

This chapter has provided a theoretical framework for engagement with mathematics and applied it to the use of mobile technologies in the primary classroom. In each of the studies explored here, there were similarities and differences between the depth of engagement. This was due to various factors, including the use of different software applications (with varied affordances), different levels of teacher confidence and experience, and the diverse ways in which the devices were used in terms of mathematical activities and the number and type of devices. There is little doubt that when used thoughtfully, mobile devices can improve engagement with mathematics, but it is more than just the device that makes the difference. Ultimately, it's the way they are used, the purpose for their use and the pedagogical practices that embed their use that determine how engaging they are.

The examples of engaging use of mobile technologies provided in this chapter give only one side of the story. There are also examples of mobile technology use that result in either no change, or a decrease in engagement. Often the disengaging uses are the result of poor pedagogical relationships or pedagogical practices that assume the devices alone (with no teacher input) will engage students and pedagogical content knowledge that requires further development. In addition, the distraction caused by logistical issues such as unreliable wifi access, or software and hardware malfunction, can lead to lowered levels of engagement and significant time wasting. Teachers need to be thoroughly prepared and have a strong awareness of the technological limitations within their individual contexts. This also includes having a thorough understanding of the affordances and limitations of the software applications they are using. However, it is important to focus on successful use of mobile technologies.

Finally, we must consider whether the use of mobile technologies is just a result of the novelty effect. Because mobile devices are developing so rapidly, there has been little time for longitudinal research to investigate whether the use of such devices result in sustained student engagement. However, for the moment, we can conclude that when used well, mobile technology does improve student engagement at operative, cognitive, and affective levels. As one seven-year-old student said: "So basically it is fun and you also get to learn stuff which is pretty good" (Grade 2 student, Study 3).

References

Attard, C. (2013). *Introducing iPads into primary mathematics pedagogies: An exploration of two teachers' experiences*. Paper Presented at the Mathematics Education: Yesterday, Today and Tomorrow (Proceedings of the 36th Annual Conference of the Mathematics Education Research Group of Australasia), Melbourne.

Attard, C. (2014). "I don't like it, I don't love it, but I do it and I don't mind": Introducing a framework for engagement with mathematics. *Curriculum Perspectives, 34*(3), 1–14.

Attard, C. (2015). Introducing iPads into primary mathematics classrooms: Teachers' experiences and pedagogies. In M. Meletiou-Mavrotheris, K. Mavrou, & E. Paparistodemou (Eds.), *Integrating touch enabled and mobile devices into contemporary mathematics education* (pp. 197–217). Hershey, PA: IGI Global.

Attard, C. (2016). *Research evaluation of matific mathematics learning resources: Project report*. Penrith, NSW: Western Sydney University. https://doi.org/10.4225/35/57f2f391015a4.

Attard, C., & Curry, C. (2012, July). *Exploring the use of iPads to engage young students with mathematics.* Paper presented at the Mathematics education: Expanding horizons, (Proceedings of the 35th Annual Conference of the Mathematics Education Research Group of Australasia) Singapore.

Beavis, C., Muspratt, S., & Thompson, R. (2015). 'Computer games can get your brain working': Student experience and perceptions of digital games in the classroom. *Learning, Media and Technology, 40*(1), 21–42.

Bray, A., & Tangney, B. (2015). Enhancing student engagement through the affordances of mobile technology: a 21st century learning perspective on realistic mathematics education. *Mathematics Education Research Journal, 28*(1), 173–197.

Brigham, T. J. (2015). An introduction to gamification: Adding game elements for engagement. *Medical References Services Quarterly, 34*(4), 471–480.

Calder, N. S., & Campbell, A. (2016). Using mathematical apps with reluctant learners. In: *Digital experiences in mathematics education*. https://doi.org/10.1007/s40751-016-0011-y.

Chang, M., Evans, M. A., Kim, S., Norton, A., & Samur, Y. (2015). Differential effects of learning games on mathematics proficiency. *Educational Media International, 52*(1), 47–57.

Cristol, D., & Gimbert, B. (2014). Academic achievement in BYOD classrooms. *Journal of Applied Learning Technology, 4*(1), 24–30.

Fair Go Team NSW Department of Education and Training. (2006). *School is for me: Pathways to student engagement*. Sydney: NSW Department of Education and Training.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–110.

Goehle, G., & Wagaman, J. (2016). The impact of gamification in web based homework. *Problems, Resources, and Issues in Mathematics Undergraduate Studies, 26*(6), 557–569.

Handal, B., Campbell, C., Cavanagh, M., & Petocz, P. (2016). Characterising the perceived value of mathematics educational apps in preservice teachers. *Mathematics Education Research Journal, 28*(1), 199–221.

Hickey, D. T. (2003). Engaged participation versus marginal nonparticipation: A stridently sociocultural approach to achievement motivation. *The Elementary School Journal, 103*(4), 401–429.

Hill, H. C., Ball, D. L., & Schilling, S. G. (2008). Unpacking pedagogical content knowledge: Conceptualising and measuring teachers' topic-specific knowledge of students. *Journal for Research in Mathematics Education, 39*(4), 372–400.

Hilton, A. (2016). Engaging primary school students in mathematics: Can iPads make a difference? *International Journal of Science and Mathematics Education*. https://doi.org/10.1007/s10763-016-9771-5.

Hu, H., & Garimella, U. (2014). iPads for STEM teachers: A case study on perceived usefulness, perceived proficiency, intention to adopt, and integration in K-12 instruction. *Journal of Educational Technology Development and Change, 7*(1), 49–66.

Ingram, N., Williamson-Leadley, S., & Pratt, K. (2016). Showing and telling: Using tablet technology to engage students in mathematics. *Mathematics Education Research Journal, 28*(1), 123–147.

Kingsley, T. L., & Grabner-Hagen, M. M. (2015). Gamification: Questing to integrate content knowledge, literacy, and 21st-century learning. *Journal of Adolescent and Adult Literacy, 59*(1), 51–61.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge?. *Contemporary Issues in Technology and Teacher Education, 9*(1), 60–70.

Meletiou-Mavrotheris, M., Mavrou, K., & Paparistodemou, E. (2015). *Preface Integrating touch-enabled and mobile devices into contemporary mathematics education* (pp. xx–xxvii). IGI Global, Hershey, PA.

Muir, T., & Geiger, V. (2016). The affordances of using a flipped classroom approach in the teaching of mathematics: A case study of a grade 10 mathematics class. *Mathematics Education Research Journal, 28*(1), 149–171.

Munns, G., & Martin, A. J. (2005). *It's all about MeE: A motivation and engagement framework*. Paper Presented at the Australian Association for Academic Research Focus Conference, Cairns. http://www.aare.edu.au/05pap/mun05400.pdf.

OECD. (2015). *Students, computers and learning: Making the connection*. Paris: pISA < OECD Publishing. https://doi.org/10.1787/9789264239555-en.

Pierce, R., & Ball, L. (2009). Perceptions that may affect teachers' intention to use technology in secondary mathematics classes. *Educational Studies in Mathematics, 71*(3), 299–317.

Selwyn, N., Potter, J., & Cranmer, S. (2009). Primary pupils' use of information and communication technologies at school and home. *British Journal of Educational Technology, 40*(5), 919–932.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *American Educational Research Journal, 15*(2), 4–14.

Zhang, M., Trussell, R., Gellegos, B., & Asam, R. (2015). Using math apps for improving student learning: An exploratory study in an inclusive fourth grade classroom. *TechTrends, 59*(2), 32–39.

Catherine Attard is an Associate Professor in primary mathematics education at Western Sydney University. She is a multiple award-winning educator who has transformed teaching and learning in primary mathematics at Western Sydney University for over 10 years. Catherine's research is focused on student engagement with mathematics and issues surrounding the pedagogical practices that influence students' engagement. Catherine is also actively researching contemporary teaching practices through the use of digital technologies, and the use of financial literacy education as a tool to engage children with mathematics. She has won several teaching awards, including a 2016 Australian Awards for University Teaching (AAUT) Teaching Excellence Award and an Office of Learning and Teaching citation for Outstanding Contributions to Student Learning.