# Exploring the Use of iPads to Engage Young Students with Mathematics

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One of the most significant influences on student engagement is the teacher's pedagogical practices, including the incorporation of technology into the teaching and learning of mathematics. This paper reports on a qualitative study investigating how the incorporation of iPads into a Year 3 primary classroom during a six month trial influenced teaching and learning practices and student engagement with mathematics. All of the students appear to have had a positive experience during the trial and the classroom teacher believed their engagement with mathematics had improved as a result. Although there were challenges involved in integrating the iPads into mathematics lessons, some teaching practices were adapted to accommodate the technology. The integration of the iPads highlighted the need for teacher professional development and the importance of developing strong Technological Pedagogical Content Knowledge.

## Introduction

It has been well documented that there is widespread concern over lowered levels of student engagement with mathematics during both primary and secondary schooling in Australia (see for example, Commonwealth of Australia, 2008; Sullivan & McDonough, 2007) and internationally (Boaler, 2009; Douglas Willms, Friesen, & Milton, 2009; McGee, Ward, Gibbons, & Harlow, 2003). One of the most significant influences on student engagement is the teacher's pedagogical practices, including the incorporation of technology into the teaching and learning of mathematics (Hayes, Mills, Christie, & Lingard, 2006; NSW Department of Education and Training, 2003). While there are many primary and secondary schools investing in a range of newer, more mobile technologies such as iPads and iPods, teachers are often expected to integrate the technologies into teaching and learning without the support of professional development, particularly in relation to using the technology to enhance teaching, learning and student engagement. To date there is little evidence of whether the implementation and integration of technologies such as iPads serve to improve student engagement with mathematics in the early years of primary schooling or how their integration influences teacher practices.

This paper reports on a study exploring how the introduction and incorporation of iPads into a Year 3 primary classroom affected one teacher's teaching and learning practices and his students' engagement with mathematics. The study was conducted under the umbrella of a larger study, the *Fair Go from the Get Go* project, investigating exemplary early career teachers and their engaging pedagogies. The theoretical framework underpinning this paper is based upon the technological pedagogical and content knowledge (TPACK) framework (Mishra & Koehler, 2006) and current definitions of student engagement. A brief overview of the literature is now provided.

## Technology and the Mathematics Classroom

The use of information and communication technologies (ICT) has the potential to change teaching and learning by acting as a source of knowledge, a medium for transmitting content and a resource that fosters dialogue and exploration (Levin & Wadmany, 2008).

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Mishra and Koehler (2006) argue that it is not enough to simply introduce technology to the educational process. In order for teachers to make the transition from a traditional mathematics teaching approach to one in which ICT plays an integral role, a commitment to learning how and when to use the technology is required (Goos & Bennison, 2008; Pierce & Ball, 2009). A framework that addresses what teachers need to know to successfully integrate technology into teaching and learning is TPACK (Mishra & Koehler, 2006), which builds on Shulman's pedagogical content knowledge (PCK) framework (1986).

Koehler and Mishra (2009), argue that there are three essential components at the heart of good teaching with technology: content, pedagogy, and technology. "The interactions between and among the three components, playing out differently across diverse contexts, account for the wide variations seen in the extent and quality of educational technology integration" (p. 62). When applied to the teaching and learning of mathematics, the TPACK framework extends beyond ways in which to use a specific tool and its operation to ways the technology can be used to improve teaching and learning (Guerrero, 2010).

Guerrero (2010), built on the original framework (Figure 1) by identifying four components that characterise TPACK in mathematics:

1. Conception and use of technology: this includes ways in which a teacher can conceptualise the use of specific technologies to support teaching and learning mathematics;
2. Technology-based mathematics instruction: this includes the teacher's ability to make changes to pedagogy and recognise the need for flexibility in instruction that results from the use of technology;
3. Management: this includes a range of issues relating to implementation of technology including maintaining student engagement, dealing with the physical environment and hardware issues, and dealing with behaviour management; and
4. Depth and breadth of mathematics content: this component deals with the teacher's knowledge base in terms of the mathematics content and a willingness to allow students to explore mathematical content that may arise during students' investigations using technology.

A developmental model for mathematics TPACK developed by Niess et al. (2009) recognises that teachers require guidance in the development of their ability to effectively use technology to enhance the teaching and learning of mathematics. The model identifies five steps that teachers progress through when integrating a new technology such as the iPad. The steps illustrate the progression from simply recognising the alignment of the specific technology with mathematics but not integrating it into teaching and learning, through to accepting, adopting, exploring and evaluating the decision to integrate the appropriate technology with the teaching and learning of mathematics. The authors of the model claim the emergence of each new technology requires teachers to move through the steps of the model each time, strengthening the argument that new technologies such as the iPad should be supported by appropriate professional development.

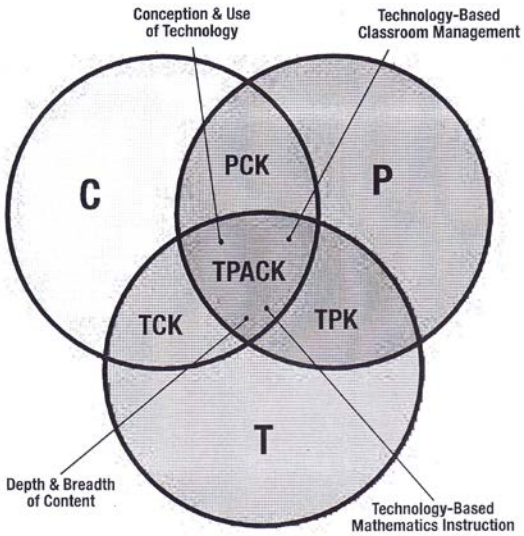


*Figure 1*. Four central components of mathematics-related TPACK (Guerrero, 2010, p. 134).

One important aspect of the development of TPACK for teaching mathematics is the teacher's ability to maintain positive student engagement once the novelty of the new technology has worn off. Although Guerrero (2010) claims technology has been proven to have positive effects on student engagement, when implemented inappropriately, too often, or too infrequently, it can result in student disengagement. At this point and because a focus of this paper is the effect of the introduction of iPads on the participants' engagement with mathematics, a definition of engagement is introduced.

## Engagement

The concept of engagement has been defined in several different ways. Some view engagement at a purely behavioural level (Hickey, 2003), and others define it as "a deeper student relationship with classroom work" (Fair Go Team NSW Department of Education and Training, 2006, p. 9). In this paper, engagement is viewed as a multi-faceted construct which operates at three levels: cognitive, affective and behavioural (Fredricks, Blumenfeld, & Paris, 2004). On a general level, cognitive engagement involves the idea of investment, recognition of the value of learning and a willingness to go beyond the minimum requirements. Affective engagement includes students' reactions to school, teachers, peers and academics, influencing their willingness to become involved in school work. Finally, behavioural engagement encompasses the idea of active participation and involvement in academic and social activities, and is considered crucial for the achievement of positive academic outcomes.

When translated into a mathematics classroom context, engagement occurs when all three facets come together. This occurs when students are procedurally engaged during mathematics lessons and beyond, they enjoy learning and doing mathematics, and they view the learning and doing of mathematics as a valuable, worthwhile task, useful within and beyond the classroom (Attard, 2011). For the purposes of this study and from this point on, the concept of engagement will encompass behavioural, cognitive and affective engagement, leading to students valuing and enjoying school mathematics and seeing connections between school mathematics and their own lives. This view of engagement, combined with the TPACK framework, will be used to address the central questions of this study: How does the introduction of iPads influence teacher practices in the mathematics

classroom? Does the introduction of iPads into mathematics teaching and learning improve student engagement?

## Methodology

The participants in this study were of a mixed gender and ability Year 3 class (the fourth year of primary school in NSW) and their teacher (who was given the pseudonym of Mr Milroy) at a government primary school in Sydney. The site was chosen as they were involved in a Department of Education and Communities iPad trial that involved the loan of 30 iPads for a period of six months and because Mr Milroy was already a participant in the larger, Fair Go from the Get Go study. Mr Milroy's willingness to participate was the result of a desire to improve his pedagogical practices and improve his students' low levels of engagement with mathematics. At the time of data collection Mr Milroy was in his second year of teaching and was also the school's technology coordinator.

The school population consisted of 240 (15% indigenous) students of low to mid socio-economic status. Prior to the iPad trial the only ICT accessible to the students was a class set of laptops supported by a specialist ICT teacher. In the two years leading up to the iPad trial the Year 3 group had undertaken a one-hour computer class once a week. The focus of these lessons was to enhance the students' computer skills.

The data collection method consisted of a semi-structured interview with Mr Milroy at the commencement and again at the completion of the trial to gain an understanding of his experiences with the iPads and the impact they had on his classroom practices. Mr Milroy also recorded written reflections detailing his thoughts following the trial. Students were selected by Mr Milroy for a focus group comprising of mixed ability and mixed gender to allow for a representative sample. The focus group met once at the beginning and again at the end of the trial. During the focus groups the students discussed their engagement with mathematics both prior to their use of iPads and following the six month trial. An observation of a mathematics lesson featuring the iPads was carried out in the final weeks of the trial. All interviews and focus groups were transcribed and participants' responses were analysed and coded using open and selective procedures into categories to identify emerging themes which were used for interpreting the data.

While the data collected is not representative of the perceptions and practices of all teachers and students across all schools, the insights gathered from the study are valuable for furthering our understandings of the relevant issues related to the use of iPads for teaching and learning mathematics within a primary school setting.

## Results and Discussion

Over the course of the six-month iPad trial, the students and Mr Milroy experienced a range of changes to their mathematics lessons. This resulted in a number of challenges to Mr Milroy's pedagogical practices and a perceived improvement in student engagement. The following is a brief discussion of the results of this study.

### *Conception*

The data and discussion of Mr Milroy's experiences with introducing the iPads will be framed around the TPACK framework and Guerrero's (2010) four components that characterise TPACK in mathematics. The first component, conception, involves how Mr Milroy conceptualised the use of the iPad to support teaching and learning within his classroom. When interviewed at the start of the study, Mr Milroy envisioned using the iPads

as an additional source of information that his students could access when a teacher was not available. He saw the affordance of having access to the Internet and to instructional video tutorials as an opportunity for students to access direct instruction on demand, and not necessarily be limited to the confines of mathematics lesson time. It was Mr Milroy's aim to increase his students' independence through having access to the iPads: "I am hoping that technology will get that idea across to them that hey, you can teach yourselves and guess what, you can use that to teach each other."

Mr Milroy also identified another affordance in the form of mathematics applications (apps) that students could use to practice mathematical concepts and skills. However, early in the study he found that some students did not have the skills or understandings required to successfully engage with the specific apps he had selected. This was evidenced during a classroom observation where one student appeared to be guessing the answers to a mathematics game, claiming "this is the wrong answer game". This scenario is evidence that the teacher's knowledge of the individual needs of students, the appropriate pedagogy and the appropriateness of using technology is an important aspect of the development of TPACK and is an important consideration when planning teaching and learning activities.

As the study progressed, other affordances of the iPad were identified by Mr Milroy as being of benefit to mathematics teaching and learning such as potential to provide interactivity and instant feedback via the use of mathematics game apps. These affordances will be discussed further throughout the paper.

### *Technology-based Mathematics Instruction*

The second component, technology-based mathematics instruction, involved Mr Milroy making significant changes to his pedagogical practices which initially relied heavily on the use of worksheets, mathematics investigations and a commercial, computer-based program that provided drill and practice of computation skills. Mr Milroy admitted it was a challenge to plan mathematics lessons in terms of sequencing content in an engaging manner, indicating his level of pedagogical content knowledge was still developing, possibly as a result of his status as a beginning teacher. This challenge may have had some impact on the integration of the iPads into his mathematics lessons.

During the course of the study Mr Milroy experimented with different ways of using the iPads within his mathematics lessons and in other subject areas. Initially, the iPads were used for group activities based on apps that were fundamentally game based. Mr Milroy then revised his use of the iPads and extended the ways in which he used them, including the incorporation of online tutorials accessed via the Internet. Once students had participated in an online tutorial covering a specific content area or skill, they then moved on to using apps that required them to practice the skills and content, often in the form of a game. Using the iPads in this way also resulted in lessons that were based on a rotation of group activities (not necessarily cooperative groups) rather than whole class lessons.

### *Management*

Although the iPads were used regularly and in a variety of ways, their integration was not without problems. The third component, management, saw restrictions in the ways the iPads could be used and their initial set up and maintenance was found to be a cumbersome burden that was perceived by Mr Milroy to impact on the effectiveness of their implementation. The fact that the iPads had to be shared with students from another class group also meant that they could not become an integral part of teaching and learning because they were not always available for use in Mr Milroy's classroom. Mr Milroy

perceived a different aspect of the management component, student engagement, to have been improved as the result of introducing the iPads, stating:

> ...in comparing and contrasting how I taught initially without and then with the technology of iPads, wifi, IWB and USB document camera, I can unequivocally claim I successfully engaged the kids in more content creation, criteria based projects in a reflective and learning-cultured class environment. The students mostly used higher-order thinking skills, reflection and analysis throughout the entire day aided heavily by the above technology.

An affordance of the iPads mentioned above was the immediate feedback students were able to receive through the incorporation of mathematics games. Rather than wait for the teacher to correct answers as would normally occur when worksheets are used, the games provided an immediate response. The benefit of instant feedback is reflected in this student's comment:

> Well it makes me feel happy because if you touch it and you make a mistake it just like takes it away, straight away, not like if it is on paper and then it is an exam with no rubbers, if it's on the iPad you can just go oh, that's wrong and you can take it away.

The affordance of instant feedback highlights the iPad's potential for building students' confidence in terms of risk taking and feeling safe to make mistakes and try again, building persistence. This in turn promotes positive affective, behavioural and cognitive engagement.

Students made several comments specifically comparing the iPads to the use of worksheets, with this comment typical of the group's sentiments: "I think learning with the iPad is better because some children don't concentrate when it's on paper but when it's on an iPad because it's electronic and modern they can concentrate more." However, students could also see a slight disadvantage with using the iPads in that they were aware that they could be distracting, making it difficult to focus and stay on task. This issue highlights the importance of teacher supervision and management skills as well as the importance of being aware of individual students' capabilities, an important component of effective TPACK.

For most of the students the games appeared to improve affective engagement and for many, cognitive engagement because of the level of challenge within the games. Many students claimed lessons were more 'fun'. This could be attributed to the mathematics games the students were playing and the level of interactivity required, increasing behavioural engagement. It is not possible to conclude if it was purely the game aspect that made the lessons fun (behavioural and affective engagement) or whether the students were cognitively engaged and actually learned mathematics as a result of playing the games. As stated earlier, during a classroom observation, one student was observed to be disengaged from the mathematics whilst still playing a game and interacting with the iPad. Clearly although it appeared all students were behaviourally and affectively engaged, not all were engaged on a cognitive level possibly due to a mismatch between their ability and the given task. Although an affordance of using iPads is the potential to address diversity by differentiating learning through a range of activities, it appears that during the trial their use during mathematics lessons was limited to the use of a small number of mathematics based apps and the on-line mathematics tutorials.

### *Depth and Breadth of Mathematics Content*

The final component regarding Mr Milroy's depth of understanding of mathematics content and the potential for students to explore mathematics appeared to be the most challenging aspect of introducing the iPads into mathematics lessons. A benefit of using the iPads was the increased opportunity to differentiate learning by providing a broader range of activities for students to engage with when compared to the limited range of activities used

prior to the introduction of the iPads. Before the trial, the students perceived their mathematics activities to be based on worksheets. The iPads provided students with opportunities to work in groups on a range of activities within each lesson and to do so in a more flexible learning space, allowing students to move around the room from one activity to another. Arguably the increased variety within their mathematics lessons would have contributed to the increased engagement of the students.

During Mr Milroy's final interview at the completion of the trial, he indicated that in future he would plan mathematics activities using the iPads that were based more on mathematical investigations and problem solving. This was the result of his 'trial and error' approach and his self-evaluation of the effectiveness of the iPad trial. Throughout the six months it is evident Mr Milroy progressed through the developmental model described by Niess et al. (2009), and this process may be repeated until a stronger level of TPACK is achieved.

## Implications and Conclusion

In this study, the introduction and integration of iPads into mathematics teaching and learning appears to have had a positive impact on the teaching and learning of mathematics for the participants involved. The iPads allowed the teacher to introduce a wider range of teaching strategies that included group work and a rotation of tasks within each lesson as opposed to whole-class, worksheet based lessons. The use of the iPads appears to have increased student engagement by providing a resource that promoted interactivity, immediate feedback, challenge and fun.

All of the participants in the Year 3 class appear to have had a positive experience during the trial. The classroom teacher, Mr Milroy, believed their engagement with mathematics had improved, with students displaying increased enthusiasm and higher levels of participation during mathematics lessons. The iPad integration provided an opportunity for Mr Milroy to reflect upon and adjust his pedagogies and although he was already a confident user of the technology, he felt compelled to spend a significant amount of time researching apps for use within the classroom, therefore taking some responsibility for his own professional development. The findings in this study highlight potential difficulties when implementing new technologies, particularly for beginning teachers who are still developing their pedagogical content knowledge. Further support in the form of opportunities to develop his TPACK through formal professional development may have been beneficial and could have avoided the 'trial and error' approach.

The fast-paced development of mobile technologies such as the iPad and their potential for use in the classroom requires careful professional development that highlights the importance of developing strong TPACK. Pre-service teacher education and the development of TPACK is also an issue that may benefit from further research.

Although this study has several limitations in that it was conducted with only one group of students in one school, it provided the opportunity to investigate a common occurrence in our schools today. That is, the implementation of new technologies without appropriate support through professional development opportunities that explore and develop teachers' technological pedagogical content knowledge. The findings suggest that further, much deeper investigation into the use of iPads and other mobile technologies to teach and learn mathematics is warranted and timely. Research conducted over a longer period of time with a more representative sample would be of benefit and would highlight further the benefits and disadvantages of using mobile technologies.

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