Introducing iPads into Primary Mathematics Pedagogies: An Exploration of Two Teachers' Experiences

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Many primary schools in Australia are investing substantial funds introducing mobile technologies such as iPads to enhance teaching and learning. However, when new technologies are first introduced, teachers are often expected to integrate them into their practices without the support of appropriate professional development. This paper reports on a recent qualitative multiple case study that explored the pedagogical practices implemented by four primary teachers during the first six months of iPad use. Results of the study highlighted that although the iPads do have the potential to enhance teaching and learning of primary mathematics, appropriate professional development that addresses all aspects of technological and pedagogical content knowledge is required to ensure successful integration of new technologies into current teaching practices.

Although not originally intended for use within educational settings, many primary schools in Australia are investing significant funds into iPads and other similar devices in the hope they will improve education by catering to the specific needs of contemporary learners. Although there are claims iPads and other mobile devices have the potential to revolutionise classrooms (Banister, 2010; Ireland & Woollerton, 2010; Kukulska-Hulme, 2009; Melhuish & Fallon, 2010), teachers are often expected to integrate such new technologies into their existing teaching practices with little or no support in terms of appropriate professional development. This in turn makes it difficult for teachers to reconceptualise their practices to accommodate the new devices (Niess et al., 2009).

Due to the rapid pace of technology development, there is little published research to date investigating the issues relating to primary mathematics teachers and the ways in which iPads are introduced and used in their classroom practices. Such research is critical in terms of providing documented, research-based evidence of new practices that teachers could use as exemplars of effective learning and teaching.

This paper reports on findings of a recent qualitative case study that explored the pedagogical practices employed by four primary teachers during the first six months of iPad use in mathematics teaching and learning. For the purpose of this paper, the stories of two of the four teachers will be discussed in order to highlight the need for appropriate and timely professional development for all teachers regardless of their experience, when introducing new technologies into existing practices. The two teachers were chosen for inclusion in this paper, as one was the teacher with the least experience (three years) while the other was the most experienced out of the group (22 years). The theoretical framework underpinning this paper is based upon the Technological Pedagogical and Content Knowledge (TPACK) framework developed by Mishra and Koehler (2006) and other current research pertaining to mathematics, education and technology.

iPads and the Mathematics Classroom

The need to integrate ICT into the teaching and learning of mathematics is now an integral aspect of Australian classrooms, with recent curriculum documents expressing explicit expectations that ICTs are integrated into the teaching and learning of mathematics

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(Australian Curriculum and Reporting Authority, 2012; Board of Studies New South Wales, 2012). Literature around pedagogy and ICT suggest the implementation of new technologies has potentially changed teaching and learning radically, providing opportunities for a shift of focus from the mechanics of action to a more problem-solving based approach. This notion is supported by Yelland and Kilderry (2010), who claim the traditional view of mathematics that was focused on memorisation and rote learning is now replaced with a view of mathematics that has purpose and application.

Although there are arguments that suggest the use of ICT has potential to transform education (Levin & Wadmany, 2008), there is some evidence of barriers that could negatively influence on student outcomes and engagement as a direct result of how teachers incorporate ICTs with their existing pedagogies (Bingimlas, 2009). Bingimlas lists such barriers as a lack of teacher confidence and competence, a lack of professional development opportunities, difficulty with accessibility and a lack of technical support.

The introduction of iPads as teaching and learning tools can potentially remove some barriers to successful ICT integration with many believing the devices have the potential to address a disparity between the way young people use digital media outside school, and the ways in which digital media are used within the classroom (Henderson, 2011; Selwyn, Potter, & Cranmer, 2009). This disparity is described by Selwyn et al. as a 'digital disconnect' between schools and learners. Distinct affordances offered by iPads when compared to traditional ICTs include their affordability and ubiquitous access, mobility, ease of use, opportunities for more flexible learning spaces and more flexible opportunities for students to author their own work rather than simply consuming the work of others (Ireland & Woollerton, 2010; Kiger, Herro, & Prunty, 2012; Melhuish & Fallon, 2010).

However, such affordances may not be used to their full potential and teachers may be less likely to embed them within their practices if there are limited opportunities for planned and sustained professional dialogue, support in developing new approaches to teaching and time to think deeply about pedagogical practices (Bennison & Goos, 2010; Hayes, 2007). The Technological Pedagogical Content Knowledge framework (Mishra & Koehler, 2006) may provide a foundation for professional development when integrating new technologies.

TPACK and Mathematics

The TPACK framework (Mishra & Koehler, 2006) aims to address what teachers need to know to successfully integrate technology. Koehler and Mishra (2009), claim there are three essential components at the heart of good teaching with technology; content, pedagogy, and technology. There are wide variations in the extent and quality of technology integration within educational contexts due to the interactions between and among the three components.

Although a generic framework, a study conducted by McGrath, Karabas and Willis (2011) found the TPACK teachers required differed from one subject area to another and depended on context. Guerrero argues that when applied to mathematics, the framework extends beyond ways in which to use a specific tool and its operations, to ways it can be used to improve teaching and learning (2010). Guerrero situates TPACK in the mathematics classroom and proposes four components that characterise the framework:

1. *Conception and use of technology*: ways in which a teacher can conceptualise the use of specific technologies to support teaching and learning mathematics;

2. *Technology-based mathematics instruction*: 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*: the 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*: 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.

The TPACK model and the incorporation of Guerrero's four components (2010) will assist in addressing the following research questions discussed in this paper:

1. What pedagogies were used when integrating iPads into primary mathematics classrooms?
2. What issues arose as a result of a lack of professional development opportunities?

Methodology

This exploratory multiple case study used qualitative methods for collecting data and focused on the experiences of four primary school teachers and their students in relation to the introduction of mobile technologies into their mathematics pedagogies. As explained earlier, data collected from two of the teachers is used in this paper in order to represent opposite ends of the spectrum of teaching experience. Although some simple robotics (*BeeBots* and *ProBots*) were included in the study, the technology focus of this paper is the iPad and the ways in which it was used as this was the major focus of the larger study.

The participants were derived from one setting, a Catholic primary school in the western suburbs of Sydney. The school's population came from a mid to low socioeconomic status and a variety of cultural backgrounds. The students covered a broad spectrum of academic achievement levels. The school was chosen as an appropriate site because it had recently purchased sets of six iPads for each grade cohort (there were two class groups in each cohort). Each teacher in the school was also provided with an iPad.

The school principal identified prospective teacher participants as a result of their interest in iPad technology for learning and teaching. The identified teachers were invited to partake in the study resulting in four teachers and their students participating – Kindergarten, Year 2, Year 4 and Year 5. None of the teachers had previously incorporated iPads into their pedagogies prior to involvement in the study yet each had experience using computers and interactive whiteboards (IWBs). The school did not provide any professional development to support the use of iPads. The following is a brief profile of the two teachers featured in this paper.

Dianne: A Year 2 teacher, Dianne had three years of full-time teaching experience. During her initial interview she discussed her belief that task differentiation is crucial in addressing the needs of all learners. Dianne claimed her teaching is student-centred and she felt it would be a challenge incorporating the iPads into her lessons.

Alison: The Year 4 teacher, Alison, had 22 years of teaching experience. Alison's philosophy of teaching emphasises the importance of making mathematics relevant to the lives of her students. Alison expressed a hope that the iPads would engage some students who were challenged behaviourally and assist with their mathematics learning.

Data Collection and Analysis

The study spanned six months and data were gathered from several sources. The teacher participants took part in a semi-structured interview at the start and at the conclusion of the study. Interview prompts related to their beliefs about teaching and learning mathematics, student engagement, and the importance of integrating technology.

Each teacher selected six students who formed a focus group (one focus group from each class) that met at the start of the study and on its completion. Their teachers selected the children as a representative sample of their class group and each group comprised of mixed gender and mixed ability students. Discussions were centred on the students' perceptions of mathematics teaching and learning, including the inclusion of technology.

Four mathematics lesson observations in each classroom were conducted across the span of the study and were carried out by the researcher and a research assistant. A comparative analysis was then undertaken to ensure reliability. Initial analysis of research themes was conducted immediately following each episode of data collection.

Analysis of the data was conducted within each of the cases before a cross-case analysis was carried out to identify similarities and differences in pedagogical practices and related issues. The pedagogical practices observed in the classrooms of Dianne and Alison will described briefly before discussion and analysis is presented.

Year 2: Dianne's Lessons

During her initial interview, Dianne discussed how she expected the iPads could enhance her students' perceptions of mathematics: "I think it is going to make maths different; the kids will see it in a different way…not just the traditional way they see maths now." During their focus group discussion, Dianne's students' expectations were that the iPads would be used to play games. Several students talked about ways they used computers and iPads at home. This comment highlights the different uses of iPads at home and school "…at home I just play games, at school I learn", implying the digital divide described by Selwyn et al. (2009). Although the students expected to play games, they appeared to understand that the purpose of the games was to enhance their learning.

Two out of the four lessons observed in Dianne's classroom utilised iPads (the other lessons featured robotics). In the first lesson Dianne was working with a group of 10 students (the other students were working with another Year 2 teacher within an open-plan, shared classroom) and used an application (app) called *ShowMe* as a tool to practice the jump strategy (an addition and subtraction mental computation strategy that involves splitting a number into tens and then ones using an empty number line). The app allows the user to draw while simultaneously recording audio. This can be played back as a short movie clip. Prior to the lesson Dianne had pre-recorded herself demonstrating the task and this was used at the start of the lesson by projecting the iPad screen onto an IWB. The students were directed to complete a subtraction equation of their own choosing using an empty number line while explaining their reasoning. Some students worked in pairs while others worked individually. At the conclusion of the lesson some of the students were selected to share their recordings with their peers on the IWB. Other students were able to provide feedback and the work was used as a stimulus for further mathematical discussion.

In the second lesson, Dianne introduced the topic of 2D shapes using the *Draw* app. The students were to work in pairs where one would sketch a shape on the iPad using a stylus and the other would ask questions and guess the shape, drawing and labelling each shape that was guessed in a workbook. The students had difficulty with the requirements of

this task because the need to replicate the shape on paper interrupted the flow of the activity and took a substantial amount of time. Some student misconceptions around the properties of 2D shapes were also observed, and this may have been made worse by the inaccurate representations caused by limitations of the *Draw* app.

Year 4: Alison's Lessons

Unlike the other class groups participating in this study, Alison's group included a large number of students who were achieving well below average in numeracy and literacy. Some of these students were identified as having special needs in relation to learning and/or behavioural issues. At a very early stage of the study Alison commented on how her students had already shown signs of wanting to engage with mathematics through using the iPads. She said: "A child used one (iPad) the other day and said 'Wow, can I keep going?' For me that is a blessing because he wants to do it." During their initial focus group discussion, the students from Alison's class focused more on learning rather than technology in their discussions and several expressed anxiety towards mathematics: " I just feel like I'm going to get everything wrong."

As with Year 2, Alison used the iPads in two lesson observations. Alison's mathematics group consisted of a group of seven students who were identified as needing additional support. The remainder of her class took mathematics lessons with another Year 4 teacher. In the first observed lesson, the iPads were used in the body of the lesson. The lesson focus was to develop speed and accuracy when adding 1 and 2 digit numbers. All but one student were provided with iPads. This student was told he would be the 'boss'. This role required the student to observe the others as they interacted with the *Bubbles* app, which involved addition of numbers to 20. The 'boss' was given a small whiteboard and asked to record any problems the others encountered, including any specific errors. After five minutes of the students interacting with the app Alison asked the 'boss' to report on what he had noticed, and this included several errors made by the other students. Alison then facilitated a quick lesson on addressing the specific type of error identified before swapping the 'boss' role with another child and allowing the group further practice.

In the second lesson, the iPads played a smaller role. The topic was measuring length, and the iPads were used to introduce the topic by allowing the children to recall photographs of them measuring objects outside the classroom taken using the iPads in the previous lesson. Alison used the photos as a method of revising how the students measured, with a specific focus on how to use a ruler to measure accurately. The students then moved into the body of the lesson, which involved using BeeBots to explore length.

Discussion

The following discussion of Alison and Dianne's observed practices in relation to how they incorporated the iPads into their practices will be framed around the TPACK framework and Guerrero's four components (2010) as described earlier.

Conception and use of iPads

Guerrero (2010), claims teachers must make a decision about whether to, and how best to use technology. During the observed lessons, Dianne appeared to move beyond using the iPad apps for game playing and drill and practice, to more student-centred tasks that required the students to author work rather than be consumers, an important affordance of iPads as described by Ireland and Woollerton (2010). However, during the lesson focused

on 2D shapes, the structure of the task and the selected app were not well suited to the mathematics topic and the task itself could have been implemented without the iPads, using concrete manipulatives such as pattern blocks to produce more accurate responses and deeper understanding. Dianne's status as an early career teacher may have been a contributing factor to this lesson's level of success, and opportunities to further develop her pedagogical content knowledge within the TPACK framework, may assist her in mathematics planning and programming in the future (Niess et al., 2009).

Dianne's lesson using the *ShowMe* app appeared to be more successful in terms of progressing the learning of her students. The activity promoted mathematical thinking and reflection by requiring the students to record themselves explaining their thinking while working through the jump strategy, allowing the students to extend their understandings (Yelland & Kilderry). The added opportunity to share their work with their peers also provided valuable feedback and reflection (Hattie & Timperley, 2007) and appeared to consolidate the student's understanding of the lesson content.

Alison's conception of how the iPads could be used differed from Dianne's in that she admitted she found it challenging to envisage uses for the devices beyond drill and practice apps, aligning with Yelland and Kilderry's description of a unidimensional use of technology, where the device does not extend the task's capacity or complexity from a pen and paper task (2010). However, the lesson that incorporated the *Bubbles* app appeared to be effective due to the task structure, allowing Alison to monitor the students' progress and intervene when necessary. It could be argued that Alison's lesson utilising the iPad as a camera could have been conducted with digital cameras. However, the iPads allowed students access to the photographs without interrupting the flow of the lesson, taking advantage of the iPad's portability (Ireland & Woollerton, 2010).

Technology-based Mathematics Instruction

During the study both Dianne and Alison adapted their pedagogies to integrate the iPads. In her final interview Dianne spoke about how she had begun to include the iPads in her planning: "It's on my mind…when I am planning and programming the maths, I think, well can I incorporate this into what I am doing? Is there another way for me or the children, showing or demonstrating their knowledge, or practising their knowledge?" Dianne found the iPads were particularly helpful for demonstrating concepts and explaining lesson activities. The ubiquitous access and 'just in time' learning opportunities (Melhuish & Fallon) were affordances of the iPads that were clearly recognised by the teachers participating in this study.

On the other hand, Alison continued to find it challenging to incorporate iPads into her lessons. Although her pedagogical content knowledge appeared to be strong, her knowledge and understanding of the affordances of iPads and ways they could be used to teach and learn mathematics appeared to be limited. This is in line with Compton's (2010) suggestion that having the technology does not guarantee its effective use. Alison indicated a desire to discuss and share iPad teaching ideas with other teachers: "You can't be going around purchasing every single app that's there, and it's probably about having that conversation with other teachers."

Management of the iPads

When asked if she needed support with the physical management of the iPads, Alison said: "no that's all okay…syncing the iPads and purchasing, all of that sort of thing is fine,

but it is time". Likewise, Dianne claimed the sourcing of apps and syncing of devices was time consuming. Apart from time issues, Dianne and Alison claimed they encountered no difficulties managing the iPads or their software. This aligns with findings from Chrichton, Stuewe, Pegler and White (2012) who found the majority of teachers they studied eventually made the iPad management a part of their daily routines. Both teachers agreed that more devices would be of benefit to their students, however, increasing the number of devices may result in making the management of iPads more time-consuming and problematic. Although Melhuish and Fallon (2010) cite the ability to provide individualised learning experiences as a distinct affordance of the iPad, in this study students often shared the devices successfully in pairs or in small groups. Sharing in groups of up to three students did appear to provide opportunities for peer mentoring, collaboration and communication.

Depth and Breadth of Mathematics Content

The observations in this study supported Guerrero's view that teachers need to be confident in their ability to address the depth and breadth of knowledge able to be explored as a result of using the technologies (2010). Dolores spoke about how the iPads promoted exploration in her classroom: "they just run with it", when compared to a traditional pen and paper based lesson. During most of the observations Dianne and Alison were able to deal confidently with the mathematics involved and their students' responses to the tasks. In Dianne's lesson on 2D shapes the way in which the Ipads were used may not have been of benefit to the students, leading to possible misconceptions. Dianne's lack of experience may have been the reason she did not foresee the issues involved with using the *Draw* app. This supports the argument that appropriate professional development is critical for successful integration of new technologies (Bingimlas, 2009). In contrast, Alison's use of the iPads to teach mental computation strategies illustrated a strong understanding of content and pedagogy, enhancing her students' learning.

Implications and Conclusion

This paper provided a small snapshot of a larger study that investigated the pedagogies implemented when introducing iPads into mathematics classrooms without the support of professional development. Due to the limitations of this paper, two out of the four teachers and their class groups participating in the study were used to illustrate the need for professional development when introducing new technologies. However, the experiences of the teachers were representative of the entire group participating in the study. The teachers, Dianne and Alison, represented two different perspectives: that of a beginning teacher, and that of an experienced teacher. Each of the teachers experienced different pedagogical challenges but both had some struggles with understanding how the technology could be used within a primary mathematics classroom to enhance learning.

Although the study was limited to one school and four teachers, lessons learned may be useful to a wider audience. The practices identified in this study illustrated the iPad's potential for enhancing teaching and learning, while also demonstrating the importance of professional development that address all aspects of TPACK: technology, pedagogy and content knowledge. Without appropriate professional development, the potential for technologies such as iPads to transform teaching and learning, and the costs involved in purchasing and implemented the technologies may be wasted.

Further, more sustained research across a broader range of contexts would be useful in identifying and promoting effective pedagogies that integrate iPads and similar technologies into contemporary classrooms. Investigations of iPads use in other curriculum areas and educational settings would also be worthy of future research, as would investigations of classrooms that utilise a one-to-one iPad approach.

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