ICT THE CHANGING LANDSCAPE

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Lorraine Day provides a follow up article that reports on a second survey of ICT use in primary mathematics classrooms. Not surprisingly, the rise in popularity of mobile devices resulted in a significant rise in ICT use between the first and second survey.

An earlier edition of APMC reported a snapshot of the use of information and communication technology (ICT) in primary mathematics classrooms in Western Australia (Day, 2013). This snapshot was taken in 2011. Eighteen months later a similar online survey was sent to the 118 school principals who had responded in 2011. Although only 40 responses were received, there were data that indicated that the landscape was changing rapidly in primary school classrooms. The striking difference evident in the second survey was how quickly mobile devices have become established as major providers of ICT access in primary mathematics classrooms.

In eighteen months, the change in the number of mobile devices, mainly iPads, was dramatic. When principals were asked how students in their schools could access ICT, the second survey demonstrated nearly a 70% increase in mobile technologies from the first survey. Although a direct comparison cannot be made between the two surveys, this figure is clearly significant, especially as most of the other numbers are quite consistent from one survey to the next. An extra question in the second survey asked principals to nominate the one way in which most students access ICT. Mobile devices (90% of which were iPads) were nominated in 22.5% of cases, running a close second to the ubiquitous interactive whiteboards. The software reportedly used to teach mathematics also reflected the increase in mobile devices, as over 50% of schools in the second survey reported the use of mathematics applications (apps), whereas not one school in the first survey reported mathematics apps amongst their software resources used.

With this rapid increase of availability and usage of mobile devices and the ever-increasing number of apps becoming available, the immediate questions teachers might ask are:

- How can I integrate this new technology into my teaching and learning of mathematics?
- What professional learning experiences will assist me in integrating this technology into my teaching and learning program?
- How do I go about selecting and using apps in my classroom?

Even though ICT has been available for many years, the primary uses are still for demonstration, verification, and drill and practice rather than in the development of mathematical concepts and higher-order processes (Niess et al., 2009). Although the availability of mobile devices has the potential to create a significant

shift in the way mathematics can be taught, many teachers are choosing not to make that shift (Crompton, 2010). It would appear that unless the effective integration of ICT into the learning of mathematics catches up with the evolution of mobile technologies, then the same mistakes of the past may be repeated (Niess et al., 2009).

Implications for teaching

Before teachers can successfully integrate ICT into their classrooms, they need to have a sound level of pedagogical content knowledge (PCK). Shulman (1987) described PCK as "that special amalgam of content and pedagogy that is uniquely the province of teachers" (p. 8). Not only do teachers have to know the particular mathematical content well and know what teaching strategies support learning, they need to understand which pedagogical practices are the best to utilise when teaching particular mathematical concepts within a particular context.

Table 1. Comparison of the two surveys summary.

	April 2011 survey	October 2012 survey	
Students are able to access ICT using			
Interactive whiteboards	90.5%	92.5%	
Clusters of computers in classrooms	61%	72.5%	
Computer laboratory	66%	70%	
Mobile devices	14%	82.5%	(62.5% iPads)
Most students access ICT using			
Interactive whiteboards	Not asked	25%	
Mobile devices		22.5%	(20% iPads)
Computer laboratory		17.5%	
Clusters of computers in classrooms		15%	
Software used to teach mathematics			
Mathletics	62%	74%	
IWB software	70.5%	61.5%	
Internet programs	84%	59%	
Apps	0%	54%	
Resources considered best to teach mathematics			
Mathletics	36%	49%	
iPads	0%	41%	
Internet	43%	15%	
IWB software	51%	13%	

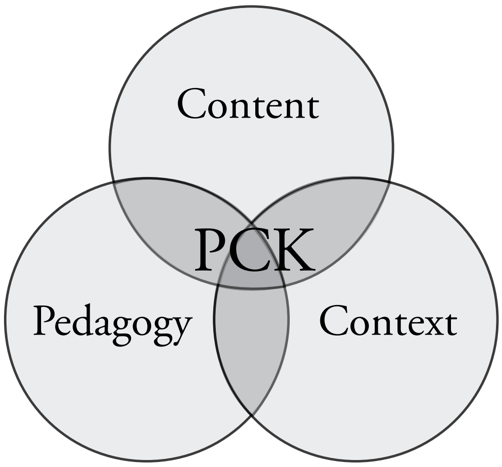

Figure 1. Pedagogical content knowledge (PCK).

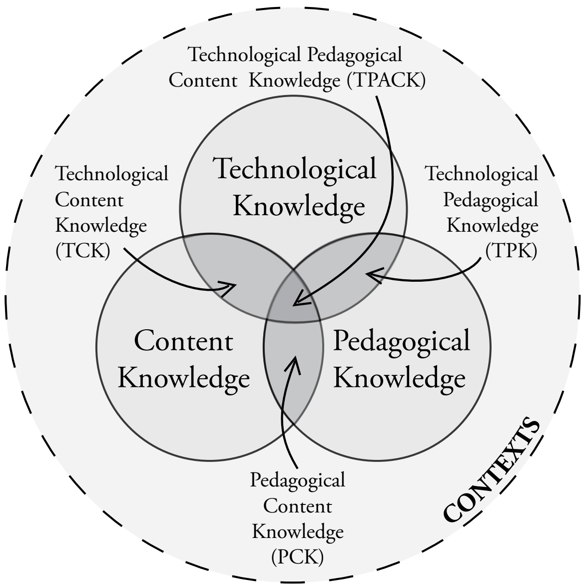

Figure 2. Technological, pedagogical and content knowledge (TPACK).

The emergence of networked and mobile technologies adds another dimension of complexity to teachers' pedagogical reasoning processes. Mishra and Koehler (2006) draw a distinction between teachers' content knowledge, pedagogical knowledge and technological knowledge. A model that describes the synergenistic relationship between these knowledge types has become known as technological, pedagogical and content knowledge (TPACK), which sees the integration of ICT into the teaching and learning process as seamless, while contributing to the development of both content and good pedagogical practices (Mishra & Koehler, 2006). TPACK provides a conceptual framework for teachers to reflect upon the knowledge needed to design learning experiences for thinking about teaching and learning mathematics employing ICT (Attard & Curry, 2012; Bate, Day & Macnish, 2013; Niess et al., 2009). Earle (2002) highlighted the importance of PCK, rather than just the technology, in the integration of ICT in mathematics teaching: "Technology involves the tools with which we deliver content and implement practices in better ways. Its focus must be on curriculum and learning" (p. 8).

To be confident to modify their pedagogical practices to integrate ICT seamlessly through a TPACK approach, teachers need to be critical users of ICT, deciding if, when, what and why to use ICT in their mathematics classrooms. The time spent on researching the many thousands of mathematical apps that are available must be a consideration for teachers. Banister (2010) suggested this could be alleviated by reading reviews and rankings of apps among users, such as the excellent list compiled by Attard (2013).

Teachers also need a deep understanding of the mathematical content that may surface when students are investigating mathematics using ICT, be flexible enough to follow the mathematics in the direction it is taken (Attard & Curry, 2012; Guerrero, 2010), and be willing to hand over some the control of ICT to their students if they wish to promote higher-order thinking about mathematics (Bate, Day & Macnish, 2013).

Five questions

There are five questions (at least) that teachers should ask themselves when they are considering the use of iPads in their mathematics lessons:

1. What is the mathematical content to be covered?
2. What types of tasks will assist students to learn this content?
3. Can and how could iPads enhance the teaching and learning of this content?
4. How might the use of iPads be embedded within the pedagogical framework of the lesson?
5. How can evidence of student learning be demonstrated and collected? (Attard, 2013).

Implications for learning

Mobile technologies, including Internet access, are already ubiquitous and today's students have grown up with them. These students have both a need and a desire to learn differently and mobile devices such as iPads are seen as a perfect platform for this to occur (McCaffrey, 2011). With more schools opting for iPad access, it would appear that there is a real opportunity for a transformative shift in mathematics learning to occur. Kukulska-Hulme (2009) stated that:

> The key attributes of mobile learning are identified as the potential for learning to be personalized, situated, authentic, spontaneous and informal (p. 162).

This may challenge the preconceived notions of what many students and teachers think mathematics classes should look like. ICT holds the potential to engage students in deep mathematical learning through exploration of mathematics, rather than simply being used to crunch numbers or engage in drill and practice activities. ICT also has the capacity to strengthen students' risk-taking, confidence, persistence and engagement by offering private, instant and non-judgmental feedback. Using ICT to aid in mathematical investigation, to develop mathematical understanding and thinking, encouraging co-operation with peers to solve real problems, and developing the confidence to take charge of their own learning is an exciting possibility. As one of the pre-service teachers in the Bate, Day and Macnish (2013) study stated, "With the technology I didn't realise how much further you can go into the software… to take the problem further to extend the kids' learning" (p. 19).

Attard and Curry (2012) point out that student engagement in mathematics occurs when students are procedurally engaged in their lessons, enjoy learning mathematics and view this learning as worthwhile. McCaffrey (2011) believes that mobile devices have the potential to "engage students, foster deep and meaningful learning, and result in today's kids reaching frontiers that generations before them could never hope to glimpse" (p. 22).

Many of the apps that may be the most useful in mathematics classrooms were not designed for mathematics in particular. There are functions that are built into the iPad, such as the camera, maps and the calendar, and then there are generic apps such as *Explain Everything* and *Show Me* that allow students to record their work and explain their mathematical thinking. Other generic apps that teachers of mathematics may find useful include *Google Earth*, *World Factbook*, *Keynote*, *Whereis*, *World Clock*, *Strip Designer* and *Garage Band*.

The vast majority of the mathematical apps available concentrate on the development of fluency using drill and practice. There are some which combine an element of problem solving and reasoning alongside the development of fluency. The National Council of Teachers of Mathematics (NCTM) have made several of their problem solving learning objects available as apps. These include *Deep Sea Duel*, *Okta's Rescue* and *Pick a Path*.

Implications for professional learning

With the explosion of iPad use in classrooms, teachers are often expected to integrate them into their teaching and learning programs without appropriate professional learning for themselves, particularly in relation to improving learning outcomes, pedagogical practices and student engagement (Attard & Curry, 2012). Bennison and Goos (2010) indicated that teachers who are provided with professional learning opportunities are better equipped to understand the benefits of using ICT, to integrate them with pedagogical practice and to facilitate student understanding of specific mathematical concepts. Many teachers instead are faced with having to use a 'trial and error' approach as the expectation of their schools are for mobile technologies to be seamlessly integrated with little or no professional learning support provided.

In their study involving pre-service teachers, Bate, Day and Macnish (2013) found that the use of ICT in an authentic manner to develop deep mathematical learning allowed teachers to view the development of their own pedagogical content knowledge. This allowed the teachers to see the possibilities for using ICT to improve the learning outcomes for their students through the development of mathematical concepts. It was seen as crucial for the pre-service teachers to personally explore the software, working collaboratively with their peers as students, before

examining the implications for teaching. The National Council of Teachers of Mathematics (NCTM) supports this approach: "If teachers are to learn how to create a positive environment that promotes collaborative problem solving, incorporates technology in a meaningful way, invites intellectual exploration, and supports student thinking, they themselves must experience learning in such an environment" (NCTM, 2007, p. 119).

Simply providing teachers with iPads and encouraging them to learn how to use them informally will not necessarily translate into expertise of how to use them to explore mathematical concepts and enhance the teaching and learning process. Without professional guidance, teachers will tend to use the iPads to extend their existing practices and the power of the tool may be lost. Poor selection of apps can also inhibit the potential benefits of the tool. Murray and Olcese (2011) reported that many of the apps available were out of touch with contemporary learning theories and consequently did not assist teachers to extend their repertoire of teaching and learning strategies. It is clear that school administrators need to be cognisant of the necessity for appropriate professional learning opportunities that develop strong TPACK if the introduction of iPads is to make a significant impact on the learning of mathematics.

Ten mathematical apps

These apps may provide a foundation for your collection:

- Math Doodles
- ABS Stats
- Bee Bot
- Pattern Blocks
- Teaching Graphs
- Numbler
- Sums Stacker
- Geoboard
- Tap Tap Blocks
- Symmetry Shuffle

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