MOBILE LEARNING IN MATHS TEACHER EDUCATION: USING IPADS TO SUPPORT PRE-SERVICE TEACHERS' PROFESSIONAL DEVELOPMENT

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Abstract

An emerging body of literature explores mobile learning in teacher education contexts. A common theme is the facilitation of collaborative, authentic professional learning experiences, often leveraged by the immediate and spontaneous nature of learning in informal settings. This paper takes a snapshot of current developments with mobile learning in teacher education. It draws on analysis of data from a study investigating mobile learning approaches in this context, with a particular focus on pre-service Maths teachers' professional development. The study was developed as part of our institution's activities in the national Teaching Teachers for the Future (TTF) project.

Introduction

Like other recent technological developments, there is considerable interest in exploiting the huge appeal and availability of mobile devices for their pedagogical uses. Consequently, various educational applications of mobile technologies ('mobile learning', or 'm-learning') are being examined. However, mobile learning in the context of higher education is relatively new and under-theorised both in initial teacher education and more generally in university teaching. In this paper we introduce a study in which we are seeking to gain an understanding of ways mobile learning technologies might mediate pre-service Maths teachers' professional learning. The paper outlines contemporary uses of mobile learning technologies in teacher education and reports on findings from our study in the context of a national Australian project—The *Teaching Teachers for the Future* (TTF) project—aiming to develop pre-service teachers' Information and Communication Technology in Education (ICTE) proficiencies.

Background

There is a burgeoning interest in mobile learning approaches in Teacher Education and consequently academics are involved in sharing and exchanging information on research and potential uses of mobile technologies through communities of practice, working groups and professional learning communities (e.g. Schuck, Aubusson, Kearney & Burden, 2012). For example, Broda, Schmidt and Wereley (2011) explore meaningful strategies for using iPads both in pre-service teacher education and within K-12 contexts. They emphasise the need for educators to adopt a "progressive ethic for teaching and learning, supporting efforts to think differently and use the technology tools to explore and embody the fluid nature of learning and teaching" (p. 3150). More recently, Hodges et al., (2012) explored possibilities for pre-service teachers to develop their technological, pedagogical and content knowledge (or TPACK – see Mishra & Koehler, 2006) through the use of iPads in teacher education, including the transfer of relevant skills and techniques to K-12 settings.

Similar interest in the use of handheld devices is evident in Maths Education contexts. Bannon, Martin and Nunes-Bufford (2012) found that both pre-service and in-service teachers saw value in integrating iPads into Maths education as a tool to promote student learning. For example, supporting learning through the use of Maths games applications ('apps') targeting specific concepts. The project noted the need for careful preparation in iPad implementation to initiate transformation in teacher education.

Also, smart phones have been exploited to extend mathematical thinking and enhance problem-solving procedures (Tangney et al, 2010). Given the potential of these devices to support collaborative and contextualised learning, their use may address some of the concerns in Maths teaching such as didactic approaches and de-contextualised material removed from real-world settings. At the school level, Tangney et al explore innovative uses of smart phones among school Maths students studying in 'out of class' settings. Informed by a social constructivist pedagogical approach to m-learning, the authors provide examples whereby the functions and capabilities of smart phone applications can be used as a basis for scaffolding learning scenarios occurring in real-life contexts, opening up student exploration of trigonometry and fractions concepts and developing higher order thinking skills.

Niess's (2006) work has been significant in understanding the opportunities and challenges of integrating technology in Maths teacher education, particularly using the TPACK framework. She considers whether it is possible to "teach the important ideas embodied in the mathematical concepts in such a way that the technology places the concept in a form understood by the students" (p. 196). Sample technological tools considered are the calculator, spreadsheet, Geometer's sketchpad and some applets. However, teacher educators need to be prepared to explore the learning possibilities of mobile devices in Maths education and "need to develop a professional attitude of evaluation and reflection about tools for teaching – a thoughtful visioning that investigates and considers the impact of the tools for teaching Maths" (p. 199).

A framework for interrogating mobile learning

Research studies have attempted to examine m-learning through identified theoretical perspectives and frameworks such as activity based approaches, authentic learning, action learning and experiential learning (Sharples, Taylor & Vavoula, 2007). More recently, Kearney, Schuck, Burden and Aubusson (2012) espoused a pedagogical framework of mobile learning informed by a socio-cultural perspective, comprising three central features: personalisation, authenticity and collaboration. How learners ultimately experience these distinctive characteristics is strongly influenced by the use of 'time-space': the organisation of the temporal (scheduled/flexible; synchronous/asynchronous) and spatial (e.g. formal/informal, physical/virtual) aspects of the m-learning environment (see Figure 1).

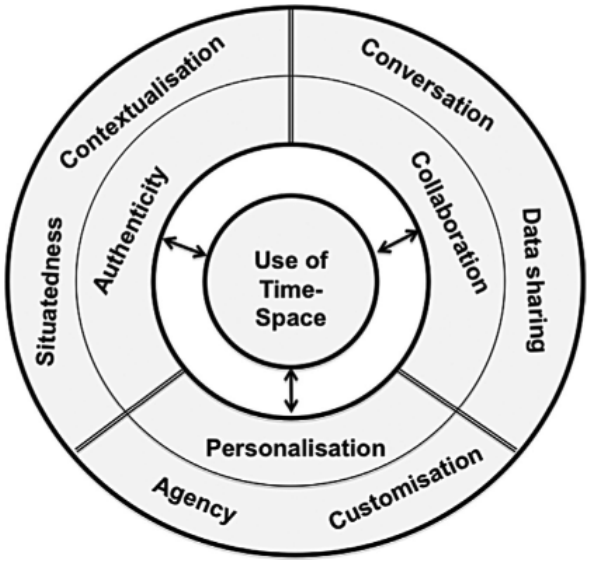


Figure 1: From Kearney et al. (2012, p.8).

The rationale behind these scales is provided through the use of sub-themes under each of the central features and which pinpoints the critical features of m-learning from a pedagogical perspective. Personalisation consists of the sub-themes of agency and customisation. High levels of personalisation would mean the learner is able to enjoy a "high degree of agency in appropriately designed m-learning

experiences" (p. 9) together with the ability to customise and tailor both tools and activities, leading to a strong sense of ownership. In the case of authenticity, the sub-themes of contextualisation and situatedness bring to bear the significance of rich, contextual tasks both in formal and informal settings. Thirdly, collaboration consists of conversation and data sharing sub-themes, as "people engage in negotiating meaning" (mediated by a mobile device) potentially 'making rich networking connections to other people and sharing information and resources across time and space' (p. 10). The authors emphasise that the framework provides a useful lens to explore how technology in the form of mobile handheld devices works in a range of formal and informal learning settings. Hence, it was used in this study to analyse participants' mobile learning scenarios in the context of their professional learning.

Study design

Participants were 16 fourth year Bachelor of Education (Primary) pre-service teachers completing a Maths Education subject and two staff members (experts in Maths Education) who taught in this subject. All participants were issued with an iPad purchased by the University for the duration of the semester (3 pre-service teachers and 1 staff member used their own device). The project focused on participants' use of their iPads in professional learning activities, including Maths-specific activities (e.g. using discipline-specific apps and other tools) and more generic organisational, communicative and reflective activities. These activities took place on-campus, in school settings and more informal settings, in the context of their Maths Education subject.

The aim of the research project was to gain an understanding of the way mobile learning approaches can enhance pre-service Maths teacher education, particularly in the development of pre-service teachers' TPACK. The research question relevant to this paper is: *How do pre-service primary Maths teachers use handheld technologies to support their professional learning?* A qualitative methodology (Erickson, 1986) was used for this research, drawing on aspects of case study methods. Data were collected during semester one, 2012 using participant journals, pre-service teacher focus groups, staff interviews and artefact collection (e.g. new media recordings and annotations). Data was analysed according to emerging themes across all sources. An interpretive approach was employed for this analysis, providing insight into how participants made sense of their experiences (Mason, 1996).

Findings

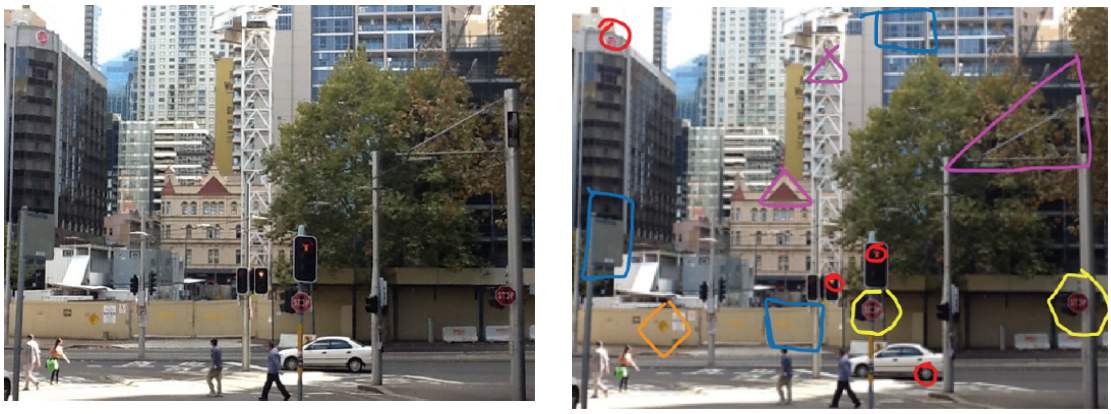
An analysis of data (the pre-service teachers' journal entries and interviews with two staff members) revealed that pre-service teachers were exploring ICT-enabled opportunities to think about rich, everyday Maths contexts in their teaching. They exploited the organisational benefits of the iPad in their own professional learning, with a focus on planning and observing lessons, record-keeping, reflective practices and peer conversations. These experiences stimulated their thinking about mobile learning applications and pedagogies in K-6 Maths teaching contexts.

Exploring Maths in the real-world

A strong emerging theme was the pre-service teachers' use of the iPad to explore and become more aware of Maths in everyday environments and to initiate their thinking about real-life contexts for K-6 Maths learning experiences. Activities involved capturing and annotating images from rich, meaningful, user-generated contexts. These artefacts subsequently became the focus of university class-based discussions with peers and staff as a catalyst for their thinking about authentic, technology-mediated Maths Education. In this way, they were developing knowledge about their nuanced use of ICT in their Maths teaching (or 'Maths TPACK'). Geometry and fractions were the Maths domains most often used in these scenarios.

Joanna was walking through the city and noticed geometrical shapes in the urban landscapes. She used her iPad to take a photo (Fig. 2) and later, on the train travelling home, she annotated it to highlight the shapes in the photo (Fig. 3). She later showed these photos and discussed relevant Maths concepts

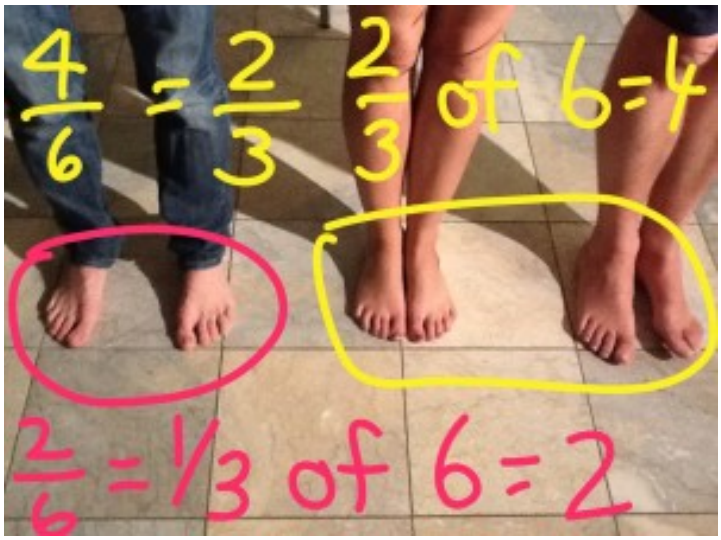
with her peers and lecturer in a small group conversation 'around the iPad' during a campus-based class.



Figures 2 and 3: Shapes in the City (recorded and annotated by Joanna)

Sally and Mary took a similar approach using images to introduce everyday contexts into Maths education. On a trip to an amusement park, Sally took photos of 'angles' she observed in various park scenes. She annotated some of the photos (e.g. see Fig. 4) but planned to use other photos (e.g. Fig. 5) for her K-6 students to annotate. Like Joanna, Mary took a photo of a building and highlighted the shapes. She also used her iPad to capture and annotate images depicting fractions in real-life scenarios to convey specific knowledge about manipulating fractions (see Figs. 6 and 7)

Figures 4 and 5: Angles at an amusement park (captured and annotated by Sally)



Figures 6 and 7: Fractions in everyday life (captured and annotated by Mary)

Mary used this immersion experience to think about her own Maths teaching incorporating real-world contexts in this kind of image-based exercise and how this type of task caters for a range of K-6 student abilities and interest levels:

> *Use of an iPad for fractions could be great fun for kids. How many ways can they illustrate fractions using a photo app such as Skitch? I have photographed a couple of different fraction examples, which could add to a gallery of work by students. This approach allows for differentiation in ability, in creativity, and in interests.* (Mary, journal)

In her interview, lecturer Isabelle expanded on the value of pre-service teachers noticing out-of-class Maths phenomena. She emphasised that many pre-service primary Maths teachers often don't see Maths in their everyday environment and indeed, many are fearful of Maths. She believed this type of mobile learning exercise allowed pre-service teachers to generate artefacts depicting rich contexts, enhancing their recognition and observation skills and developing more positive attitudes towards Maths. The iPad allowed them to follow-up and discuss the Maths associated with these artefacts: "Seeing [the phenomena] was spectacular. Having the facility to do something about it was also important…. the experience probably broadened what they might do in the future [in their teaching]" (Isabelle, interview). Indeed, one of Joanna's journal entries supported her lecturer's views about the effect on students' Maths lesson planning:

> *The iPad has allowed me to find inspiration from my surroundings and to then immediately develop and create a lesson plan from it. I realise that I can draw inspiration for math lessons everywhere…it means that no matter where I am, if I think of a really good lesson, or I see something that could be used in class to assist with placing mathematical concepts in real life situations, I can photograph or type it up using this mobile device.* (Joanna, Journal)

Kim stressed the importance of in-class, teacher-mediated conversations to follow-up these types of m-learning activities in K-6 contexts. In an audio-based journal entry, she discussed her observations of the relatively unstructured nature of children's 'out-of-class' problem-solving (she used a mobile game playing context for this discussion) before noting the importance of using class-based discussion to link 'out-of-class' informal learning experiences with formal school-based learning.

Productivity and capturing evidence of learning

Pre-service teachers used the iPad to enhance organisational aspects of their professional learning. They initially used productivity apps in class, often in a 'just in time', spontaneous fashion to take notes; plan, evaluate and observe lessons on professional experience; and record and annotate media—including their own multi-modal reflections. They particularly valued file-sharing apps such as Evernote and Dropbox to synchronise their notes, images and other work with their own array of personal computer devices to enhance the organisation of their learning. Larry for example, emphasised the convenience and access benefits: "My notes were automatically pushed to my iMac and iPhone. This meant that the notes that began in the classroom could be viewed and edited either on the bus while I was standing or at home in the office" (Larry, Journal).

Many pre-service teachers mentioned the ability of the mobile device to conveniently keep records of their own learning journey both on and off campus. Nancy mentioned: "Personally I think I am more motivated to keep records of what I do and my thoughts now that I have the iPad" (Nancy, Journal). Participants took photos of university class-based activities to help them 'follow up' on concepts and also to share with absent colleagues. In one (campus-based) Maths class where exemplary activities were modeled around the room, they took photos of selected workstations and materials. They later annotated these image-based records with their own written reactions and thoughts. Their lecturer, Isabelle, observed them annotating their images during class discussions, using the images as reflective prompts to think further about their Maths teaching.

The student teachers also considered use of the iPad to collect evidence of children's Maths learning, for example, through journal and portfolio assessment procedures. Kim's comments were typical, describing how the iPad could enhance reflective processes—how children could spontaneously "write something about their learning … take a record of their learning, what's going on!" (Kim, journal). Indeed, the student teachers trialed a range of iPad-mediated K-6 Maths assessment techniques during their school professional experience, including children's drawings (e.g. using iPad apps such as 'Show Me'), concept mapping and student interviews about concepts (White & Gunstone, 1992). For example, Sabrina used her iPad to conveniently record an interview about fractions with one of her students. She then played back excerpts of the interview with the child, discussing areas for improvement. She believed this was a powerful technique, as the student could immediately listen to her response before discussing the strengths and weaknesses of her explanation:

> *I was able to demonstrate to her [the K-6 student] that while she understood how to work out problems using fractions, it was difficult to understand what she meant when explaining each of the fractions. After listening to what she had already told me, the student was able to understand what I meant, and we were able to discuss clearer ways of describing fractions. This is definitely a tool that I would like to incorporate into my teaching of Maths concepts in the future.* (Sabrina, journal)

'Fit' with established model of mobile learning

The pre-service Maths teachers' iPad-mediated professional activities were analysed using the six sub-scales from the Kearney et al (2012) framework to rate the critical features of these m-learning activities from a pre-service teacher learning perspective. A critical friend, a co-developer of the framework, was invited to provide a third rating to enhance the validity of the scores. When our three ratings differed, differences were resolved through group consensus. From this analysis, we selected three samples (see Table 1) to show a range of typical contexts and an indication of the extent to which features of the mobile learning model were exploited (Table 2).

Table 1.

Brief description of 3 samples of m-learning scenarios in Maths Education

Sample Scenario	Brief description
A. Use of iPad at the Art Gallery by Beth. *This activity takes place in an informal setting to a relatively unfixed schedule and pacing.*	During a recreational visit to the Art Gallery, Beth decided to explore "how the iPad could be used to interact with the exhibition" for children visiting on an excursion. Using her iPad, she downloaded and evaluated a Maths Education resource. One of her 'findings' is described in her journal: "Children may be able to view a painting such as *Three Figures Under A Tree* to explore the concept of area. They could create a list of the shapes they can see, then create a simplified drawing of this painting on squared paper using only geometric forms and then calculate the area these figures fill on the picture. Students can use the application Skitch to create their drawings. The image can then be emailed to the teacher from the iPad and a class art gallery can be developed."
B. Geometry in the city by Joanna. *Takes place in an informal setting to an unfixed schedule and pacing.*	Joanna was walking through the city when she noticed geometrical shapes in a few of the 'city landscapes' she was passing and decided to photograph the scenes using her iPad. On the way home in the train, she used an 'app' to trace and highlight the geometric shapes in the pictures (see Figs. 2 and 3). She showed the images to colleagues and her lecturer in her next Maths Education class and this stimulated a discussion about the shapes and Maths teaching implications.
C. In-class use (on campus) by Amanda. *Takes place in a university Maths Ed. class. It was in a structured setting within a fixed schedule.*	Amanda was in class, viewing a presentation from another pre-service teacher on Maths apps. She was taking notes on her iPad and decided to download and view relevant apps (during the presentation). Her journal notes describe the spontaneous nature of this episode: "I slid my iPad toward me and checked out the credibility of the apps, determined if it might be a good app to use in my classroom, slid my iPad away and resumed listening for any more useful information."

Table 2.

Ratings for 3 sample m-learning scenarios (described in Table 1)

SCALE	Sub-scales	A *Use of iPad at Gallery*	B *Geometry in the city*	C *In-class use*
PERSONALISATION	Agency	High	High	High
	Customisation	High	High	High
AUTHENTICITY	Contextualisation	High	High	Medium
	Situatedness	Low	High	Low
COLLABORATION	Conversation	Low	Medium	Low
	Data sharing	Low	Medium	Low

The pre-service teachers' professional m-learning activities rated highly in the scales of personalised learning and authenticity. The analysis revealed that pre-service teachers were taking advantage of the agency and customisation offered by the iPads in their own professional learning. Activities were characterised by autonomy in terms of choice of content, goals etc. (agency) and typically involved student teachers customising their own experiences from both a tool and activity level ('just-enough, just-in-time, just for me'). A strong sense of personal ownership of the device and associated activities underpinned these experiences. (One participant commented: "It has become my new best friend and companion!") Pre-service teachers chose a range of relevant formal and informal contexts but not always participatory, in terms of being embedded in real, professional community practices (situatedness). There were surprisingly low ratings in the *Collaboration* scales. The pre-service teachers mainly used the iPad to elicit small group, face-to-face peer learning conversations *at* (rather than through) the device (Crooks, 1999). There has been minimal use of larger scale 'networked collaboration' and data sharing of learner-generated content (e.g. through Web 2 facilities such as microblogging). Access to wireless facilities may have been a hindering factor in their online collaborations, although participants new to using tablet computers indicated they felt more comfortable using their iPad to facilitate more familiar, small-scale face-to-face conversations. So as these participants were becoming more familiar with media recording and networking facilities, it was not surprising to find an emphasis on fairly isolated 'data acquisition' activities (accessing apps, journal papers etc.) rather than sharing of learner-generated data such as text (e.g. tweets), images and video assets.

Conclusion

This paper provides an overview of contemporary developments in Maths teacher education, presenting findings from a project exploring how mobile learning approaches can enhance pre-service teachers' professional learning. The national TTF project has given us impetus to explore m-learning tasks in this context and a recently established framework (Kearney et al., 2012) has been used to examine features of mobile pedagogy associated with these activities.

The pre-service Maths teachers used their iPads to mediate their own professional learning, exploiting features of authenticity and personalisation in both formal and informal settings. They used their mobile devices to notice and capture 'out-of-class' Maths phenomena, following-up and discussing implications for their Maths teaching. They used the technology to facilitate an enhanced awareness of Maths in everyday contexts, and then used this knowledge to develop rich, contextualised ideas for their own ICT-mediated K-6 Maths tasks. A high level of personal ownership of the devices (Burden et al., 2012) leveraged these benefits, although further investigations are needed to explore these links. Features of collaboration were less noticeable. There was minimal larger-scale networked collaboration (e.g. conversations and data sharing through social media), though the student teachers valued the visual and presentational role of the tool in facilitating face-to-face peer learning conversations around the iPad 'campfire' (Thornburg, 2004).

Other findings include the use of iPads to enhance the pre-service primary teachers' productivity and ability to capture evidence of their professional learning. They exploited the iPad's potential to conveniently and spontaneously take notes, observe lessons and make multi-modal reflections. They also trialled a range of iPad-supported Maths assessment techniques in K-6 settings, often involving the generation and annotation of new media, such as audio-based 'interviews about concepts' (White & Gunstone, 1992) and e-portfolio development. In this way, they developed their knowledge of using technology to support Maths teaching (or 'Maths TPACK').

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