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Enhancing Teacher Education in Primary Mathematics with Mobile Technologies

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Abstract: A challenge of teacher education is to produce graduate primary school teachers who are confident and competent teachers of mathematics. Various approaches to primary school teacher education in mathematics have been investigated, but primary teacher education graduates still tend to be diffident in their teaching of mathematics. In an age where personal use of mobile technologies is becoming ubiquitous, such technologies could provide a conduit into making mathematics teaching and learning more accessible to primary teacher education students. This paper introduces the use of a pedagogical framework which can scaffold mobile learning in mathematics teacher education programs. The paper discusses ways in which this framework, the Mobile Pedagogical Framework, can contribute to enhanced primary teacher education in mathematics, using mobile technologies. The Framework has three major dimensions: authenticity, collaboration and personalisation. Each of these will be discussed in terms of their alignment with current ideas about quality teaching in mathematics.

Introduction

Teacher education is facing existential challenges currently that are unprecedented internationally. These challenges arise from external pressures on autonomy, concerns about quality, and the increased importance of market forces (Bullough, 2014; Darling-Hammond, 2010; Grossman & McDonald, 2008). In particular, the area of STEM (science, technology, engineering and mathematics) teacher education has been highlighted as needing urgent attention, particularly in English-speaking countries (Blackley & Howell, 2015; Office of the Chief Scientist, 2014). In Australia, shortages of effective and confident teachers in mathematics, and the high numbers of out-of-field teachers (Marginson, Tytler, Freeman, & Roberts, 2013) have focused attention on mathematics teacher preparation.

There is much research which indicates that to increase the uptake of, and engagement in, mathematics at the secondary and post-school level, improved experiences at the primary school level are critical (Blackley & Howell, 2015; Epstein & Miller, 2011; Office of the Chief Scientist, 2014). Consequently, the need for teacher education programs to focus attention on primary school teacher preparation in mathematics and to graduate primary school teachers who are confident and competent teachers of mathematics has been identified as important in many English-speaking countries (Blackley & Howell, 2015; Office of the Chief Scientist, 2014).

The situation in mathematics education (and more generally in STEM) is described using terms such as ‘crisis’, and in Australia such language is justified by the recent report on STEM education by Marginson et al. (2013). Eacott and Holmes (2010) argue that to address this crisis in mathematics education, it is imperative to develop a framework for mathematics education that takes into account current local and international developments and contexts. One such development is the increase in access to, and use of, mobile technologies.

This paper discusses the way that an existing framework, *The Mobile Pedagogical Framework*, developed by Kearney, Schuck, Burden and Aubusson (2012), has the potential to support and enhance learning and teaching in primary mathematics teacher education in a context of widespread mobile technology usage. The framework fits with calls that mathematics teacher education should include new approaches that are relevant for a time and context in which mobile technologies are becoming ubiquitous and are being used for a multitude of purposes (Royle, Stager & Traxler, 2014).

Mobile technologies, such as smart phones, tablets and other handheld devices, have increasingly powerful functions and applications. They are becoming ubiquitous companions which accompany people through their daily events. They are frequently used for a host of purposes, which include sharing events through multimedia, interacting through social networking, and finding locations through geo-location (GPS) widgets. They are changing the nature of what, where and how we learn. The flexibility, ease of access and diverse capabilities of these technologies suggest that we turn our attention to investigating how best to use these capabilities in formal schooling (Churchill, Fox & King, 2012) and to addressing how best to prepare teachers to do so. Given the capabilities of these technologies, and their ubiquitous nature, it seems essential that teacher education programs include contexts for learning that are essentially different from contexts already in existence (Royle, et al., 2014). The term 'mobile learning' will be used in this paper to describe these new contexts for learning, which arise from using mobile technologies such as those described above and which capitalise on the particular affordances for learning provided by mobile technologies, such as the ability to learn anywhere, any time and in any way (Norris & Soloway, 2013). The Mobile Pedagogical Framework (Kearney et al., 2012) explicates how specific characteristics of mobile devices can be exploited in learning. The framework is underpinned by socio-cultural theory and was developed to provide a pedagogical framework for mobile learning, that is, a framework which foregrounds pedagogy rather than technology. To date, the dimensions in this framework have been validated with teachers (Burden & Kearney, 2016; Kearney, Burden & Rai, 2015).

Teacher education is currently facing risks of becoming irrelevant and inauthentic, if it continues with current practices, which, even when technology is integrated into programs, tend to be outdated and out of touch with what is needed in schools and with the ways that new technologies are used for social purposes (Ally, Grimus & Ebner, 2014; Royle et al., 2014). Given the ubiquity of mobile devices and the ease and comfort with which they are used in private and social ways, it is apparent that excluding them from teacher education programs limits opportunities for such programs to be current and authentic. Royle et al. suggest that the way technologies tend to be used in teacher education programs is either in institutionally regimented ways, or in ways that fit corporate use. For example, the use of learning management systems forces users to work in a pre-determined way in a context set by the university. The use of interactive whiteboards promotes the presentational approaches used by corporations to provide their sales pitches. These types of use of technologies are in contrast to the ways that mobile technologies are used in personal contexts, for example, to communicate with peers and colleagues in ways and places of personal preference, or to create a blog or video.

Current technology use in teacher education programs is also in contrast to the discourse regarding the aims of schooling. Student teachers should be prepared to further the aims of school education, which currently include the requirement to build a well-educated, digitally competent society with citizens who are prepared to work collaboratively and creatively and have resilience to flourish in uncertain futures (Ainley, 2010). Teacher education programs have the opportunity to propose new ways of teaching that incorporate and adapt to social ways of learning that occur with the use of mobile technologies. Areas of teacher education in need of attention, such as primary mathematics teacher education, might profit from discussion of new ways of teaching and learning with new technologies

One challenge for teacher educators is to support student teachers to learn how to use technology for teaching mathematics to primary school students in ways that are pedagogically sound (ACARA, 2014; Bereister, 2002; Mitchell & Laski, 2013). Another challenge in mathematics teacher education is the detrimental effect that the beliefs held by many pre-service primary teachers about mathematics learning and teaching may have on their development of appropriate strategies and approaches. Concern about pre-service primary teachers' beliefs about mathematics teaching and learning has been enduring for more than two decades (Schuck, 1999; Ball, 1990; Hiebert, Morris & Glass, 2003; Ma, 1999). Indeed, a study by Seaman, Szydlik and Beam (2005) replicated a study done in 1972 by Collier and found very little change in pre-service primary school teacher beliefs about mathematics. Seaman et al. call for student teachers' beliefs to be explicitly challenged to align better with reform movements in mathematics education (e.g. Ball, Thames & Phelps, 2008; NCTM, 2000; ACARA, 2014). The question then arises as to how change can be encouraged in the beliefs, pedagogies and actions of student primary school teachers, to gain this outcome.

Accordingly, the underlying research question that this conceptual paper seeks to address is: how might a mobile pedagogical framework enhance primary school student teachers' study of mathematics and its associated pedagogies, in ways that are future-oriented, meaningful and relevant? This paper makes the argument that the challenging of teacher beliefs regarding mathematics teaching and learning might be effectively done using a mobile-intensive pedagogy in teacher education courses, that is, a pedagogy which exploits the characteristics of mobile devices and student teachers' uses of such devices in social settings, to present a view of mathematics that is dynamic, flexible, connected and authentic.

Literature Review

School, teacher and student engagement with technology for learning is a key policy issue in Australia (DEEWR, 2013) and internationally (OECD, 2010). The national curriculum (ACARA, 2014) encourages the use of new technologies in all subject areas. Teachers are currently facing the challenge of implementing a new curriculum in which new technologies are utilised. It is clear that teacher education institutions have an important role to play in preparing student teachers for this new context. The challenge for teacher education programs is to help student teachers to develop skills in the use of effective technology-enhanced learning based on evidence of how different technologies contribute to quality learning of school curricula (Pegrum, Oakley, & Faulkner, 2013). In this paper, the focus is on the use of mobile devices in the preparation of teachers of primary mathematics, with the aim of investigating how mobile learning and the associated Mobile Pedagogical Framework might support student teachers in their learning how to teach mathematics in primary schools.

The Design of Teacher Education Programs

Teacher education has, in the last five years, become once again an area under review by policy makers (see for example, Dept of Education and Training, 2015; Donaldson, 2011; Wiseman, 2012). Although there have been numerous reviews of teacher education over the past several decades, the impact of past reviews has been slight (Smith, 2000). In Australia, the government has recently issued a discussion paper on teacher education, and made a number of recommendations (Dept of Education and Training, 2015). The recommendations regarding the structure and nature of teacher education are not suggesting radical change, either in this report, or in the many other reviews that have occurred over the years. The lack of change in teacher education structures is surprising given the increased requirements for teacher education to respond to social, political and international pressures. In addition, the emergence of educational technologies has the potential to change the nature of teacher education in both structure and design. Yet these changed techno-social and political contexts appear to have had minimal impact on design of teacher education programs.

As noted above, many critics of teacher education programs indicate that the system is becoming irrelevant and unable to produce teachers of quality (Royle et al., 2014). Even if such criticisms are arguable, teacher educators do need to reassess their programs' structures and designs to ensure they are relevant and support quality teaching and that they are able to provide counter-examples to their critics (Bullough, 2014). As well, teacher educators need to be aware of the aspects of education that matter to teachers and consider the relational aspects of teaching (Grossman & McDonald, 2008).

It is the contention of this paper that the emergence of new mobile technologies and the corresponding emergence of strong social use of such technologies is a powerful stimulus for re-examining how best to incorporate these technologies in teacher education programs to ensure their ongoing relevance. It is essential to recognise the ways that student teachers experience the world, and to incorporate these ways into teacher education programs to make them relevant, sustainable and able to support the development of quality teachers.

The Challenge of Mathematics Teacher Education for Primary School Prospective Teachers

Alongside the struggle for relevance of teacher education programs in the neo liberal context in which many countries currently find themselves (Darling Hammond, 2010), there is a particular challenge for teacher education in the area of mathematics teacher preparation of prospective primary school teachers. In many English-speaking countries, reform initiatives have been introduced to address a so-called crisis in numeracy and hence in mathematics education, as a result of a slippage in standing in international tests such as PISA and TIMMS (Eacott & Holmes, 2010). These initiatives often focus only on aspects of mathematics education that can be measured and are performative in nature. This is particularly true in Australia, with increased emphasis on national tests, increased benchmarks in numeracy and literacy for teachers, and a focus on the improvement of mathematics and literacy in primary school (Eacott & Holmes, 2010). These moves are a response to the perceived current crisis in STEM education.

It is interesting that when the author reviewed the literature in this area for this paper, she came across scholarly articles written in the 1970s and 1990s which examined the crisis in school mathematics education in much the same terms that are being used today. However, the proposed solutions appear different. In earlier literature, the assumption was that if mathematics could be made relevant and meaningful for students, the crisis would be addressed (e.g. see NCTM, 1989). Today, policy makers and governments call for more rigorous measures of mathematics attainment in schools, as though increased testing in itself will provide the much needed motivation for increased engagement (Eacott & Holmes, 2010). Interestingly, this situation is mirrored in primary mathematics teacher education programs, where increased calls for testing of student teachers' numeracy and literacy skills (Dept of Education and Training, 2015) have been in conflict with the desire of teacher educators to make the mathematics education program more meaningful and relevant for their student teachers without subjecting them to increased anxiety-inducing testing.

The push to make mathematics more engaging and consequently increase its uptake in secondary and tertiary studies was not universally taken up in previous reform efforts. Although the reform movement in mathematics education that started with the Standards (NCTM, 1989) has been in existence for over two decades now, it is still common to find teacher practices that are unchanged from those existing before the reform movement, in their emphasis on instrumental and procedural mathematics rather than a focus on rich and authentic tasks requiring an inquiry approach (Gill & Boote, 2012; Schuck, 2009). A number of studies have examined possible reasons for this lack of change (e.g. Ambrose, 2004; Schoenfeld, 2006). Many of these studies identify the classroom culture as problematic (Turner & Meyer, 2004); others discuss teachers' beliefs and lack of reflection as part of the problem (Philipp, 2007). However, in both cases these constructs are not explanations in themselves but areas that require interrogation and explanation themselves (Gill & Boote 2012). Unfortunately, it is often the case that policy makers hold teacher education programs accountable as the sole reason for the lack of change of teaching practice (Schuck, 2002). While teacher education programs cannot be held accountable for the entirety of the lack of change, it is necessary for such programs to investigate if their content and approaches may be able to address the lack of change to some degree.

Given that student teachers arrive at university with a set of strongly held beliefs about the nature of mathematics, it is essential for teacher education programs in mathematics to interrogate those beliefs and where student teacher beliefs are focused on a vision of mathematics "as an authoritarian discipline" (Seaman, et al., 2005, p.206), the goal for teacher education continues to be the need to challenge these beliefs. Clearly previous efforts in this regard have not enjoyed universal success. Perhaps there is a need to make use of new tools and the subsequent new ways of learning that might be in existence today as a result of the emergence of mobile technologies. Roscoe and Sriraman (2011, p.603) contend that teachers' beliefs "are dyamic, changing, and subject to influence" and this contention is supported by earlier researchers e.g. Seaman et al. (2005). Therefore mathematics teacher educators have responsibilities to promote engagement with current contexts and tools, to promote problem solving and critical thinking and to facilitate student teachers' learning in ways that allow students to question the authority of experience and of the past (Cady & Rearden, 2007; Munby & Russell, 1994).

Integrating Technology into Mathematics Teacher Education in Primary Programs

Governments in many western countries have invested large amounts of money and policy in the integration of technology into teaching (New Media Consortium, 2014) and into teacher education, for example in the Australian project, Teaching Teachers for the Future (Romeo, Lloyd, & Downes, 2012). However, evidence of changes in teaching and teacher education as a result of such implementation is varied (Bate, Day & Macnish, 2013; Kramarski & Michalsky, 2010). There is speculation as to why technology has not had the expected impact on teaching and hence on learning in schools (Polly, 2014). Studies have identified barriers that impede integration of technology (for example, Aubusson et al., 2014; Ertmer et al., 2012; Ottenbreit-Leftwich, et al., 2010). Royle et al. (2014), note the challenge provided by technology to formal education, especially by mobile technologies, given their ubiquity in general use. In particular, given the need to transform teacher education in mathematics as discussed above, a focus on mathematics teacher education and on mobile technologies is important.

It has been stated that many of the problems that student teachers have with mathematics learning are due to their lack of engagement with mathematics (Main & O'Rourke, 2011). A review of numeracy in Australia suggested that mathematics "is not generally perceived as a popular subject among young people" (Stanley, 2008, p.1). Consequently, and in line with Royle et al.'s recommendations, an investigation of how a popular technology might be used to increase engagement of student teachers in mathematics learning seems valuable. One study with school students has been conducted by Main and O'Rourke (2011) who investigated how handheld devices could increase mental mathematics skills and promote positive attitudes to mathematics learning. The authors indicated the importance of pedagogies that engage students. They stressed the value of providing students with choice and the possibility of following their own interests. Consequently, it becomes important to model such teaching in teacher education programs, and provide student teachers with opportunities to develop their own interests in mathematics education, and to learn how to exploit mobile technologies to do so, given that most student teachers already are familiar with mobile devices and use them extensively for social purposes.

The challenge for teacher education in mathematics is not only the adoption and utilisation of new technologies in schools, but the preparation of student teachers to become confident and competent leaders in this adoption. Consequently, teacher education programs must focus on ways to create learning environments which provide student teachers with choice, engage them in the study of mathematics, and provide role models for teaching that are future-oriented and meaningful.

A Mobile Pedagogical Framework for Mathematics Teacher Education

In this section, a suggestion is discussed for using a recently developed pedagogical framework for teacher education in mathematics. This framework highlights central features of mobile learning, underpinned by a socio-cultural theoretical background. The way that this framework can help us engage primary student teachers in mathematics is analysed.

The impetus by governments and schools to implement Bring your own device (BYOD) policies indicates that it is necessary for teachers to know how to use these technologies in the classroom and beyond, in ways that will enable their students to have enriched learning experiences. The preparation of teacher education students for mobile learning will benefit their future students when these students enter future workplaces. Teacher education needs to play an important role in preparing school teachers of the future. While educational leaders and technological innovators are making critical decisions about what pedagogies should be promoted and what technologies are made available in schools, such decisions will have little impact if student teachers are not prepared to be competent and confident initiators and implementers of such decisions.

Numerous frameworks for m-learning exist (e.g. Danaher, Gururajan, & Hafeez-Baif, 2009; Parsons, Ryu & Cranshaw, 2007; Vavoula & Sharples, 2009), but a feature of many of them is a focus on technological affordances. The framework under discussion here is based on socio-cultural theory, that is, it is underpinned by a view of learning as being in a reciprocal relationship with the tools being used. For example, a mobile device will lead to particular ways of learning and in return, the way that this tool is used for learning will impact on the way the mobile device and the associated applications are developed. In this theoretical position, learning is seen as social, influenced by cultural and societal factors related to the learner and mediated by the tool, in this case the mobile device and its applications (Wertsch, 1991). Key socio-cultural constructs in learning are those of learning through interaction and through making personal meaning. Vygotsky emphasised the importance of meaning-making, of the personal/individual, and of the collaborative/social as key aspects of learning (Vygotsky, 1997). Combining these socio-cultural understandings with an examination of which constructs are particularly supported by mobile learning led to the development of the *Mobile Pedagogical Framework* (MPF), (Kearney et al., 2012) as discussed below.

The MPF consists of a validated set of central dimensions of mobile learning: authenticity, collaboration and personalisation. These dimensions emerge from socio-cultural constructs as discussed above, and comprise the components of the MPF as they are all supported in mobile learning. In analyses of learning activities, location on these dimensions provides a nuanced interpretation, describing and articulating the underpinnings of quality mobile learning and pedagogy. The framework has been shown to be useful in scaffolding the ways that these fundamental dimensions of mobile pedagogies are being employed in classroom practices (Kearney, Burden & Rai, 2015; Schuck, Maher, & Perry, 2015). It has provided useful guidance to teachers in designing mobile tasks in schools (Schuck, et al., 2015).

Figure 1 below demonstrates what the Framework looks like, and takes into account the malleability of time and space that is characteristic of mobile learning. By this we mean, that mobile learning allows learning to take place at the time and place of the learner's choosing and this is a factor that needs to be considered by teachers if they wish to utilise the full power of mobile learning. The dimensions of authenticity, collaboration and personalisation that are afforded by mobile learning, provide a scaffold for teachers to ensure their learning activities exploit these dimensions. Each of the dimensions is further divided into two categories, which explicate aspects of each dimension. These are expanded upon below.

The construct of authenticity comprises two aspects of authenticity that arose in the testing of the framework. These two aspects or sub-dimensions are situatedness and contextualisation. These sub-dimensions categorise activities that fit with notions of authenticity. Situatedness talks to the way activities are situated in the real world and reflect problems encountered by practitioners. Contextualisation talks to the relevance to the learner.

The sub-dimensions of collaboration are conversation and data sharing. These sub-dimensions reflect the way that mobile devices are used collaboratively. Conversation takes place through use of telephone connections or through apps that encourage conversation such as Viber, Skype or WhatsApp. Mobile device users tend to share images, text and video with each other, either through blogs and image sharing sites, or through SMS, and sharing apps that are 1-1 or many-many such as WhatsApp.

The third dimension comprises agency and customisation. The ability to learn anywhere at any time provides the learner with an agency to choose time, place, content and manner of learning. Customisation relates to the choice of apps, backgrounds for screens, and ways of using the mobile device.

When the MPF is investigated in terms of contributions to mathematics teacher education, certain implications are clear. The flexibility of time and place in the use of mobile learning should prompt teacher educators to question institutional norms of programs that require students to learn at a set time in a set place. Further, the freedom of choice enabled by mobile learning also encourages discussion about what content should be learned by teacher education students of mathematics. Mathematics teacher educators should be making daily choices about what technologies they employ in teaching and about how to support their students to use these technologies both to learn mathematics and to learn about mathematics pedagogies.

In what follows, each of the dimensions is explored with a focus on how the framework may scaffold pedagogy in mathematics education. The types of activities that are promoted using mobile devices often have the dimensions discussed above embedded in them. The discussion below indicates examples of mathematics learning that would be well served by using the MPF as a scaffold for effective and engaging learning and teaching of mathematics in primary teacher education programs. The MPF considers use of mobile devices for learning, and it highlights the socio-cultural dimensions of activities that are made possible by the use of mobile technologies. In this way, student teachers' personal and social use of mobile devices is expanded to develop mathematics learning that is relevant, motivating and rich.

Authenticity

activity and the situatedness of that activity. These sub-dimensions fit well with developments in mathematics education over the last two decades. A focus in the Australian mathematics curriculum is on "numeracy capabilities

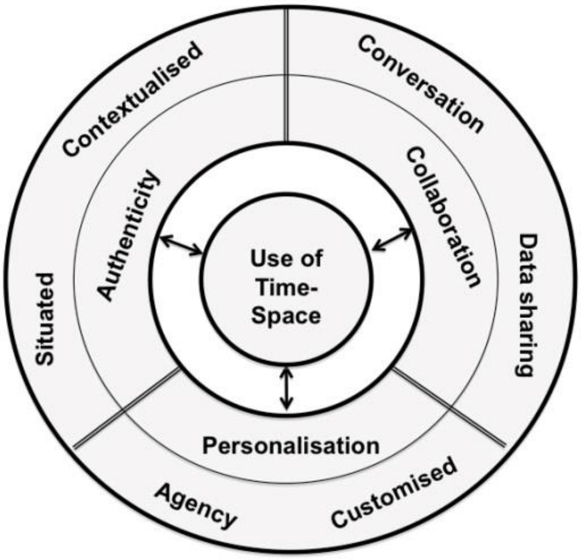

Figure 1: Current framework comprising three distinctive characteristics of mobile learning experiences, with sub-scales. From Kearney, et al. (2012).

that all students need in their personal, work and civic life, and provides the fundamentals on which mathematical specialties and professional applications of mathematics are built." (ACARA, 2014). To develop these capabilities there is a need to teach mathematics that is both authentic in terms of the tools, settings and people and that is useful for future work. Student teachers need to get a sense of how mathematics is used by mathematicians and by non-mathematicians in everyday life (Office of the Chief Scientist, 2014). Such usage is not generally bounded, in contrast to learning in the classroom at set times. Mathematicians work in a variety of settings with a variety of tools. Student teachers need to learn how to translate examples of such use into accessible mathematics examples that motivate and engage their school students. Examples of mobile learning in primary mathematics that are located on the 'high-end' of the authenticity scale would be the use of geo-location apps to investigate distances, coupled with the reading of timetables provided in transport apps, and the calculation of the time needed to make a journey to the city. Data capture apps that allow common social issues to be investigated should also be used in teacher education programs to model how student teachers can motivate and assist their future charges. The investigation of 'big ideas' is one way of encouraging student teachers to investigate what mathematics they need to solve a particular problem e.g. water quality or calculation of 'food miles'. Importantly, these activities need to be followed by discussion on what the data mean and how they can be used.

Collaboration

The second dimension of the MPF is that of collaboration, comprising two sub-dimensions of conversation and data sharing. Examples such as the ones above would fit here as would conversations with a community of mathematicians to find out what mathematics they need to solve problems of the day (as in the Mathematics Inside project, being implemented by Coupland, Prescott, Schuck, Bush, 2015-2018). In this project, mathematicians are producing videos of their work with explanations of how they use mathematics in this work. Students are able to access these videos from their mobile devices at any time and place to gain ideas for their teaching. Data can be shared, stored and collected through the mobile device and then analysed collaboratively using collaborative spreadsheets and writing tools. Encouraging student teachers to photograph tile patterns and tessellations and then create a lesson in collaboration with others which investigates area using these resources, is a more dynamic (and authentic) way of learning about area.

Personalisation

The third dimension of the MPF is the personalisation one. The dimension has two sub-dimensions, agency and customisation. This dimension refers to the way that the user is able to design their own experiences and can customise both the device and the activities to suit them. With respect to mobile learning in mathematics, this dimension would enable students to collect data as and when they wish to, to develop their own projects to investigate using inquiry-based learning, and to work at individual levels in a differentiated way. Encouraging student teachers to own their activities and demonstrate agency in the choice of how, where and what they wish to investigate should motivate a deeper engagement with the mathematics needed to implement their projects. By designing their own learning experiences they are also differentiating in terms of the depth in which they wish to investigate a concept. This is helpful in modelling how teachers can implement differentiation in the classroom (and outside).

Other examples of activities that fit well with the different dimensions of the MPF include the following: virtual gaming, which if appropriately designed to involve mathematical choices, allows students to collaborate or compete, choose individualised pathways and learn mathematics in an engaging and interesting way. Flipped learning encourages student teachers to do the lower order aspects of their mathematical program outside of their teacher education institution, thus freeing the students to engage in problem solving and collaborative work in class. Immediate feedback for lower order skills motivates students to continue to work on mathematical questions that may otherwise be viewed as routine and tedious. Finally, the ability to use the external environment as a resource allows students to see how mathematics exists in buildings, designs, timetables, tides and other locations, and is not restricted to a subject that has meaning only in the classroom. This mobility of learning highlights the authentic nature of the concepts. All of these activities should be modelled in teacher education programs to provide student teachers with powerful exemplars of mobile learning. At the same time, the nature of the activities fits well with student teachers' ways of interacting with the world, and so should be motivating and attractive options for learning mathematics and learning how to teach mathematics in primary schools.

The research programs in which the author is currently engaged consider how to support teachers to use mobile-intensive pedagogies in mathematics education, in ways that are authentic, collaborative and personalised. These pedagogies align well with ongoing moves in mathematics education to encourage the use of rich tasks, differentiation and ways of engaging students in mathematics. Communities of learners are also encouraged and fit well with ideas of collaboration indicated by the Framework.

Conclusion

Student teachers' beliefs can be challenged and influenced during their teacher education programs. The discussion above indicates that there is an ongoing need to engage primary school student teachers in mathematics and to help them see the authentic, rich and valuable contribution that mathematics can make to our lives. The efforts over the past few decades to enhance mathematics learning and improve attitudes to mathematics have met with limited success.

There is potential for a different way to enhance engagement in mathematics learning for prospective primary school teachers. We need to exploit student teachers' current personal interest in the use of mobile technologies. Features of mobile technologies that support reform initiatives in mathematics education are likely to be helpful in bringing about some change. These are the features of authenticity, personalisation and collaboration. These are particular features afforded by mobile learning, and at the same time provide a strong basis for learning mathematics.

The challenge now is to provide form and substance to the ways that the Framework can be used in mathematics teaching. Recommendations for further research are to investigate how student teachers can develop their own interests through mobile learning. Research should consider how to motivate the study for mathematics to explore big questions, questions that important beyond the classroom. Such questions should involve problem solving and development of skills for 21st century learning that goes beyond the instrumental and rote methods of learning mathematics that are still so common in many primary school classrooms.

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