EMBRACING DIGITAL LEARNING TECHNOLOGIES (DLTs) IN PRE-SERVICE TEACHER MATHEMATICS EDUCATION.

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Abstract

The focus of this paper is on how pre-service teachers’ confidence and competence with using digital learning technologies (DLTs) in their teaching of mathematics can be improved. The impetus for this was the change to the nature of their assessment in their final mathematics unit of the Bachelor of Education program. Despite being tagged as “tech-savvy” pre-service students use digital technologies primarily for social networking and information retrieval. These uses of ICTs do not guarantee any facility for their utilisation of learning technologies which may result in them being unprepared for effective use of expensive equipment in schools. The provision of a communal constructivism environment supported educator and student learning as the students met the challenge of creating interactive digital applications to teach a mathematical concept to their peers. This paper is likely to be of interest to mathematics educators who are trying to steer pre-service teachers away from “worksheet maths” as well as other pre-service teacher educators who need to incorporate digital technologies into their content and methodology units.

Keywords: digital learning technologies, pre-service teachers, mathematics education.

Introduction

While current pre-service teachers may be collectively referred to as “digital natives” (Prensky, 2001) an issue for universities that provide teacher education programs is the extent to which this facility with Information and Communication Technologies (ICTs) can be embedded into the emerging pedagogical practices of these students as they develop their identities as teachers. Chen, Kim, and Tan (2010) in their study found that more than 90% of pre-service teachers (N = 1554) commencing their studies at the National Institute of Education, Singapore (NIE) used ICTs primarily for social networking and expedient information retrieval. Other researchers have also found similar high usage of ICTs by pre-service teachers (e.g., Caruso & Kvavik, 2005; Iding, Crosby, & Speitel, 2002). However it appears that despite an apparent facility with ICTs as social or entertainment technologies, the progression for pre-service teachers to using ICTs as a learning technology is difficult (Katz, 2005; Kirkwood & Price, 2005). Educators in pre-service teacher programs are charged with the responsibility to provide learning environments in which these students develop an appreciation of and facility with the relationship between content, pedagogy, and technology (Lock, 2007).

In recognition of this, using ‘ICTs’ as an all-encompassing term seems to be counter-productive in the area of teacher education. Teacher training programs need to focus upon what is referred to in this study as digital learning technologies (DLTs), with the emphasis on learning. This term is used to distinguish between communication and information retrieval (ICTs) and applications that have the capacity to provide engaging models and representations of fundamental concepts, supported by student interaction: namely DLTs. In mathematics education, DLTs necessitate pre-service teachers having strong content, pedagogical content, and technical pedagogical content knowledge (Mishra &
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Kohler, 2006). This is a challenge for many pre-service primary teachers who do not have a positive self-efficacy in doing or teaching mathematics. The issue is compounded further by these pre-service teachers’ beliefs about how mathematics is learnt and should be taught which for many are based upon their personal experiences at school rather than exposure to relevant research. Clifford, Friesen, and Lock (2004) and Hughes (2004) argued that effective technology integration in pre-service teacher education should be addressed within curriculum and pedagogy units, and not as an isolated just-in-case ICT course (Jacobsen, Clifford, & Friesen, 2002) or an add-on unit (Kent, 2004). Furthermore, researchers have promoted the idea of providing pre-service teachers with opportunities to create, develop, implement, and evaluate instructional activities that incorporate technology skills (Brush, Glazewski, Rutowski, Berg, Stromfors, Van-Nest, et al., 2003; Howard, 2002; Kariuki & Duran, 2004). For this project, the researcher melded the work of Ertmer (2005) and Pierson and McNeil (2000) to frame a process that could challenge or formulate the pre-service teachers’ beliefs about DLT integration through successful execution of original applications, observing and sharing ideas and skills with their peers, and increase their positive self-efficacy in relation to teaching mathematics.

Background

This study was carried out at the Brisbane campus of the Australian Catholic University (ACU). All mathematics content and pedagogy tutorials are conducted in the mathematics laboratory which is equipped with seven stand-alone networked computers, a data projector, and a Smartboard with a number of mathematics-specific software programs (e.g., Geometer’s Sketchpad). In the ACU Bachelor of Education, Primary (B.Ed.) students undertake four units of mathematics: two content and two teaching methodology. Table 1 shows the placement of these units in the four year program.

Table 1
Mathematics units in the Bachelor of Education (Primary)

<table>
<thead>
<tr>
<th>Year</th>
<th>Semester 1</th>
<th>Semester 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>Teaching &amp; learning unit (whole number, measurement, and geometry)</td>
<td>Content unit (whole number, measurement, and geometry)</td>
</tr>
<tr>
<td>Two</td>
<td>Content unit (rational number, algebra, probability &amp; statistics) – EDMA309</td>
<td>Teaching &amp; learning unit (rational number, algebra, probability &amp; statistics) – EDMA310</td>
</tr>
<tr>
<td>Three</td>
<td>No mathematics units</td>
<td></td>
</tr>
</tbody>
</table>

After listening to students’ concerns about the mismatch between the use of DLTs at ACU and their practicum schools, as the third year practicum coordinator and Lecturer-in-Charge (LIC) and lecturer and tutor for both third year units, the researcher decided that investigation into the use of DLTs as instructional tools within the mathematics units at ACU was warranted. Students expressed concerns about the expectations of their supervising teachers in regards to using Interactive Whiteboards (IWBs), Scootle, and various software available on the schools’ intranets.
A *communal constructivism environment* (Holmes, Tangney, Fitzgibbon, Savage, & Meehan; 2001) was the framework used to implement the unit EDMA310 so that the students and the lecturer (also the researcher) could work together to develop understandings. Furthermore the knowledge generated by the students was meant not only for their personal benefit but also for their peers and the lecturer (Foulger, Williams, & Weyzel, 2008). The rationale for using this framework was the lecturer’s lack of experience and expertise with the IWB and associated software which resided in the mathematics laboratory where all units of mathematics are taught.

**Methodology**

**Participants**

Pre-service teachers at ACU do not undertake any stand-alone ICT units in their four year Bachelor of Education course. It is the responsibility of the lecturer-in-charge to embed ICTs into their unit outlines; this is generally achieved by a reference to the Learning Management System in use, and the listing of specific Graduate Attributes and Professional Standards that directly refer to the use of technology. 88 third-year Bachelor of Education students (aged between 20 and 50+ years of age) were invited to participate in this study at the beginning of the semester. Project details were explained during the first lecture of the semester and interested students were provided with an Information Letter and a Consent Form. 90% of the students agreed to be involved in the research dimension of the unit; the other students still participated in the assessment tasks and tutorials, but did not undertake the questionnaires or post-presentation reflection.

**Embedding digital learning technologies into pre-service teacher education programs**

Students were exposed to digital learning technologies during both the lecture and the tutorials of the third year Bachelor of Education unit (EDMA310). The researcher (also the lecturer and tutor) used the technologies in PowerPoint presentations to cover unit content as well as stand-alone modelling of pedagogical practices commensurate with a focus upon the use of technology as a tool to represent mathematical concepts. The digital learning technologies targeted for this study were: (1) *Fun with Construction* (FWC) (Heulab Pte. Ltd., Singapore), (2) use of the Smartboard and accompanying notebook, (3) various websites that provide interactive applications and simulations such as rolling dice and spinners, and (4) productivity tools such as PowerPoint and Excel. *Fun with Construction* is a creative digital learning technology which requires users to have sound mathematical concept knowledge in order to engage with it, as opposed to other software that is pre-programmed and simply require input. FWC was selected as its functionality linked well with the Smartboard in terms of click-drag mobility and inking manual text. The program allows for dynamic construction, layering of pages, and recording and play-back of construction steps. In terms of using the Smartboard and the Smart notebook the researcher was positioning herself as a co-learner rather than an expert. Although the researcher was able to demonstrate the functionality of the FWC software, the use of the Smartboard and associated software was a source of joint discovery.

The assessment components of the unit were redesigned to focus on the use of digital learning technologies to teach mathematics in a classroom. The rationale for focusing upon the assessment components was based on the research of Teo, Lee, and Chai (2007) which surmised that “pre-service teachers perceive their own behaviour to be highly affected by their important referents” (p. 136). This decision was also supported by Venkatesh and Davis (2000) who found that the degree to which a person perceives the demands of others on that individual had a significant effect in a mandatory setting but no effect in a voluntary setting. The key assessment task required students to work in pairs...
to create an original application for the Smartboard to support the teaching of a concept in mathematics within the realm of the content areas studied in semester 1 (namely: rational number, algebra, probability or statistics). Each pair presented their application to their tutorial group as they would use the application in a classroom for a designated year level. The pairs also submitted a brief written report which outlined links to curriculum documents (e.g., Australian Mathematics Curriculum) and theories of teaching, as well as ways in which the application would support the development of their particular concept. The second assessment task consisted of creating a four to five week mathematics unit for a chosen year level and topic, and required specific DLT resources to be included.

Currently most Australian schools have at least one IWB (Campbell & Martin, 2010) and so it is important for pre-service teacher educators to ensure that developing teachers are not only conversant with the operation of this tool but are also judicious in their choice of activity to be used with the IWB to maximise student learning. The focus for all of these DLTs was not to “replicate the functions of older presentation technologies” (Schuck & Kearney, 2007, p. 8) but rather to offer opportunities to integrate creative and dynamic materials with manipulation of images.

The student participants selected their partners and primarily worked on their applications in their own time. Site licences for the FWC program were purchased by ACU and the software was installed on all of the computers in the mathematics laboratory and in two other computer laboratories in the same building to facilitate student access. Students nominated times and days for which they would develop and practise using their applications. The researcher was present on each of these occasions to provide feedback, pass on her own learning, and to probe the efficacy of the applications in terms of supporting the development of a mathematics concept. Additionally, the researcher coached the student pairs to varying degrees on an as-needed basis during and outside the tutorial sessions. However, most of the presentation preparation was expected to be undertaken outside of tutorial time and independent of the lecturer’s input. The students informally supported each other by sitting in on other pairs’ practice sessions and establishing a Facebook site for the cohort which was used to seek advice for functionality problems and feedback on proposed application contexts.

Between two and four presentations occurred each week during the tutorials from week 7 to week 10 inclusive. Each presentation was approximately 15 minutes in duration, with another ten minutes for questions and feedback from the tutorial group. At the end of each week, the students who had presented were emailed the post-presentation reflection questions and their responses were collected as they were posted on the ACU learning management system.

Data collection

The pre-questionnaire (Appendix A) was based on the questions used by Guy, Qing, and Simanton (2002) in their study and the items were chosen to gain information about participant confidence and prior experience with digital technologies. The pre-questionnaire was implemented at the beginning of semester 2, and consisted of seven questions: combining a Likert-type scale, with check boxes and written responses.

The purpose of the pre-questionnaire was two-fold: (1) to determine the students’ perceptions about their use of ICTs to this point in their pre-service teacher training, and (2) to position their thinking in a reflective mode as they engaged with the demands of this unit.

The post-presentation reflections (Appendix B) attempted to capture timely thoughts and opinions from the students in regards to themselves as learners and teacher practitioners directly preceding their presentation. The four questions were sent electronically to each student following their presentations, and participants had the option of submitting their reflections anonymously.
During the last tutorial of the semester, participating students were asked to complete the post-questionnaire (Appendix C). This questionnaire sought to determine whether participant confidence in incorporating digital technologies into their practice had increased as a result of participating in this unit. Participants were also given the opportunity to express concerns that they may have in regards to using digital technologies in schools, and ways in which the unit could be improved for the following year. As with the pre-questionnaire, the post-questionnaire was comprised of responses based on Likert-type scale, check boxes, and open written responses.

Data analyses

The data collected from the Likert-type scale and check box questions of the pre-questionnaire were analysed numerically, while the written responses were analysed using axial coding. This coding resulted in the identification of four themes: student engagement, teacher-student connection, teaching mathematics, and teacher training.

The responses to the post-reflection questions were transcribed and coded using Nivo9, and analysis resulted in six main themes relating to confidence, challenges, and teacher identity.

The data obtained from the post-questionnaire were handled in the same fashion as that collected from the pre-questionnaire. In this way comparisons could be made between similar questions, and the analysis of the written responses could reveal any participant self-reported growth in confidence and competence in using the DLTs.

Results

Pre-questionnaire

Based on the pre-questionnaire data, 57% of these third-year students at the beginning of their last mathematics unit of their program indicated that they were ‘a little’ to ‘not confident’ in teaching mathematics to students across the primary years of schooling. Furthermore, only 33% indicated that they felt confident about incorporating ICTs into their teaching practice. In regards to question 4 (To date in your pre-service training, how do you rate your access to digital technologies in mathematics?) only 21% of students expressed satisfaction with their access to digital technologies in mathematics units. Examples of the comments provided by the participants included:

- Little to no access to Smartboards; little exposure to maths games; no exposure to the mathematical value of [PowerPoint] or Excel in a primary setting.
- No opportunity given in any subject.
- Need more working Smartboards, HDMI inputs and training on using equipment.
- Found the Cabri program difficult to use; not enough training given, especially for first year.
- I would like more chance to practise and learn about the different options.
- I don’t even know how to use an IWB and I’m in 3rd year.

Responses to Question 7 (What role (if any) do you see digital technologies having in mathematics teaching and learning?) showed that these students valued the use of these technologies. Some of the main themes were:

- Student engagement
  
  Hopefully many as students are more engaged and enthusiastic when ICT is included in lessons.

- Teacher-student connection
  
  It allows teachers to connect with the students on a level they understand.

- Teaching mathematics
Reducing reliance on worksheets and textbooks; increasing the amount of ways we can teach maths to cater for more styles of learning.

*Students are more engaged in the lesson; they are at the centre of their learning.*

- Teacher training
  
  *We need to be taught earlier in our course in order to be proficient in the technology before we graduate.*

  *Digital technologies will play a crucial role in mathematics to succeed in our digitalized culture. I believe they will become more prominent through the years; therefore our experience at uni should at the very least match what is occurring in schools.*

**Post-presentation reflections**

Appendix D provides examples of student dialogue taken from the post-presentation reflections. Coding of the post-presentation reflections revealed five prominent themes, four of which are considered to be positive and one negative. The positive themes were related to student self-reported increased confidence to use the interactive whiteboard and ICTs to teach mathematics, improved personal engagement with mathematics, the effectiveness of learning from peers, and the development of their identity as teachers of mathematics not just students. The negative theme that was prevalent reflected the students’ frustrations with the equipment available to them at the university. This frustration stemmed primarily from their lack of access to interactive whiteboards on campus to practise using the technology.

**Post-questionnaire**

Data collected using the post-questionnaire indicated that 13% of participants reported being ‘very confident’ in incorporating digital technologies in their teaching of mathematics; 56% reported being ‘quite confident’; 29% indicated that they were ‘somewhat confident’; and only 2% reported feeling ‘a little confident’.

In regards to the second question (*Which digital technology (if any) would you definitely incorporate into your future teaching of mathematics?*) the distribution of preferred technologies was reasonably even: 26% for Interactive whiteboards, 29% for PowerPoint, 28% for Fun with Construction, and 17% for Excel. Other technologies nominated by the respondents were: iPads, YouTube, Internet, and Scootle.

Table 2 presents data from the third question (*What challenges (if any) could hinder your use of digital technologies in your teaching of maths in schools?*).

<table>
<thead>
<tr>
<th>Attitudes of other teachers</th>
<th>Access to software</th>
<th>My self-confidence</th>
<th>Access to hardware</th>
<th>Planning</th>
<th>Networking issues</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>28%</td>
<td>5%</td>
<td>20%</td>
<td>5%</td>
<td>16%</td>
<td>16%</td>
</tr>
</tbody>
</table>

There were two additional challenges mentioned by students: (1) the principal’s opinion of using technology in the classroom (in their practicum school), and (2) the time needed for the students to prepare for the use of digital technologies, including searching the internet and creating Smartbook pages or PowerPoint slides.
Question 4 of the post-questionnaire sought feedback in terms of teaching the unit in following years (In terms of digital technologies, how could this unit be improved?). 21% of participants felt that better access to the hardware, and in particular, the IWBs, was necessary. 15% of participants responded that access to the software needed to be improved; specifically the Smart Notepad. More training in the use of the hardware and the software and more time to become proficient with these was the response of 31% of participants (e.g., A tute where we are all in computer labs using FWC.). 33% of the respondents were satisfied or very pleased with the unit (e.g., I don’t think anything really needs to be improved. I really enjoyed this course and learnt a lot from it. Peer examples and presentations were a great way to learn.).

Discussion and conclusion

These pre-service teachers demonstrated a high degree of initiative. The majority of students downloaded the 30-day free trial of Fun With Construction and many of these students then went on to purchase the software. Other students, becoming frustrated with the limited access to the IWBs and associated software, downloaded the free trial version of the software for the Smartboard and thus were able to work more effectively off-campus. These students also found a wealth of tutorials and hints for use of the IWB technology on the website which they shared with the cohort on their Facebook site.

The most striking result from this study was the increased participant self-reported confidence with using ICTs: from 33% at the commencement of the project to 69% reporting to be ‘very confident’ or ‘quite confident’, with an additional 29% claiming to be ‘somewhat confident’. Although this purported increase in confidence does not necessarily translate into changes in practice, the students certainly have reflected on their prior learnings and new learnings which may be a positive step forward for them as they complete their training.

The unexpected outcomes resulting from the students participating in the unit were of more interest to myself as an educator. One such positive outcome of this study was the challenge to and deepening of the students’ conceptual knowledge of mathematics and how to deconstruct this knowledge in order to co-construct it with students. The DLT-based assessment task required that all students reflect on and, to a certain extent articulate, their understandings of big ideas in mathematics rather than become complacent with superficial, procedural or computational activity. The application task made the majority of students uncomfortable and required them to provide an environment for inter-activity and student-generation of knowledge. Perhaps such challenge and discomfort are prerequisites for transformative learning to take place.

The frustration felt and vocalised by several students was as much about their lack of ability and knowledge as it was directed at myself and the university. They were particularly critical about the lack of IWBs throughout the campus, and the limited access to the IWBs that were on campus. I also believe that the students found it difficult to conceive that a lecturer would set them tasks for which they themselves were novices; it is not clear if these students colluded with the attempt at creating a communal constructivism environment.

Another exciting outcome was that the students began to recognise the potential of such creative DLTs as a bridge between the use of familiar hands-on materials as representations and abstract representations of mathematical models. Many students referred to the DLTs as “hands-on” or “concrete materials” which led to discussion regarding concepts and pedagogical practices. After a time, most students could discriminate between actual hands-on materials and virtual manipulative materials, and recognise the potential of utilising both in their teaching of mathematics. Some even reflected on the notion that digital technologies do uniquely what other resources cannot do, for
example, the functionality of FWC to deconstruct an image of a 3D shape into separate plane shapes, and then snap the faces back together to reform the shape.

The most notable outcome was when these students realised that they had the capacity to create learning episodes for mathematics that were removed from the prevalent and ever-present “worksheet maths”. Interestingly some of the mature-age students of the group were vocal in their commendation of FWC to create worksheets more quickly and accurately, rather than embrace the interactive nature of the software. Other students shared their concerns about using DLTs in actual school classrooms in front of 30 or so students. This anxiety about performance had been evident in tutorials when students were unwilling (and some refused outright) to “do” mathematics on the whiteboard in front of their peers and tutor. This apparent low self-efficacy in terms of presenting mathematics was believed to fall further if they were required to use DLTs with which they were even less experienced and confident. Having the exploration and utilisation of DLTs directly linked to the assessment in the unit ensured buy-in and necessitated engagement with the software by the students. Furthermore, confidence was gained by the students after successfully presenting their DLTs to their peers, and their self-efficacy in using technology to teach mathematics increased due to these enactive mastery experiences.
References


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Appendix A            Pre-Questionnaire

1. How confident are you to teach mathematics across the year levels in primary school?

2. How confident are you to incorporate digital technologies into your teaching of mathematics?

3. What kinds of digital technologies have you experienced or observed being used on mathematics lessons during your Professional Experience block?

4. To date in your pre-service training, how do you rate your access to digital technologies in mathematics?

5. How does the use of digital technologies in mathematics units in your course so far differed from other units?

6. What kinds of digital technologies are you confident in using to teach mathematics?

7. What role (if any) do you see digital technologies having in mathematics teaching and learning?
Appendix B  

Post-presentation reflections

1. In what ways (if at all) has preparing for your app presentation improved your:
   (a) confidence in using ICTs in maths (b) competence in using ICTs in maths?

2. What were some particular challenges that you faced in undertaking this task?

3. Would you continue to pursue your use of ICTs for teaching maths? Why / why not?

4. Has seeing other apps being presented motivated you? If so, in what way/s?
Appendix C  Post-questionnaire

1. How confident are you now in incorporating digital technologies in your teaching of mathematics?

2. Which digital technologies (if any) would you definitely incorporate into your future teaching of mathematics?

3. What challenges (if any) could hinder your use of digital technologies in your teaching of mathematics in schools?

4. In terms of digital technologies, how could this unit be improved?
# Appendix D

## Post-presentation reflections

<table>
<thead>
<tr>
<th>Theme</th>
<th>Percent</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased confidence to use IWBs &amp; ICTs to teach mathematics</td>
<td>60%</td>
<td><em>I started with literally no knowledge of how to turn on an IWB let alone teach from it. I now know enough about this technology that I think I would be able to carry out a maths lesson using an IWB.</em></td>
</tr>
<tr>
<td>Equipment challenges</td>
<td>75%</td>
<td><em>It has improved my confidence quite a bit in using ICTs in maths as before preparing for this app presentation I had not had much experience with ICTs specifically in maths and had not considered how to use the IWB in teaching and learning maths. I am now confident to consider using ICTs and the IWB and to think outside the square and try new ways of incorporating ICTs into maths.</em></td>
</tr>
<tr>
<td>Engagement with mathematics</td>
<td>95%</td>
<td><em>I think it’s a great and interactive way to teach maths. Gives a bit of fun within the classroom and allows students to participate, manipulate and view maths in a different form.</em></td>
</tr>
<tr>
<td>Learning from others</td>
<td>75%</td>
<td><em>[seeing others’ presentations] provided different perspectives and methods to teach particular strands. Seeing different approaches has also helped in my own mathematics knowledge and teaching methods. It was a very worthwhile piece of assessment.</em></td>
</tr>
<tr>
<td>Teacher identity</td>
<td>40%</td>
<td><em>I honestly thought that maths was taught through sheets but using the IWB has shown me that there are fun ways to learn and teach mathematical concepts. I will definitely be using IWB and ICTs for teaching maths.</em></td>
</tr>
</tbody>
</table>

The students coming through schools today have more access to technology than ever before. It’s essential for me as a teacher to utilise these resources and give them learning experiences which incorporate these everyday resources.