MATHEMATICS EDUCATION ITE STUDENTS EXAMINING THE VALUE OF DIGITAL LEARNING OBJECTS

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Abstract

One issue in mathematics initial teacher education (ITE) is how to best support students to use digital technologies (DTs) to enhance their teaching of mathematics. While most ITE students are probably using DTs on a daily basis for personal use, they are often unfamiliar with using them for educative purposes in New Zealand primary school settings. Our mathematics education programme is finding ways to address this issue, beginning with a small research project. The study's aim is to support ITE students to develop critical thinking, confidence, knowledge and skill using DTs in teaching and learning. This paper arises from the larger action research study that sought 40 Year two ITE students' perceptions about the mathematical content of particular Digital Learning Objects (DLOs) promoted by the Ministry of Education, and how these might be used with learners in the classroom. Key research methods were survey instruments, field notes and classroom observations. Findings from two questions in student perception surveys (centred on any mathematics concepts and skills they thought the relevant DLOs would support children's learning, plus how these same DLOs could be used in primary classrooms) suggest that they would mainly use the DLOs to consolidate ideas already taught or learned.

Keywords

Mathematics education; digital technology; ITE students; TPACK

Background

In Aotearoa New Zealand, mathematics education continues to be a priority learning area in schools. Research findings indicate that mathematics understanding is enhanced when teachers engage with a range of instructional strategies and processes in their teaching, in order to accelerate learning (Anthony & Walshaw, 2007; Education Review Office, 2013). The *New Zealand Curriculum* states that "schools should explore not only how ICT can supplement traditional ways of teaching but also how it can open up new and different ways of learning" (Ministry of Education, 2007, p. 36). *Te Marautanga o Aotearoa* (Ministry of Education, 2008) also states that the use of ICT across the curriculum is critical for learners. Regardless of whether students are learning mathematics in English or Māori-medium classrooms, digital technologies (DTs) can increase the range of instructional resources available to both teachers and learners. Digital learning objects (DLOs) are a group of resources available to New Zealand teachers and initial teacher education (ITE) programmes. Digital technologies used in primary schools, such as DLOs, have the potential to help students see what happens when they manipulate geometric shapes, numbers or formulae.

Research into the use of DLOs can add to the existing explorations of other digital technologies for learning in New Zealand such as those undertaken by Calder (2011), and Ingram, Williamson-Leadley, Bedford, and Parker (2015). Internationally, Handal, Campbell, Cavanagh, and Petocz (2016) examined mathematics educational mobile apps in ITE. Their key finding was that ITE students should have opportunities to critically appraise the value of the DTs to include within their pedagogical practices. Lei (2009) has also highlighted concerns ITE students raised regarding developing such pedagogical and critical proficiencies.

Internationally, Mishra and Koehler's (2006) TPACK (Technological Pedagogical and Content Knowledge) framework, has gained wide acceptance as a model for understanding how teachers learn to use and evaluate the value of digital technologies. The interaction between content, pedagogy and

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technology forms the core of TPACK, which can also be used to inform teacher preparation as Koehler, Mishra, and Cain (2013, p. 13) argue, "The development of TPACK by teachers is critical to effective teaching with technology." The authors observe that such development best occurs as close to teachers' own practices as possible. In other words, as technological pedagogical content knowledge grows, pedagogical content knowledge shifts, influencing actual practices that positively affect the nature and quality of tasks that learners engage in (Assude, Buteau, & Forgasz, 2010).

Sutton (2011) concludes in her research that if preservice students are to develop skills and confidence in using DTs effectively, they need authentic learning experiences using technology as part of their teacher preparation programmes. They need lecturers who model using DTs in the same content areas they will be expected to teach in primary school classrooms. Without such experiences, ITE students have difficulty appreciating the relevance of digital technologies to specific learning areas. They also need time to reflect on and retain the digital technology skills they may be acquiring. This may also be true for teacher educators.

Teachers' mathematical knowledge for teaching can affect the way they use technology (Orlando & Attard, 2016). For ITE students who lack positive self efficacy in their own mathematical practices or teaching of mathematics, they have an additional hurdle to manage when they also are required to develop an appreciation of digital technology affordances for primary school classrooms. This can be further compounded if ITE students hold perceptions about what it means to teach mathematics that are based on personal experiences rather than research (McDonald, 2012). Encouragingly, Edson and Thomas (2016) suggest that teacher educators can do more than provide ITE students with digital resources. They can offer students opportunities to

- "construct their own mathematical knowledge as learners" (p. 233);
- "build robust knowledge" (p. 233) of how to use digital technology for teaching mathematics; and
- practise in the field. Practicum is an opportunity to safely take risks and try out resources and tools.

With this literature in mind, and the problem we faced of ITE students having difficulty appreciating the relevance of digital technologies to specific learning areas, we decided that investigating DLOs to support mathematics learning might enhance our understanding.

Research design

Although we were aware that our ITE students appeared 'tech savvy', we could also tell that often their digital use was confined to social networking and retrieving information (Lei, 2009; McDonald, 2012; Starcic, Cotic, Solomonides, & Volk, 2015). We therefore designed a project using action research to investigate how to support our ITE learners to teach mathematics well with DLOs. Ulvik's (2014) principles, extracted from a literature review about action research in ITE, provided the impetus to frame the research. Her principles included

- focusing on one aspect at a time;
- recognising students as important sources of information;
- having an impact on both theory and practice;
- prompting a rethink about pedagogical design;
- encouraging thinking with others;
- articulating experiences and learning;
- exploring one's own practices and resources;
- improving teaching and learning; and
- focusing on systematic information gathering.

These principles, coupled with reference to TPACK (Mishra & Kohler, 2006) were compelling in designing a project in which we sought the help of students to examine the value of DLOs to primary school mathematics lessons. To that end, we constructed a project based on TPACK principles and used a mix of qualitative and quantitative tools to find out what their experiences of using DLOs meant to them. Our overarching questions were:

- What are ITE student perceptions about the digital learning material and their use that they explore as part of their mathematics education course?
- What do the mathematics teacher educators learn about ITE student appropriation of digital technologies for their emerging pedagogical practice in mathematics?

Ethics approval was granted in advance of the project beginning, and consent and responsibilities protocols were discussed with all students before seeking their consent to use their contributions for the study.

Method

Main methods used in this project were surveys and lecturer evaluations of their own classroom observations. This article centres on two questions from the survey asked of the 40 ITE undergraduate students in a second year compulsory mathematics education paper. The two questions we chose as the focus of this paper are:

3. What mathematical concept(s) or skills do you think these DLOs will help children to develop?
4. If a colleague chose to use these DLOs, how and when would you suggest they be used?

The methods we chose were our best fit for combining Ulvik's action learning principles and Mishra and Koehler's (2006) model of developing teachers' knowledge and confidence to use digital technologies in learning. For example, across the wider project, we observed students working in groups, administered paper-based surveys and reviewed students' own teaching unit plans and reflections. Another method was the conversations between the two mathematics teacher educators and the teacher educator colleague who acted as the digital technology and action research adviser. This latter method helped us review our actions and interim explanations as well as track our own confidence in trying out different digital technologies.

Surveys were one part of the wider study and centred on students' use of the DLOs. To that end, we created learning opportunities in which our ITE students tried DLOs related to specific mathematical concepts appropriate for primary-school aged classrooms. The class spent 2–3 hours on an investigative task exploring relationships between area and perimeter, judging both the value of such a task and the pedagogical implications of the investigative approach. The task consisted of the following scenario:

> Holly just got a new lamb. Her mum offered to help her make it a moveable pen. They found they had 24 metres of fence netting.
>
> What shapes and sizes of pen could they make for the lamb?
>
> Holly is worried the lamb won't get enough to eat. Justify what shaped pen would give the lamb the most grass.

Students used grid paper and measurement materials to explore the problem. In exploring it, they could start with any shape and discuss ideas while writing and explaining their findings. The third lesson was a 45-minute session in a computer lab exploring selected DLOs on nzmaths.co.nz. The DLOs were about finding the area of rectangular, compound and various triangular shapes.

These DLOs were targeted at New Zealand Curriculum Levels 3 and 5 (children aged 10–14). The ITE students needed to identify the mathematics ideas within the DLOs and evaluate them for learning particular measurement ideas. ITE students were also expected to note any advice they would offer a colleague in recommending (or not) these DLOs.

Data Analysis

Given that TPACK (Mishra & Koehler, 2006) principles helped shape the structure of the project, it is fitting to use it as an analysis lens. In the wider project, we considered the pedagogical content knowledge students and lecturers were learning, alongside any growing technological pedagogical content knowledge. For the purposes of this article, however, we have restricted ourselves to focusing on the two questions as noted above. Analysis took the form of categorising frequency counts of responses, which helped identify patterns and trends. This was supported by using the frequency count affordance of word clouds to identify other ideas that might not have otherwise been immediately apparent as a crosscheck.

Results

After exploring the digital learning objects, students completed a written survey which consisted of seven questions, although responses from only two are examined here. Student responses were transcribed and coded from 1 to 40. Transcripts were then read by the first author to identify the mathematical themes or concepts. Nine themes were identified with the frequency of each theme calculated. Where students identified more than one mathematical idea, these were all recorded in the different category or theme. Data and themes were then presented to the other two authors and checked for consistency.

The following tables present a summary of students' responses to the two focus questions. Examples of responses to the first question are outlined in Table 1, which identified nine mathematics concepts or skills. The numbers in brackets indicate which participant code's idea is used to illustrate each mathematical idea. Where participants offered more than one idea, all were noted. To recap, n=40. Examples of responses to the second question are outlined in Table 1.

Table 1: Key Mathematical Ideas and Frequency of Responses

<table>
<tr><th>Key concepts or themes</th><th>Frequency</th><th>Examples of student responses (student code number/s at end)</th></tr>
<tr><td>Area</td><td>20</td><td rowspan="2">Calculating area of different shapes (16).
How to calculate area and different ways this can be achieved (5).
Looking at how you can apply simple formulas to more complex shapes (compound shapes). Identifying formulas (23).
Formula ½ height x base (19).
Some [of the DLOs] help understand the concepts behind often-used formula (17).</td></tr>
<tr><td>Use of formulae</td><td>17</td></tr>
<tr><td>Perimeter</td><td>2</td><td rowspan="2">Student codes
(36) and (40) (perimeter);
(32) and (31) (estimation).</td></tr>
<tr><td>Estimation</td><td>2</td></tr>
<tr><td>Number</td><td>9</td><td>Comments included
part whole thinking in regard to calculating the area of shapes (30);
multiplication and addition (28);
times tables (17);
basic facts (31);
multiplication (38) (36);
basic addition/ multiplication (29).</td></tr>
<tr><td>Shape</td><td>5</td><td>How to recognise certain shapes and geometry in itself (35)
Shape ID (3).
Breaking up a big shape into smaller triangles and squares (21).</td></tr>
<tr><td>Language & calculator skills</td><td>5</td><td>Language and using a calculator.
Mathematics language (37) (38) (40) (36).
How to use a calculator (17).</td></tr>
</table>

Many students focused on area and the use of formulae to identify what they thought the DLOs were useful for. This may also be in response to the focus of the lesson in which these DLOs were explored. However, being able to identify key mathematical ideas that DT resources and tasks promote is important for teachers expecting to positively impact on student learning (Orlando & Attard, 2016). Successful pedagogy relies on a number of factors, including teacher clarity about specific mathematics concepts and how these might be facilitated for learning (Roche, Clarke, Clarke, & Sullivan, 2014). Many ITE students in this study were able to not only recognise relevant mathematics ideas promoted by the DLOs, but were also able to make links to other less explicit mathematics ideas. They could also point to important skills such as developing language and using calculators. These responses are positive and may translate into successful learning in classrooms with relevant DLOs.

The second question, centred on suggestions for using DLOs in primary classrooms, encapsulated the findings as a frequency count (Table 2).

Table 2: Frequency Count of Potential Classroom Uses

Suggestions for use	Frequency count	Examples of student responses
Follow up task	25	As a follow-up task after explicit teaching tasks where teachers can see the students' answers … are still necessary to see student progress (3). ... after learning and exploring in a practical way e.g., drawing our own shapes finding out the area, using a 24m perimeter first then reinforcing it with an online game representing the same context (4). As an "after activity' concluding the lesson for students who are finished work (7). When concepts/formulas are already understood they could be used as consolidation of thoughts, ideas … (17). Follow-up activities for advanced students (31).
Children who struggle	5	Use for students who do not understand the concepts—extra help (30). To help struggling students understand as they are visually appealing (31).
Introduction to topic	3	When a student has no previous knowledge of calculating areas for compound shapes (10). At the start of teaching a new topic (39).
Teaching	2	As a support task alongside teacher-led learning (14). Model first to the class to explain how to navigate the website (24).
Independent group work	2	… could be used … when teachers are busy with another group (6) When you're working with a math group, the other group could use these DLOs to learn and stay on task (13).
Other	5	… could be used as a free time activity (6). Monitor learning and progression (4). Maybe midway through a geometry unit (37). For children who learn better with visual aspects (31). If students learn better with technology (29).

These results show that the ITE students saw DLOs as resources that could consolidate or reinforce learning after the main teaching has been completed. Perhaps such responses indicate that these ITE students do not see the DLOs as having a place in the centre of their teaching programme related to key mathematical ideas, but at the periphery. It is heartening to see that students were still able to suggest a range of alternative uses also for the DLOs that included supporting struggling students, introducing the topic of area, catering for visual learners and independent learning.

Discussion

Responses to the two questions suggest that ITE students felt that children need to explore the mathematics concepts—but before using a DLO, using other means. Perhaps this means that the ITE students did not see that DLOs should be treated as integral to teaching a concept or mathematical idea, but as tools to consolidate learning. One student proposed that a DLO could be used as a "support task alongside teacher-led learning". Tangentially, another student offered the idea that DLOs might form part of how to navigate the web, rather than an explicit focus on mathematical concepts. We wondered if these perceptions were related to how we, the mathematics educators, facilitated the DLO use with the ITE students. We had introduced the DLOs only after our students had explored specific measurement ideas using pen and paper activities. Perhaps, too, their responses were influenced by the way they had seen digital technologies being used in schools while on practicum. An unknown factor is the extent to which their own personal experience in harnessing DTs for learning is activated and we are still unsure of their confidence levels (Lei, 2009; McDonald, 2012; Starcic et al., 2015).

Using DTs as part of normal pedagogical practices can be complex. Current research findings (Edson & Thomas, 2016; McDonald, 2012; Starcic et al., 2015; Shinas, Karchmer-Klein, Mouza, Yilmaz-Ozden, & Glutting, 2015; Thompson, 2015) suggest that ITE students require much more support and guidance to understand how such technologies can be used as an integrated part of teaching than we may have first realised. This has large implications for our own technological pedagogical content knowledge and confidence.

There are, of course, some limitations to this set of findings. Firstly, a limited amount of time was devoted to exploring DLOs with these groups of students. Secondly, the findings addressed here arise from part of one very small survey. Thirdly, and perhaps significantly, the positioning of the exploration of the DLOs after they had explored the mathematics ideas on paper may have influenced the students' responses to the survey questions. This process may also have reaffirmed the idea that using digital technology to explore these ideas would be best suited as a 'follow-up'. It will be interesting to reverse the pedagogical process with a new cohort to test that hunch.

Current mathematics documents (Ministry of Education, 2007, 2008) suggest that a range of approaches and media should be used in the teaching of mathematics ideas, and research shows that not all students learn mathematics in the same way (Anthony & Walshaw, 2007; Attard, 2012). It is therefore incumbent on initial teacher educators to use a variety of approaches to model pedagogical practice, including varying the resources and technological affordances. This may go some way to expanding ITE students' knowledge and confidence in embedding DLOs into regular classroom mathematics lessons, thus simultaneously developing their TPACK expertise.

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