

Initial Teacher Education Students' Reasons for Using Digital Learning Objects When Teaching Mathematics

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A current issue in initial teacher education (ITE) in Aotearoa, New Zealand is how students can best be supported to use digital technologies for mathematics teaching. While many ITE students are familiar with digital technologies for personal use, they are less likely to know how to incorporate them into the mathematics learning process. Supporting ITE students to become more critical, knowledgeable, skilled, and confident about using digital technologies was the main aim of the study. Forty second-year ITE students were surveyed about the Digital Learning Objects promoted by the Ministry of Education that they would choose to use to teach area measurement. Several different reasons were reported.

In Aotearoa, New Zealand, mathematics education in primary schools has been identified as a priority learning area. Teachers have been encouraged to implement a variety of pedagogical strategies to enhance the teaching and learning process (Anthony & Walshaw, 2007; Education Review Office, 2013). The two national curriculum documents – The New Zealand Curriculum (Ministry of Education, 2007 – for English medium classrooms) and Te Marautanga o Aotearoa (Ministry of Education, 2008 – for Māori medium settings) – indicate that using ICT could be really useful for learners. For instance, the Ministry of Education (2007) 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” (p. 36).

To support teacher engagement in New Zealand with digital technologies, Te Pātaka Matihiko Our Digital Storehouse provides a gateway to a collection of digital learning objects (DLOs) produced by The Le@rning Federation (TLF), an initiative of Australian and New Zealand government departments (<https://nzmaths.co.nz/about-learning-objects#LO2>). The DLOs are interactive and designed to support student learning of key mathematical ideas from Year 1–10.

Research indicates that learning to use digital technologies effectively in mathematics education is complex and requires careful consideration and development of technological, pedagogical, and content knowledge expertise (Attard, 2013; Calder, 2017). In New Zealand, there has already been some exploration of using digital technology for learning mathematics (Calder 2011; Ingram, Williamson-Leadley, & Pratt, 2016). International research by Handal, Campbell, Cavanagh, and Petocz (2016) found that ITE students require numerous opportunities to explore and appraise digital technologies in order to make decisions about their worth as part of the teaching and learning process.

Area measurement is a core component of the mathematics and statistics learning area (Ministry of Education, 2007, 2008). Teachers need to be knowledgeable about key measurement ideas such as area because developing an understanding of this topic can be challenging for some children (Huang & Witz, 2011; Muir, 2006).

Teachers' mathematical knowledge for teaching can also affect the way they use technology (Orlando & Attard, 2016). Positive self-efficacy in their own mathematical practices means that ITE students can focus more on developing an appreciation of the affordances of digital technology for primary school learners.

Edson and Thomas (2016) suggest that as well as providing ITE students with resources, teacher educators 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.

According to Skemp (2006), for deep mathematical understanding, it is necessary for learners to have both conceptual and procedural knowledge, and know how to apply these in different situations. However, often in mathematics education, children are capable of completing calculations correctly and yet have difficulty in understanding what the calculations mean, and why those particular numbers are appropriate in a given context. These difficulties arise because children learn the rules or algorithms or formulae to derive the correct answer, yet have little or no conceptual understanding of why the procedure works (Skemp, 2006). Muir (2006) and Huang and Witz (2011) state that when children are learning about area measurement, they should be offered opportunities to develop conceptual understanding.

Effective teachers understand that their pedagogical practice must be varied so that all learners are provided with maximum opportunities to access, construct, and consolidate their mathematical thinking. Digital technologies can allow children to explore mathematical ideas in visually interesting and interactive ways. Learning can be enhanced by the manipulation of objects and the exploration of patterns and relationships (Calder, 2017).

Research Design

Mishra and Koehler’s (2006) TPACK (Technological Pedagogical and Content Knowledge) framework is a model for understanding how teachers learn to use and evaluate the value of digital technologies within the context of their own practices. Interactions between content, pedagogy, and technology forms the core of the model. Koehler, Mishra, and Cain (2013) argue that if teachers are to grow their technological know-how, it must be done in tandem with trials in their own classrooms for it to be meaningful and have lasting effect. 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’s (2011) research concludes that preservice students need authentic learning experiences using technology as part of their teacher preparation programmes. It is vital that lecturers model digital technology use in content areas that ITE students will be teaching. Without such experiences, ITE students have difficulty appreciating the relevance of digital technologies in learning contexts, or reflecting on and retaining the digital technology skills and knowledge they acquire.

Although we were aware that our ITE students appeared “tech savvy”, we suspected this was superficial in many cases, since their digital use was mainly confined to social networking and retrieving information (Starcic, Cotic, Solomonides, & Volk, 2015). We therefore designed a project to investigate how we could best support our students to teach effectively with digital learning objects (DLOs). 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 students' 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?

Method

For the larger study, we used surveys, field notes, and evaluations of our own classroom observations. The participants were 40 ITE undergraduate students in a second-year compulsory mathematics education paper and three lecturers. In framing the project's methods, we turned to Ulvik (2014), who had extracted a number of action research principles used in ITE. We used some of her key principles to inform our research design. These also linked to the TPACK (Mishra & Kohler, 2006) model that combines technology, pedagogy, and content knowledge for developing teacher knowledge and confidence when using digital technologies for teaching and learning. Focusing on one aspect at a time was crucial to avoid too many variables, which is why we focused on one component of mathematics, area measurement. We also saw students as important sources of information, which led to surveying them about their perspectives on the use of the DLOs. This also meant they could articulate their experiences and learning that, in turn, would inform our pedagogical and technological practices regarding the teaching and learning of area measurement.

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 included reflective notes and conversations between the two mathematics teacher educators (who were not confident about using digital technologies in mathematics education), 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.

We created a learning opportunity in which our ITE students explored DLOs related to area measurement ideas deemed appropriate for primary-school aged classrooms. The class spent two to three hours on an investigative task exploring relationships between area and perimeter, considering both the value of such a task and the pedagogical implications of an 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. They could start with any shape and discuss their thinking with others while writing and explaining their findings. The third lesson was a 45-60 minute session in a computer lab exploring selected DLOs on nzmaths.co.nz. The DLOs were about finding the area measurement of rectangular, compound, and various triangular shapes that targeted the Measurement and Geometry strand of the New Zealand Curriculum Levels 3 and 5 (children aged 10–14).

In this paper, we focus on one task from the survey. After identifying which DLOs they would use for teaching area measurement, the ITE students were then asked to “List three reasons for your choices”. Their responses to this task are the focus of this paper. Other questions included asking the ITE students to identify concepts and skills they thought the DLOs might support children to learn, identify any reasons they might have for not using the DLOs and offer suggestions to a colleague as to how the DLOs might be used.

Data Analysis

Given that TPACK (Mishra & Koehler, 2006) principles helped shape the structure of the project, it was 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. Analysis took the form of categorising frequency counts of responses, which helped identify patterns and trends.

Results

After exploring the digital learning objects, students completed a written survey that consisted of seven questions, although only one is examined here. Student responses ($n = 40$) were transcribed and coded from 1–40. Transcripts were then read by the first author to identify the key themes that emerged from students offering reasons for their choice of the DLOs they would use for teaching and learning measurement. Six key themes were identified with the frequency of each one calculated. Data and themes were then presented to the other two authors and checked for consistency.

Table 1 presents the themes and examples of students’ reasons for the DLOs they would select to use for teaching. The numbers in brackets indicate which participant’s (numbers 1-40) idea is used.

Table 1
Key Themes for ITE Students’ Choices and Frequency of Responses

Key themes	Frequency	Examples of student responses (participant number)
Simple/easy with opportunities to reinforce learning	11	... easily manipulate shapes (3) Level 3 tasks are worthwhile as it’s simple but students will still learn concept of area (20) These help reinforce ... the area of rectangles and triangles (22) Helps students consolidate their learning (31) ...explains what to do when you’re wrong without giving the answers (35) Allows children to do more examples (39)
Understanding	9	Area of triangles helped students understand why the formula is different to the area of a square (12) Understand what a m ² is (22) ...activities break the task down so it can give the students a basic understanding on the maths (28) Basic understanding of the concept and rules of

Key themes	Frequency	Examples of student responses (participant number)
Working with different shapes	9	<p>area (29)</p> <p>By breaking down the shape into blocks, it is likely to make the concept easier for children (10)</p> <p>Provides children with different shapes and different approaches or methods to calculate the areas (10)</p> <p>Gives children the ability to work with different shapes... Lets children break down the shapes (11)</p> <p>Able to explore ways of dividing shapes (24)</p>
Engaging and interactive	9	<p>The game style makes it fun and engaging for students (5)</p> <p>It is an interactive activity which allows children to easily figure out questions (11)</p> <p>Engages children through cartoon..... relevant to their interests (13)</p> <p>More interactive for children (23)</p>
Use formulae	4	<p>Teaches how to use formulas (13)</p> <p>Because it gives you options to find the correct formula. Students struggle with identifying the correct formula so this is great (15)</p> <p>... to find individual shape areas using relevant formula (24)</p>
Visual	4	<p>Great visual aid in learning (23)</p> <p>Suited for visual learners (24)</p> <p>It gave me a visual idea of how to split the shape & do the working out (37)</p>
Others	5	<p>They show progressions to the final result (16)</p> <p>It applies basic facts to answer complex problems (16)</p> <p>I could problem solve; it wasn't done for me (19)</p> <p>Makes children estimate before working it out (39)</p> <p>Because it gives the students a chance to be exposed to mathematical language (40)</p>

Discussion

It is pleasing to see that the ITE students' reasons for the selection of DLOs that they would use for the teaching and learning of measurement covered a wide range of ideas. Students appeared to consider that the digital objects they explored could play a role in enhancing learning experiences about area measurement for children.

Learning about measuring area needs to be made as simple as possible for learners because it can be a complex topic and confuse many (Huang & Witz, 2011). It is

incumbent, therefore, on teachers to provide a variety of opportunities for learners to access, construct, review, and consolidate their mathematical thinking as simply and clearly as possible. It is noted that 11 of these ITE students expressed support for this idea and considered that the DLOs that they selected were able to provide such opportunities for this to occur.

Another factor highlighted by some students was how the DLOs could support children to actually understand mathematical concepts and/or formulae. The notion of children developing a conceptual understanding of mathematical ideas such as area measurement is important for teachers to consider if they are to become effective practitioners (Anthony & Walshaw, 2007; Huang & Witz, 2011). Table 1 shows nine students' responses indicating that they thought it important for children to understand how or why a formula arises, what a square metre actually means in terms of covering a space, and what processes and strategies are involved in measuring area. Ultimately, learners will use formulae to accelerate their calculating, as a further four students noted in a separate theme in Table 1, but this should be based on understanding how such formulae are derived (Huang & Witz, 2011; Skemp, 2006). Developing an appreciation of the role that digital technology can play in facilitating such learning, and understanding key measurement content so that their pedagogical practice is maximized, are crucial for teacher TPACK to grow (Assude et al., 2010; Koehler et al., 2013; Mishra & Koehler, 2006).

Nine responses about the usefulness of working with compound shapes indicated that some of these ITE students have an appreciation of the importance of being able to find the area of a variety of shapes. This idea corresponds to the demands of curriculum documents in New Zealand for middle and senior primary school learners (Ministry of Education, 2007, 2008) and research by Huang and Witz (2011). It is heartening, firstly, that these ITE students appreciated the strategy of breaking up compound shapes into rectangles and/or triangles to calculate smaller manageable areas that could then be added together, and secondly, that they saw value in the DLOs for supporting this learning.

Engaging children in mathematical activities is important for their learning, and ITE students need to develop skills in considering factors that encourage mathematical engagement. Nine ITE students in this study felt that their choice of DLOs would support children's engagement with the mathematics ideas because of the contexts they provided. For example, using a cartoon for learning or perceiving a task as a game was seen as helpful for encouraging children's participation. This thinking aligns with Attard (2012) and Calder (2011, 2017), who suggest that presenting children with tasks in interesting contexts using digital technology can provoke interest and interaction.

Calculating the square metres of a classroom floor, and the use of grid paper where squares are covered by an item or used to capture the surface area of a shape, help children to "see" the task at hand and develop understanding of square units (Muir, 2006). Examples of comments from four ITE students in Table 1 indicate appreciation of the DLOs also providing opportunities for visual exploration (Calder, 2017) of shapes for learning about area.

In the final theme (Other), ITE students also suggested further possibilities that the DLOs offered for children's learning. These included opportunities for problem solving, using basic facts, making estimates, progressing to a final result, and learning appropriate mathematical language. It is encouraging to see ITE students' awareness of such issues in mathematics learning (Anthony & Walshaw, 2007).

Limitations and Conclusion

Research shows that not all children learn mathematics in the same way (Anthony & Walshaw, 2007; Attard, 2012). The findings from this study indicate that these ITE students consider the DLOs can offer another avenue for learning about area measurement.

There are a number of limitations in this study. The time given to students to explore the DLOs and make key decisions as to what they would use with learners was limited. The findings in this paper also only address one of the key questions that students were asked to respond to in the survey, and interviews with students would have helped explore their reasoning in more depth. Furthermore, the exploration of the DLOs was positioned after students had examined these ideas in a more traditional pencil and paper setting.

Reversing the order of the research process is one pedagogical implication for further ascertaining insights into ITE student thinking about the use of DLOs for teaching and learning mathematics. Implications for initial teacher educators also include providing ITE students with ample time to explore the use of the DLOs in their pedagogical practice, thereby supporting the development of student TPACK expertise. These aspects go hand-in-hand with careful pedagogical designs that focus on when these area measurement DLOs are explored. In further research, the survey used in our study could be complemented with interviews including ideas from students as to how mathematics education ITE programmes might further enhance their development as teachers.

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