Using Show and Tell Apps to Engage Students in Problem-Solving in the Mathematics Classroom

Naomi Ingram, Keryn Pratt and Sandra Williamson-Leadley

Abstract Show and Tell apps, which record students as they speak and write on a tablet, have a number of affordances for student learning in mathematics. One of these affordances is their utility in engaging students in problem-solving processes. Three iterations of research into Show and Tell apps present evidence that using Show and Tell apps for problem-solving can lead to improvements in the level and quality of student engagement. Students are encouraged to socially negotiate their understandings and Show and Tell apps can make student thinking more visible during this process. The apps also scaffold students to reflect on the processes they used for problem-solving.

Keywords Mathematics · Technology · Problem-solving · Engagement
Tablet · Show and tell apps · Group work · SAMR · TPACK

Problem-Solving in Mathematics

It is generally accepted that learning mathematics involves more than mastery of facts and procedures (Schoenfeld, 1992). Students need to be actively involved in solving problems (Holton, Neyland, Neyland, & Thomas, 1999). They need to learn how to reduce a problem to a mathematical form and to make sense of it by using the tools of abstraction, symbolic representation, and symbolic manipulation (Schoenfeld, 1992). They need to "wonder why things are, to inquire, to search for solutions, and to resolve incongruities" (Hiebert et al., 1996, p. 12). Problem-solving is therefore an important classroom practice as reflected in

N. Ingram (✉) · K. Pratt · S. Williamson-Leadley
University of Otago, Dunedin, New Zealand
e-mail: naomi.ingram@otago.ac.nz

K. Pratt
e-mail: keryn.pratt@otago.ac.nz

S. Williamson-Leadley
e-mail: sandra.williamson-leadley@otago.ac.nz

N. Calder et al. (eds.), *Using Mobile Technologies in the Teaching and Learning of Mathematics*, Mathematics Education in the Digital Era 12,
https://doi.org/10.1007/978-3-319-90179-4_17

mathematics curricula worldwide. For example, problem-solving is at the heart of the Singaporean curriculum (Ministry of Education, 2012) and is one of the four proficiencies in the Australian curriculum: Mathematics (Australian Curriculum, Assessment and Reporting Authority, 2016).

Problem-solving has multiple meanings across the field of mathematics education (see Bransford & Stein, 1984). These meanings often depend on the individual's beliefs about mathematics and range from working on rote exercises to doing mathematics as a professional (Schoenfeld, 1992). In this chapter, a mathematics problem is defined as a question or situation where the method of solution is not immediately obvious (Holton et al., 1999). As such, whether something is a problem depends on a range of factors, including students' knowledge and experience in solving problems of that type.

Doing mathematics is "an inherently social activity" (Schoenfeld, 1992, p. 335) where students learn mathematics by socially negotiating meaning (Jonassen, Carr, & Yueh, 1998). By interacting with other students and teachers, students can be exposed to new concepts in a more sophisticated manner than if they were exploring them individually (Cavanagh, 2016). When students share their problem-solving with others, they need to explain and justify their methods and these are reinforced or improved as they adjust their thinking, using others' ideas and the results of their investigations (Hiebert et al., 1996).

Mathematics teachers can support students in problem-solving in a number of ways. They can develop a classroom culture that supports the social negotiation of problem-solving (Pennant, 2013). They can also ensure a wide range of materials are available (Jones, 2013) and they can work on specific aspects of the problem-solving process with students, such as using a mnemonic device to reduce a word problem to a mathematical form (Bureau of Exceptional Education and Student Services, 2010). In addition, they can use technology in ways that support problem-solving.

This chapter will explore how technology, in the form of Show and Tell apps, can be used to engage students in problem-solving in the mathematics classroom through recording students working collaboratively as well as using 'Think Aloud" protocols to record their solving of the problem. We will first explore how technology can and has been used in mathematics classrooms, and how it can enhance engagement, before considering how technology can be used to support students' problem-solving in mathematics. Finally, we will report on a body of work that has explored the use of Show and Tell apps in mathematics classrooms, focusing on how their use has enhanced students' engagement in problem-solving.

Using Technology in Mathematics Classroom

Technology allows teachers to provide a wider range of opportunities and better cater for student needs (Conole, 2012; Hammond, 2010). For example, through access to encyclopaedic referencing sites (e.g., Wolfram Alpha) and Internet search engines, technology can easily supply knowledge when the need for it is identified during the problem-solving process. Technology can also supply solutions and commentary about well-known mathematical problems (e.g., the four colour theorem). It can organise and help to record solutions and strategies (e.g., Excel, Notability), or provide access to virtual manipulatives to support problem-solving (see https://nzmaths.co.nz/virtual-manipulatives). Technology in mathematics is often used to instruct the learners (Jonassen et al., 1998) or to judge the learner's response and provide feedback about the correctness of the response (Kim & Hannafin, 2011).

When teachers decide to use technology in their classroom practices, they need to consider that "teaching with technology is a difficult thing to do well" (Koehler & Mishra, 2009, p. 67), and depends on factors such as teachers' level of professional development, their experience in the classroom, and their technological, pedagogical, and content knowledge (TPACK) (Koehler & Mishra, 2009). One way of categorising how teachers use technology is the Substitution, Augmentation, Modification Redefinition (SAMR) model (Cavanaugh, Hargis, Kamali, & Soto, 2013; Puentedura, 2009). This model describes technology use on a continuum where technology can enhance teaching and learning in the form of Substitution or Augmentation, or can progress into transforming it, via Modification or Redefinition (Puentedura, 2009). As Puentedura explained, the lowest level of use involves using technology to complete a task that was previously possible, such as using a word processor rather than typing or handwriting a document (Substitution). Moving along the continuum, Augmentation involves some improvement in functionality, due to the affordances of the technology, such as using features like cut and paste in a word processed document, or online dictionaries. Within the transformation half of the continuum, Modification occurs when tasks can be redesigned because of the technology, such as using graphing packages or allowing for collaborative writing. The final level in the continuum is Redefinition and this occurs when teaching and learning tasks that would not have been possible without technology are implemented. An example of a task at the Redefinition level would be using virtual manipulatives where objects expand to show their nets.

Teachers also need to consider both the affordances and constraints of a particular technology before deciding whether or not the particular technology will enhance teaching and learning (Koehler & Mishra, 2008), and whether or not its use will be transformative or merely a substitute for what is already possible. Researchers have found that one of the affordances of technology is enhanced student engagement (Hammond, 2010), as well as benefits in terms of accessibility, diversity, communication, and collaboration (Conole, 2012; Hammond, 2010). There are also specific affordances associated with different technology devices. For example, tablets are portable, easy to use, and promote social interactivity (Blackwell, 2014; Ng, 2015). Koehler and Mishra (2009), Sinclair, Chorney and Rodney (2016) and Ladel and Kortenkamp (2012) are further examples of single use tablet technology apps for to illustrate the concept of affordances and constraints. If we consider this concept in regards to supporting students' learning in mathematics, a single use application, such as *Chicken Coop Fractions*, "affords students to practice their [fractional knowledge] but the constraint is that the teacher is not able to make changes to make it specific to an individual student's needs or context" (Koehler & Mishra, 2009, p. 6).

Engaging Students in the Mathematics Classroom with Technology

Enhancing students' engagement is a particularly important affordance of technology as low levels of student engagement in mathematics is viewed as detrimental to student learning (Sullivan, McDonough, & Harrison, 2004). The construct of engagement has its roots in the broader literature regarding affect and is related in a complex way to elements of students' relationships with mathematics, including views of mathematics, feelings about the subject, and identities (Ingram, 2011; McLeod, 1992). Students' engagement in mathematics is deemed to be vital to their acquisition of knowledge and strategies (Sullivan et al., 2004). Student engagement has been associated with a variety of academic, social, and emotional outcomes (Christenson, Reschly, & Wylie, 2012; Reeve, Jang, Carrell, Soohyn, & Barch, 2004), including finding that engagement is positively related to achievement (Dotterer & Lowe, 2011), motivation (Attard, 2012), and emotional wellbeing (Reschly, Huebner, Appleton, & Antaramian, 2008). Although engagement can be interpreted broadly as a student's participation in school (for example, Dotterer & Lowe, 2011), here engagement refers to the "behavioural intensity and emotional quality of a person's active involvement during a task" (Reeve et al., 2004, p. 147). As such, in this setting, engagement is considered to be students' involvement in the mathematical activity of the classroom and their commitment to learning the mathematical content.

Students' engagement in mathematics can be described by both its level and quality. The level is related to the strength of the engagement. The quality is related to the student's unique engagement skills. These engagement skills, as described by Ingram (2011), include: perseverance (continuing to do a mathematical task despite experiencing difficulty); integrity (searching for understanding as well as the correct answer); intimacy (emotional engagement in mathematics); independence (solving problems autonomously); concentration (the skill of remaining focused on the mathematics); utilisation of feelings (using negative affect as a signal to persevere or change strategy); cooperation (discussing mathematics with others); and reflection (being self-aware of problem-solving processes). Various aspects of the mathematics classroom have been found to have an impact on students' engagement, including classroom culture (Sullivan et al., 2004), the use of games (Bragg, 2012), a high level of student autonomy and involvement in decisions (Calder, 2013; Skilling, 2014), and the use of relevant contexts and student interests (Skilling, 2014).

There is a common understanding that students find using technology naturally engaging (Kuiper & de Pater-Sneep, 2014). Indeed, a number of studies have shown that using technology can be engaging for a wide variety of students, in a range of learning areas, and in a variety of contexts (O'Rourke, Main, & Ellis, 2013; Williamson-Leadley, 2016). However, this is not always the case (Kuiper & de Pater-Sneep, 2014; Selwyn, Potter, & Cranmer, 2009). The degree of engagement when students use technology depends on a range of factors, including what technology is being used, how it is being used and to what purpose, the wider school context, and other contextual factors (Kuiper & de Pater-Sneep, 2014; Selwyn et al., 2009).

Technology has also been found to have an impact on engagement in the mathematics classroom (Attard, 2014). A number of studies identified an increase in engagement amongst students learning mathematics when they used various forms of technology (see Attard & Curry, 2012; Chen, Liao, Cheng, Yeh, & Chan, 2012; O'Rourke et al, 2013). In contrast, Kuiper and de Pater-Sneep (2014) found that the students in their study preferred to use books rather than drill-and-practice software packages. From the research that has been conducted, it appears that in mathematics, as in other learning areas, how engaging technology is depends both on what technology is being used, and how.

Using Technology to Explore Problem-Solving in Mathematics

In order to explore the potential of technology to enhance engagement in problem-solving in mathematics, a form of technology with the appropriate affordances needed to be chosen. After consideration of a number of apps, a set of apps, described as Show and Tell apps (Williamson-Leadley & Ingram, 2013), were identified as having this potential. Show and Tell apps, such as *Educreations*, *Show Me*, and *Explain Everything*, are tablet apps designed to record the screen interactions of people writing on the tablet and talking in real time. *Educreations* was originally designed for teachers to record a mini-lesson, to "teach what they know and learn what they don't" (http://www.educreations.com). This involved a teacher using a tablet in much the same way as they would use a whiteboard; explaining the concept as they write notes or draw diagrams on the tablet. The key advantage of a Show and Tell app is that it records the audio and anything written or drawn on the tablet, and so could be later replayed. The affordances of Show and Tell apps, such as *Educreations*, for problem-solving include the real-time capture of students' discussion and engagement with the problem, while collaborating and/or thinking aloud, and also the functionality for them and others to review what has been recorded (Ingram, Williamson-Leadley & Pratt, 2016). Although these affordances can provide an insight into students' thinking, it must be acknowledged that it is not possible to fully access the internal thinking processes of students. However, when using these apps, students are encouraged to verbalise their thinking as they work through the problems, allowing deeper insight into their thinking processes than is possible by simply viewing their solution and/or working. As such, these apps have the potential to be used in transformational ways, as defined by the SAMR framework. That is, depending on their use, they can either modify or redefine teaching and learning as they provide information for teachers that is not possible to access in pen and paper-based solutions.

Ingram, Williamson-Leadley and colleagues (Ingram, Williamson-Leadley, Bedford, & Parker, 2015; Ingram et al., 2016; Williamson-Leadley & Ingram, 2013) have explored a number of different ways in which Show and Tell apps could be used in the mathematics classroom. Williamson-Leadley and Ingram (2013) explored how *Educreations* could be used for the assessment of primary students' numeracy through working with three primary teachers and then extended this work to investigate how Educreations could be used in primary and secondary mathematics classrooms (Ingram et al., 2015). This exploration was further expanded in 2016 to include how eleven teachers used a range of Show and Tell apps for tablets (Ingram et al., 2016) in their teaching. In the latter two iterations, after professional development, teachers were encouraged to explore the use of Show and Tell apps within their mathematics programmes over a period of two weeks, recording their written reflections in journals, collecting examples of students' work from the iPad apps, and also student written reflections on their experiences. The teachers had a range of teaching experience and taught students between the ages of 5 and 14.

This body of research indicated that students working with a Show and Tell app were perceived by teachers to have higher levels of engagement in mathematics, with this engagement being of a higher quality than was likely to occur without the apps. It was also apparent that Show and Tell apps had affordances for open-ended problem-solving. An example of an affordance was evident when Oscar, a Year 10 student, stated that the Show and Tell app "gives the ability to showcase your thought process and be able to review how you approach a problem (Ingram et al., 2015, p. 29). Karen, a primary teacher, found that having students use a Show and Tell app to record their thinking when solving open-ended problems and then sharing their work with each other generated discussion after they followed the way another student has solved the problem using a different strategy (Ingram et al., 2015). This chapter extends our research agenda by explicitly focusing on the level and quality of student engagement when using Show and Tell apps for problem-solving.

Methodology

To explore how Show and Tell apps enhanced the engagement of the students when problem-solving, the data sets across all three iterations of the Show and Tell project were re-analysed for examples of students using the apps to support problem-solving. The main data set included the reflective journals and transcribed interviews of 15 primary and one secondary teacher after two weeks of using Show and Tell apps in the classroom. Examples of student work were collected by these teachers and reflective data collected from 15 Year 10 students.

The qualitative coding was guided by our research into engagement and problem-solving and our previous research, which indicated that using the Show and Tell apps affected the level and quality of students' engagement. The first step was to identify any data that related to the use of Show and Tell apps for problem-solving. The first iteration of coding then saw this data separated into being related to either the level or quality of engagement. The level of engagement was not separated into discrete levels. Rather, any reference referring to the amount of engagement was sought, for example, "it helps with getting them more engaged in the mathematics." The data was then coded for quality using the engagement skills (described above). For example, when a teacher described focus, this was related to concentration. Three themes emerged related to the data on quality engagement on problem-solving: socially negotiating the mathematics, visible thinking, and reflection, and these coding categories structured the findings.

The following sections present these findings. With the exception of Hannah and Karen, teachers who were researcher/participants in the second iteration, pseudonyms have been used to protect the identity of the teachers and students. The study was conducted after the University of Otago Human Ethics Committee granted ethical clearance and informed consent was given by the teachers, students and their parents.

Findings

Show and Tell apps were used for problem-solving in a similar way across all classrooms. Depending on the age of the students, the problems ranged from one step addition, subtraction, and multiplicative problems to multi-step, open-ended word problems (e.g., Fig. 1). The solution or method was not immediately obvious to the student and they had the opportunity to "get stuck" (Hannah). Most teachers chose the problems themselves, although some teachers had a range of challenging problems available for students to choose from.

Most students worked in groups of up to four students around one tablet, although occasionally individual students worked on the same problem on separate

Four people can paint a fence with 30 panels in 3 hours. How long would it take five people to paint a fence with 25 panels?

Fig. 1 An example of a problem given to 14 year olds tablets. The teacher or a student put a written, typed, or photographed problem on a blank page within the Show and Tell app. The students then worked to solve the problems, recording their drawings, jottings, and solutions, using the same or subsequent pages. The students were explicitly encouraged to think aloud (that is, verbalise their thinking) during the process of problem-solving. This enabled both their work on the tablet and their thinking to be recorded simultaneously. The students often played back the recording to themselves, other students, the teacher, or the whole class.

Level of Engagement

According to the teachers, students engaged highly in problem-solving when using Show and Tell apps. At times, the novelty value of both using technology and Show and Tell apps were factors in the students' high level of engagement. However, teachers with students already accustomed to using technology within their classroom also described a high level of student engagement because it was "hands on, interactive and fun" (Mary). When doing problem-solving with Show and Tell apps, the students had an "on-task busyness" where they got on with the task at hand with "more focus" (Olive). The students were vocal about their enjoyment of using the Show and Tell app, "asking every day … if they were able to go and use it" (Angela). Hannah described her students as "confident and gregarious" when using Show and Tell.

Students normally lacking in confidence with mathematics became more involved.

> Using the app helped students who didn't have confidence in maths brought in another element and increased their engagement because they wanted to give things a go. (Hannah)

In addition, Angela, Olive and Helen found that high-achieving students became more engaged because they enjoyed the mathematical challenge. Using the Show and Tell apps ensured the students explained their steps and built on others' thinking, allowing them to go "deeper into the problem-solving" (Angela). Sometimes students' mathematical thinking went beyond what the teacher expected.

> Some of their mathematical thinking went well beyond. Like I'm saying, how did you get that? (Helen)

The students were enthusiastic to share their problem-solving with others and disappointed if they did not get an opportunity to do this. Indeed, time became an issue for the teachers because so many students wanted to share back their recordings.

> The bell would ring and they'd still be wanting to share it back. (Helen)

Quality of Engagement

The teachers noted the quality of the students' engagement when using Show and Tell apps for mathematical problem-solving. They believed the students concentrated, persevered, and remained engaged in the problems when they became difficult, because they were intimately involved with the mathematics of each problem. In other words, the students enjoyed exploring the possible solutions and the structures and patterns that emerged. They seemed to care about the process as well as the product. Their discussions and negotiations demonstrated that they had integrity; they cared if their answers were wrong or right, and they cared about their understanding that led to the answer.

> If they got stuck, they'd come and ask a question or they would go and talk to their classmates. (Mary)
>
> It's that confidence in themselves. Taking the time to slow down and make sure they are actually comprehending [the problem] when they are stuck. (Sara)
>
> Once she found a mistake she wanted to go back and do it again. (Cathy)
>
> They wanted to work on the problems and enjoyed exploring. (Ruth)

The beneficial impact of using Show and Tell apps had some limitations when used with younger students (aged between 5 and 6 years old). These students had difficulty in remaining engaged when the complexity of the task increased. In Cathy's multi-age class of 5–8 year olds, she found that pairing younger students with older classmates helped them to remain focused when working remotely.

Apart from these very young students, students worked well independently when using Show and Tell. They often demonstrated autonomy by making decisions about which problems to solve, who to work with, and how to report back on their problem-solving. They could "get their hands on it, take it away, and take charge" (Jennifer). Mary suggested that they enjoyed thinking aloud and recording away from the class because it was "non-invasive" and they had the time, space and independence to do it on their own terms, "without interference".

There were three ways that the use of Show and Tell apps particularly enhanced the quality of students' engagement in problem-solving activities. The processes used with the Show and Tell apps further enhanced the quality of student engagement through: (1) enabling the students to socially negotiate the mathematics; (2) making the students' learning and thinking visible; and (3) facilitating students' reflection on their mathematical learning and engagement skills.

Socially Negotiating the Mathematics

Show and Tell apps were useful for scaffolding the social negotiation implicit in mathematical problem-solving, particularly for those students older than eight. When students experience mathematics, the meanings they get from those experiences either reinforce or alter their previous understandings (Hannula, Evans, Philippou, & Zan, 2004). Negotiating meanings socially is particularly powerful.

Angela invited students to work together by asking two students to separately record their thinking about the same problem on a Show and Tell app and then come together to share their recorded solutions. By doing this, each student had individual thinking time and therefore had ownership of the problem when it came to sharing the recording with the other person and negotiating a correct path or answer. The initial recordings were just the first step in negotiating meaning and the solution.

In general, however, teachers had students work on the tablets in groups. Some teachers only had enough tablets for one per group; others chose that way of working. Hannah's 14-year olds worked in the same groups throughout their Number Unit. When the students worked in a group, there was first work to be done on the group dynamics and there was some "initial wrangling" (Angela) about who would do the role of scribe. The students often took turns to be the scribe, with the others joining in at a particular point in the problem-solving process, reaching over to jot down their ideas as they found a connection or could move the problem forward. Working in this way meant "it got messy" (Hannah), as people talked over each other, worked on separate sections, and contributed to the written or spoken recording. Jennifer's students interacted because of the use of Show and Tell. They "showed their thinking to each other [which] provided good discussion and learning". The dialogue created in the process of recording and sharing these recordings meant that students were seamlessly justifying and negotiating their learning.

In general, the making of these recordings encouraged the students to clearly explain their thinking, which in turn helped them to discuss the solution and solve the problem. The process of thinking aloud for the recording, contributing to the cooperative problem-solving, and further justifying their thinking when sharing their recording with others, encouraged the students to explain their ideas.

> It makes you fully explain your ideas. (Roland, Year 10)

> Some ideas simply don't fall on paper and others just can't be said, but when you combine both, a combination of writing and speaking suddenly you can convey your ideas. (Mitchell, Year 10)

Nine of the thirteen teachers in the latter iterations gave the students the opportunity to share their recording with the class. Mary noted that it was a safe way for students to receive feedback because the recording started the initial conversation, rather than the student having to talk.

> It's a removed way of getting feedback in class [when they are sharing their recording]. Yes I'm on there, but I'm not standing up there giving you the answer. (Mary)

This sharing of the recording showed the range of strategies used and was a catalyst for dialogue as the class then discussed the recordings, made decisions on the most efficient strategy, or pointed out errors. Rather than the teacher solely providing student feedback, the students were co-constructing meaning through negotiation, as Helen found out when one group presented incorrect problem-solving.

> There was one group that got it all wrong. When they watched it back the other kids were able to see exactly the steps that they'd gone wrong and pointed it out to them, rather than me pointing it out, so that was, you know quite … powerful, motivating for them. (Helen)

Visible Thinking

According to the teachers, Show and Tell apps enabled the students' thinking to be visible to others. The recording, encompassing the dialogue, writing, and the drawing, captured the evolution of the problem-solving process in all its messiness. This enhanced the problem-solving for the students.

> They learnt from being able to see others' thinking visually. (Jennifer)

The app also made the students' learning processes explicit for the teachers. Two teachers found it difficult to assess the students when they worked in groups.

> When they were in groups, they worked together so I don't know who did actually what. (Ruth)

The remaining teachers found that they were able to closely monitor the thinking of individuals, even when they were working with others. By viewing the recording, teachers were able to critically analyse and assess students' understandings by differentiating the students' voices.

As they viewed the recordings, teachers of all ages of students were sometimes surprised about aspects of the students' understandings that may have been missed otherwise. Sometimes students' issues were more about misunderstanding the question, or for the younger children, their number formation, rather than their mathematical understanding per se. For example, Mike was surprised at how many students were writing the one's digit before the ten's digit in a two-digit number. At other times, the teachers found that deep understanding was not occurring, when on the surface the student appeared to understand. As Mary noted,

> Sometimes kids look like they understand it, but when you dig that bit deeper and look at them through the whole process, actually they're not. On a piece of paper sometimes you don't see all those things unfolding.

By playing back their recording, the students' problem-solving was visible and therefore they were able to reflect on their mathematics, find mistakes in their process, and self-correct. Mike described how one of his students, James, felt comfortable enough during playing the recording to scroll back through the pages and change an answer he realised was incorrect, before editing the rest of the pages in front of the audience. Mike identified the power of this:

> James had the understanding [and] he was really interested to go back and see what he did and unpack it … it's very powerful for their own learning to go back and see where they've missed a number or where they've misinterpreted something.

Reflection

Usually scaffolded by the teacher, the students engaged in reflective dialogue about the affective aspects of their problem-solving, including the different ways that they and their classmates engaged. Using the Show and Tell apps with explicit teaching about engagement gave the students the opportunity to reflect on their engagement and learning during the problem-solving processes.

> The main thing I got out of this trial was the importance of reflecting on your learning. I think that's the best thing. Using [Show and Tell on] the tablets meant that we could be explicit about engagement. The boys thought way more about their engagement. Being stuck in maths. Satisfaction. Perseverance. What maths feels like. (Hannah)

> [Show and Tell] gives you the ability to … be able to review how you approach a problem. (Oscar, Year 10)

Discussion and Conclusion

For these participants, Show and Tell apps were seen as a useful tool for problem-solving in mathematics. They worked well to record the 'messy' and iterative process of students' individual and cooperative problem-solving and, when shared, these recordings were beneficial for the co-construction of students' mathematical understandings. Teachers believed that students were both more engaged and engaged for longer in the problem-solving process when they were using Show and Tell apps. Furthermore, it appeared that using these apps enhanced the quality of student engagement. Students persevered with problems, cared about not just the answers but also the process of finding solutions, and were able to be autonomous as they worked to solve problems. The use of these apps supported the social negotiation process that is mathematical doing, made the thinking visible, and was a useful tool for student reflection regarding both the mathematical problem-solving process and the quality of their engagement in that process. The teachers were able to be more explicit about the importance, level, and quality of students' engagement when problem-solving.

Although Show and Tell apps show great promise for increasing student engagement in problem-solving in mathematics, it must be noted that there are a number of limitations to both the research done to date and the use of Show and Tell apps. The conclusions drawn are based on three small-scale qualitative studies, involving 15 primary and one secondary teacher from one city. In addition, there are a number of practical considerations that must be taken into account when deciding whether or not to use Show and Tell apps. Issues such as where data is stored, the availability of working technology, and the time required to make best use of the recorded material all need to be considered. It is clear, however, that Show and Tell apps show promise in their ability to enhance students' problem-solving.

The decision to use Show and Tell apps was made thoughtfully, based on a consideration of the affordances of the technology, and the desired outcome. In line with the TPACK framework, the technology, pedagogy, and content each had to be considered, with the choice then based on how best to integrate technology to facilitate engagement in problem-solving in mathematics. Rather than simply choosing a technology that could substitute or augment current approaches, a transformative tool was chosen. The Show and Tell apps appeared able to transform classroom practice, redefining how teachers could engage students in the problem-solving process.

References

Attard, C. (2012). Engagement with mathematics: What does it mean and what does it look like? *Australian Primary Mathematics Classroom, 17*(1), 9–13.

Attard, C. (2014). "I don't like it, I don't love it, but I do it and I don't mind": Introducing a framework for engagement with mathematics. *Curriculum Perspectives, 34*(3), 1–14.

Attard, C., & Curry, C. (2012). Exploring the use of iPads to engage young students with mathematics. In J. Dindyal, L. P. Cheng, & S. F. Ng (Eds.), *Proceedings of the 35th Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 75–82). Singapore, Singapore: MERGA.

Australian Curriculum, Assessment and Reporting Authority (2016). Retrieved from http://www.australiancurriculum.edu.au/mathematics/aims.

Blackwell, C. (2014). Teacher practices with mobile technology integrating tablet computers into the early childhood classroom. *Journal of Education Research, 7*(4), 1–25.

Bragg, L. A. (2012). The effect of mathematical games on on-task behaviours in the primary classroom. *Mathematics Education Research Journal, 24,* 385–401. https://doi.org/10.1007/s13394-012-0045-4.

Bransford, J., & Stein, B. (1984). *The IDEAL problem solver: A guide for improving thinking, learning, and creativity*. New York, NY: W.H. Freeman.

Bureau of Exceptional Education and Student Services. (2010). *Classroom cognitive and meta-cognitive strategies for teachers: Research-based strategies for problem-solving in mathematics K-12*. Tallahassee, FL: Florida Department of Education.

Calder, N. (2013). Mathematics in student-centred inquiry learning: Student engagement. *Teachers and Curriculum, 13,* 77–84.

Cavanagh, M. (2016). Introduction: The learning and teaching of mathematics. In G. Hine, R. Reaburn, J. Anderson, L. Galligan, C. Carmichael, M. Cavanagh, B. Ngu, & B. White (Eds.), *Teaching secondary mathematics* (pp. 2–27). Melbourne, Australia: Cambridge University Press.

Cavanaugh, C., Hargis, J., Kamali, T., & Soto, M. (2013). Substitution to augmentation: Faculty adoption of iPad mobile learning in higher education. *Interactive Technology and Smart Education, 10*(4), 270–284. https://doi.org/10.1108/ITSE-01-2013-0001.

Chen, Z.-H., Liao, C. C. Y., Cheng, H. N. H., Yeh, C. Y. C., & Chan, T.-W. (2012). Influence of game quests on pupils' enjoyment and goal-pursuing in math learning. *Educational Technology & Society, 15*(2), 317–327.

Christenson, S., Reschly, A. L., & Wylie, C. (2012). *Handbook of research on student engagement*. Singapore, Singapore: Springer.
Conole, G. (2012). *Designing for learning in an open world (Explorations in the learning sciences, instructional systems and performance technologies)*. London, United Kingdom: Springer.
Dotterer, A., & Lowe, K. (2011). Classroom context, school engagement, and academic achievement in early adolescence. *Journal of Youth and Adolescence, 40*(12), 1649–1660.
Hammond, M. (2010). What is an affordance and can it help us understand the use of ICT in education? *Education and Information Technologies, 15*(3), 205–217.
Hannula, M. S., Evans, J., Philippou, G., & Zan, R. (2004). Affect in mathematics education—Exploring theoretical frameworks. In *Proceedings of the Twenty-Eighth Conference of the International Group for the Psychology of Mathematics Education.* (Vol. 1, pp. 107–136). Bergen, Norway: PME.
Hiebert, J., Carpenter, T., Fennema, E., Fuson, K., Human, P., Murray, H., et al. (1996). Problem-solving as a basis for reform in curriculum and instruction: The case of mathematics. *Educational Researcher, 25*(12), 12–21.
Holton, D., Neyland, A., Neyland, J., & Thomas, B. (1999). *Teaching problem-solving: An introduction for primary and junior secondary teachers*. West Sussex, United Kingdom: Kingsham Press.
Ingram, N. (2011). *Affect and identity: The mathematical journeys of adolescents* (Doctoral dissertation). University of Otago, Dunedin, New Zealand. Retrieved from http://hdl.handle.net/10523/1919.
Ingram, N., Williamson-Leadley, S., Bedford, H., & Parker, K. (2015). Using Show and Tell tablet technology in mathematics. In R. Averill (Ed.), *Mathematics and statistics in the middle years: Evidence and practice* (pp. 18–34). Wellington, New Zealand: NZCER.
Ingram, N., Williamson-Leadley, S., & Pratt, K. (2016). Showing and telling: Using tablet technology to engage students in mathematics. *Mathematics Education Research Journal, 28*(1), 123–147.
Jonassen, D., Carr, C., & Yueh, H. (1998). Computers as Mindtools for engaging learners in critical thinking. *Techtrends, March,* 24–32.
Jones, M. (2013). *Mathematics problem-solving: What factors inhibit student achievement? What factors are effective in raising achievement?* Retrieved from http://www.educationalleaders.govt.nz/content/download/53112/441891/file/Mary%20Jones%20Sabbatical%20Report%202013.pdf.
Kim, M. C., & Hannafin, M. J. (2011). Scaffolding problem-solving in technology-enhanced learning environments (TELEs): Bridging research and theory with practice. *Computers and Education, 56,* 403–417.
Koehler, M. J., & Mishra, P. (2008). Introducing technological pedagogical content knowledge. In AACTE Committee on Innovation and Technology (Eds). *Handbook of Technological Pedagogical Content Knowledge (TPCK) for Educators* (pp. 3–29). New York, NY: Routledge.
Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60–70.
Kuiper, E., & de Pater-Sneep, M. (2014). Student perceptions of drill-and-practice mathematics software in primary education. *Mathematics Education Research Journal, 26*(2), 215–236. https://doi.org/10.1007/s13394-013-0088-1.
Ladel, S., & Kortenkamp, U. (2012). Early maths with multi-touch—an activity-theoretic approach. In *Proceedings of POEM 2012*. Retrieved from http://cermat.org/poem2012/main/proceedings_files/Ladel-Kortenkamp-POEM2012.pdf.
McLeod, D. (1992). Research on affect in mathematics education: A reconceptualization. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 575–596). New York, NY: NCTM and Macmillan.
Ministry of Education (2012). *Secondary mathematics syllabus 1–4*. Singapore, Singapore: Ministry of Education. Retrieved from http://www.moe.edu.sg/education/syllabuses/sciences/.

Ng, W. (2015). *New digital technology in education: Conceptualizing professional learning for educators* (pp. 171–189). Cham, Switzerland: Springer.
O'Rourke, J., Main, S., & Ellis, M. (2013). So the kids are busy, what now? Teacher perceptions of the use of hand-held game consoles in West Australian primary classrooms. *Australasian Journal of Educational Technology, 29*(5), 735–747.
Pennant, J. (2013). *Developing a classroom culture that supports a problem-solving approach to mathematics*. Retrieved from https://nrich.maths.org/10341.
Puentedura, R. (2009). *Transformation, technology, and education*. Retrieved from http://hippasus.com/resources/tte/.
Reeve, J., Jang, H., Carrell, D., Soohyn, J., & Barch, J. (2004). Enhancing students' engagement by increasing teachers' autonomy support. *Motivation and Emotion, 28*(2), 147–169.
Reschly, A., Huebner, E., Appleton, J., & Antaramian, S. (2008). Engagement as flourishing: The contribution of positive emotions and coping to adolescents' engagement at school and with learning. *Psychology in the Schools, 45*(5), 419–431.
Schoenfeld, A. H. (1992). Learning to think mathematically: Problem-solving, metacognition, and sense making in mathematics. In D. Grouws (Ed.), *Handbook for research on mathematics teaching and learning*. New York, NY: MacMillan.
Selwyn, N., Potter, J., & Cranmer, S. (2009). Primary pupils' use of information and communication technologies at school and home. *British Journal of Educational Technology, 40*(5), 919–932. https://doi.org/10.1111/j.1467-8535.2008.00876.x.
Sinclair, N., Chorney, S., & Rodney, S. (2016). Rhythm in number: Exploring the affective, social and mathematical dimensions of using TouchCounts. *Mathematics Education Research Journal, 28*(1), 31–51. https://doi.org/10.1007/s13394-015-0154-y.
Skilling, K. (2014). Teacher practices: How they promote or hinder student engagement in mathematics. In J. Anderson, M. Cavanagh, & A. Prescott (Eds.), *Proceedings of the 37th Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 95–102). Sydney, Australia: MERGA.
Sullivan, P., McDonough, A., & Harrison, R. T. (2004). Students' perceptions of factors contributing to successful participation in mathematics. In M. Johnsen Hoines & A. Berit Fugelstad (Eds.), *28th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 3, pp. 289–296). Bergen, Norway: Bergen University College.
Williamson-Leadley, S., & Ingram, N. (2013). Show and tell: Using iPads for assessment in mathematics. *Computers in New Zealand Schools: Learning, Teaching, Technology, 25*(1–3), 117–137.
Williamson-Leadley, S. (2016). *New Zealand primary teachers' ICT professional development and classroom practices*. (Doctoral dissertation). Deakin University, Geelong, Victoria, Australia.

Naomi Ingram is a lecturer and researcher in primary and secondary mathematics education at the University of Otago, College of Education, New Zealand. Prior to this, she was a secondary school mathematics teacher in New Zealand and the Sultanate of Oman. In Oman she worked in an international school that has delivered a one-to-one iPad programme since 2010. Teacher registration and continuing contact with the teaching community through research, educating pre-service teachers and professional development are important aspects of Naomi's identity.

Keryn Pratt has a PhD in psychology and is a researcher and lecturer at the University of Otago, College of Education. She lectures in ICT in education, distance learning and quantitative research methodologies. Her research includes the experience of distance students; both distance postgraduate students and secondary school students who are involved in distance learning using videoconferencing and other technologies.

Sandra Williamson-Leadley Originally from Canada, Sandra Williamson-Leadley has lived in New Zealand for over 30 years. She is an experienced primary teacher who has worked as a researcher and lecturer at the University of Otago, College of Education since 2012. She teaches curriculum, e-learning, ICT and technology and her research interests include professional development, the use of ICT in schools and e-learning.