Digital Technologies:
Igniting or hindering curiosity in mathematics?

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Three different digital technologies (Adobe Spark Plug Video, Padlet and Code.org) are used to stimulate curiosity, encourage higher-order thinking, and build positive mind-sets. Technology and curiosity can work in partnership to promote students' reasoning skills.

The world in which our students are learning is unique. Technology is progressing rapidly, and this is having a direct impact on teaching and learning. Teachers have the choice to embrace this or not. The instant access to information has the power to change pedagogies and students' experience of mathematics learning. Hence several questions arise: Do the digital technologies support students' curiosity towards mathematics? Or does access to the technology hinder this curiosity? How do teachers ensure that they are making appropriate use of technology to facilitate children's learning?

Engagement in mathematics

Mathematics is a complex discipline. Many parents, teachers and students have set mindsets on what mathematics is, and their ability to achieve. Thus, engagement in mathematics in the primary years is vital. In a past issue of *Australian Primary Mathematics Classroom*, Attard and Northcote (2011) outline that technology needs to be used purposefully to enhance the learning of mathematics, ultimately promoting engagement. "When good pedagogy drives the incorporation of technology into mathematics teaching and learning, ICTs have immense potential to enhance student experiences with mathematics" (p. 30). Attard (2012, p. 23) suggests that students should experience "cognitive, effective and operative levels of engagement with mathematics" resulting in an experience that inspires students to question, find out more and demonstrate curiosity. Attard and Northcote (2011) suggest that technology can be used to assist this engagement, however this needs to be done with a clear mathematical focus in mind.

The work of Boaler (2016) outlines that posing interesting and challenging questions, valuing students' thinking, and not focusing on the 'correct' answer, allows students the freedom to represent their thoughts creatively and with a desire to learn.

This positive experience towards mathematics shapes attitudes and mindsets. However, the added layer of technology has the ability to either hinder or help learning depending on how teachers use the technology (Attard, 2017; Moersch, 1995). This article addresses both of these areas to ensure teachers are intentional about how they use technology to guide students towards mathematical understanding whilst also promoting wonder and curiosity. The challenge for teachers is to ensure that engagement occurs with the mathematics not just the technology.

The role of technology in the mathematics classroom

Before considering how technology helps or hinders curiosity in the mathematics classroom, it may be helpful to look at the Substitution, Augmentation, Modification, and Redefinition (SAMR) model of using technology (Puentedura, 2009).

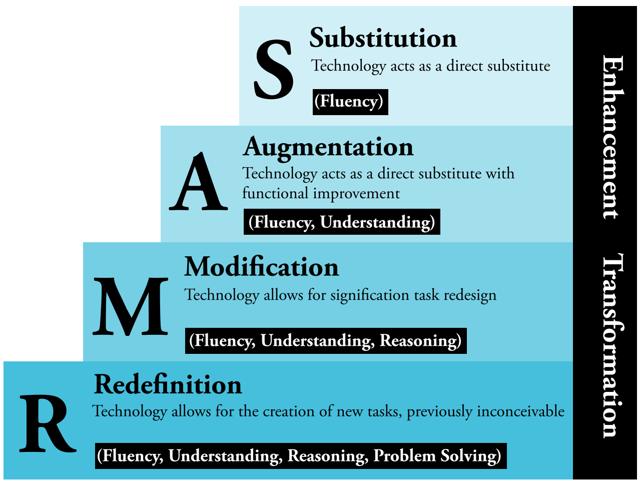

Figure 1. SAMR Model merged with Australian Curriculum Proficiencies (adapted from Attard, 2015).

The SAMR model "provides a framework to support educators and instructional designers in creating optimal learning experiences using mobile devices in education" (Romrell, Kidder, & Wood, 2014, p.1). This model outlines that technology can be used through substitution and augmentation, which uses technology as a substitute for other teaching methods. Or it can be applied through modification and redefinition which ultimately transforms learning through using technology to redesign and re-imagine learning experiences. The SAMR model has been linked to many other learning theories, including Bloom's Taxonomy (Bloom, Engelhard, Furst, Hill & Krathwohl, 1956) and Technological, Pedagogical Content Knowledge (TPCK) (Guerrero, 2010). However, Attard (personal communication, September 2017) states that a helpful way to view this model is through the *Australian Curriculum: Mathematics* mathematical proficiencies (Australian Curriculum and Reporting Authority (ACARA), 2017). Figure 1 suggests that substitution only builds fluency in a way that flash cards, dice or another non-technological resource may do. Another example is using YouTube to explain a mathematical idea. Augmentation involves similar substitution, however, understanding of mathematical concepts may also develop (for example, using online notes or shared documents to document and communicate understanding). Modification involves reasoning being explained or developed (for example, students screen recording an explanation of a mathematical procedure or concept and then sharing that with their peers). Redefinition uses applications such as iMovie or podcasting for students to explain, problem-solve and share their knowledge in a creative and collaborative manner. Using technology to allow the creation of new tasks also gives the ability to achieve all elements of the mathematical proficiencies including problem solving and reasoning. Examples of these tasks will be explored.

Thinkers Keys and Mathematics





Question Key	Reverse Key	Improvements Key
The answer is 60 minutes. What might the question be?	List 10 things that you would NOT time using seconds.	Design a new, improved clock face. Justify your improvements.
What if Key	**Construction Key**	**Alphabet Key**
What if timetables/ routines were not used at school? Create your ideal weekly school timetable/ routine.	Construct a timeline of daily events (to scale) e.g., waking up, start of school day, recess, lunch using both 24-hour time and AM and PM notation.	List words from A –Z that are realted to time.
BAR Key	**Alternatives Key**	**Brainstorming Key**
In your group, discuss the functions of a calendar. Improve the design of a calendar. Make a model of your newly designed calendar.	List ways you can measure a minute without a clock or timer. Order the ways from most to least effective.	Brainstorm as many ways to measure time as you can think of.

Figure 2. Thinkers Keys and Mathematics (Attard, 2013).

Why is curiosity important?

It has been outlined that it is important that students are engaged in mathematics to build a positive mindset towards the discipline of mathematics (Boaler, 2016). The SAMR model (Puentedura, 2009) has been shown to demonstrate that technology can be used for a range of purposes within the mathematics classroom. One of the focal points of this article is curiosity, and why it might be important to the learning of mathematics. Curiosity can empower learners to engage in interesting and incidental learning that can positively impact students' interactions and engagement with mathematics (Attard, 2017). Schwartz and Bransford (1998) compared different teaching methods and describe that when students "were given opportunities to explore the problems, they became curious, and their brains were primed to learn new methods" (in Boaler, 2016, p.66). As a result, Boaler (2016) experimented with different teaching methods including comparing teacher-directed and student exploration with similar findings. They outlined that when students are given a challenge or a problem to solve they stop focusing on following procedures and start using their own "thinking, sense making and reasoning" (Boaler, 2016, p.69). Students' curiosity consequently leads them to building understanding and seeking to know more about different mathematical methods. The work of Shah, Weeks, Richards and Kaciroti (2018) state that cultivating curiosity in the early years is a contributor to academic achievement. This is particularly apparent for students from lower socio-economic communities. As a result, it is important that play and exploration are part of children's learning experiences.

A culture of curiosity

One way to shape a culture of curiosity in the mathematics classroom may be through developing higher-order thinking skills. Stapels and Truxaw (2012, p. 258) acknowledge that "in focusing on higher-order thinking practices, we take on the particular issue of supporting students in engaging in a conceptual discourse". They argue that the language of higher-order thinking must be taught to enable students to engage in mathematics in this way. A blog post by Attard (2017) on critical thinking in mathematics recommends using 'thinkers keys'. These keys model a language of curiosity and can be viewed in Figure 2. The challenge for teachers is to merge this language of higher-order thinking with technology while still ensuring the mathematics is the focus of the inquiry, not the technology. The next part of this article will address how technology can help a child gain a real sense of self, wonder and awe in regard to learning mathematics.

When curiosity can be hindered by technology

As already stated, a teacher has the biggest impact on student engagement. Attard (2017) acknowledges that a teacher modelling curiosity and questioning is vital to a student's involvement in their mathematics learning and wondering. The danger with technology is that teachers can use applications and technological devices that simply build fluency skills and act as a direct substitute for other resources, as implied in the SAMR model (Puentedura, 2009). This teacher-directed learning does not enable the technology to be used as a tool to support higher-order thinking and can hinder curiosity. The awareness of this idea is not unique to recent times. Moersch (1995) reflected on the use of computer literacy classes and stated that technology needs to serve as a "catalyst for change" not simply to "sustain the existing curricula" (p. 40). This is still relevant today, particularly with the fast-paced progression of technology. Younie, Leask and Burden (2015) discuss the idea of a digital native generation. This generation only know a world

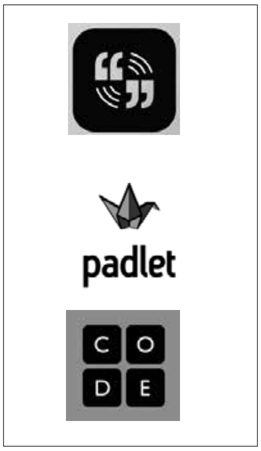

Figure 3. Digital Technology applications that can promote curiosity.

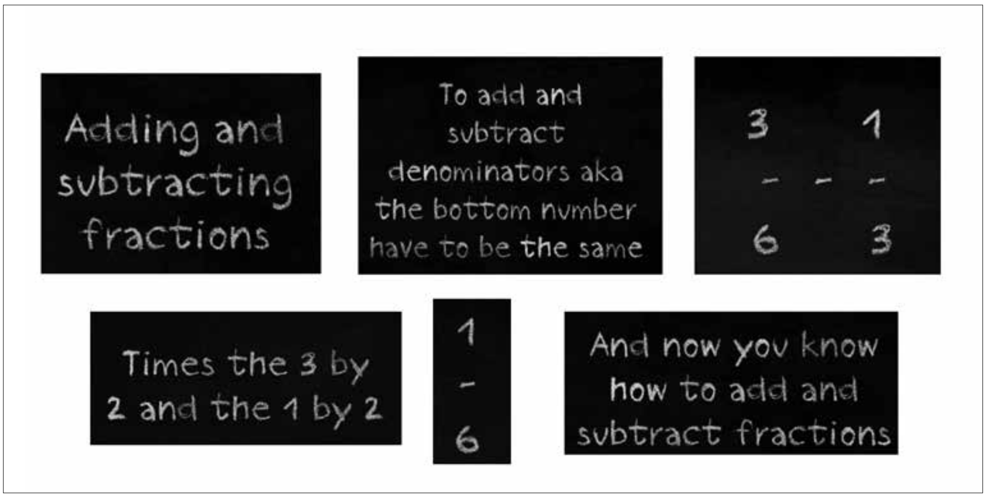

Figure 4. Screenshots from an Adobe Spark Plug Video on Fractions.

with the internet and technology. Younie et al., (2015) suggest that what happens in our classrooms influences society, although societal progress also influences what should happen in our schools. As teachers we should engage with the digital natives who are in our classroom, but also have the skills to extend and challenge them to promote curiosity. Boaler (2016, p. 206) advises to "be discerning when you choose technology to engage your students, using those that motivate students to think and make connections, not to work at speed of procedures and calculations". Technology that simply replaces pen and paper does not provide an opportunity for students to be curious. Providing this opportunity relies on a teacher's ability to use the technology in an engaging and meaningful way.

Igniting curiosity through technology

The next part of this article highlights three examples that demonstrate how technology can be used to promote curiosity in the classroom. As Goos (2010, p.68) states, "for learners, mathematical knowledge is not fixed but fluid, constantly being created as the learner interacts with ideas, people and their environment. When technology is part of this environment, it becomes more than a substitute for mathematical work". Thus, there is the potential for mathematics to evolve with the use of technology (Guerrero, 2010). Three applications that allow teachers to promote curiosity and connect learners with ideas, people and their environment are: Adobe Spark Plug Video, Padlet and Code.org (Figure 3).

Example A: Adobe Spark Plug Video

This first example illustrates how technology has allowed significant task redesign, as per the SAMR model (Puentedura, 2009).

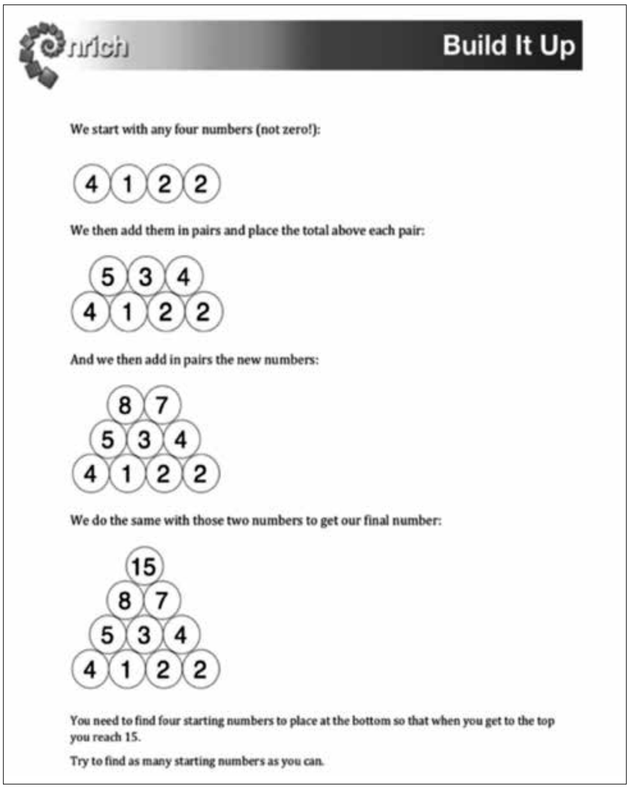

Figure 5. Nrich task: Build it Up.

Adobe Spark Plug Video is an application designed to create animations, videos and movies. The task delivered was a formative assessment seeking to understand how students communicate their understanding of fractions. The brief was to design an animation to describe to the students coming into Year 6, one aspect they have learnt about fractions. The student whose sample appears in Figure 4 chose addition and subtraction of fractions. At the beginning of the year, this particular student was described as having mathematical anxiety and would appear stressed in a mathematical environment. It was a struggle to get him to record anything using a pen and paper and he was often confused when using

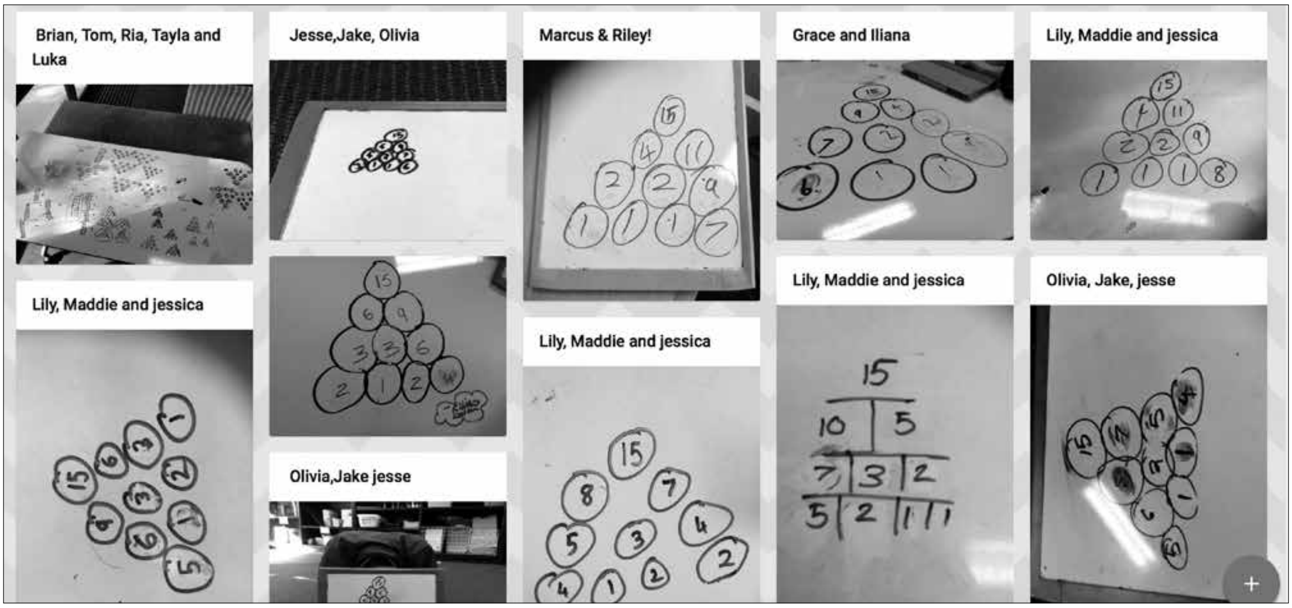

Figure 6. Student work represented through Padlet.

manipulatives. The challenge was to ensure that the technology was not going to simply substitute another resource. However, through being inspired by Adobe Spark Plug Video, the student had the autonomy and desire to find out more about fractions and he was asking questions such as:

- Why do we add and subtract fractions in this way?
- How can I communicate this knowledge so others understand?
- What does it mean to find the lowest common factor?
- I wonder who came up with this method?

The modification of the task as per the SAMR model (Puentedura, 2009) allowed this student to demonstrate fluency, understanding and reasoning as well as showing curiosity towards mathematics. Figure 4 records some screen shots from the Adobe Spark Plug Video the student created. At first glance it looks as if the technology has simply been used as a substitution. However, it is the task redesign (Puentedura, 2009) and the opportunities the technology provided for reflection and engagement, that assisted this student to achieve and communicate the answers to his own questions and wonderings. The technology also provided evidence of the mathematical thinking as the teacher was able to watch and listen to the student as they explained the concept.

Example B: Padlet

Another way to build curiosity in mathematics is using technology to make learning visible and accessible (Younie, Leask & Burden, 2015). Once students can see their peers working examples in an open environment, they begin to ask questions and show curiosity about different approaches to understanding mathematics. One tool used to promote this redefinition of a task is Padlet, a free online post-it-note application. Younie et al., (2015) suggest this resource as a way technology can be used to build creativity and collaborative skills. Students were shown the explanation of Nrich task 'Build it up' (n.d). (See Figure 5.). Nrich (n.d) outline that this task is designed to make connections and be creative with mathematical patterns. As an open-ended task with multiple entry and exit points, this task was rich on its own. However, the use of technology provided access to examples, and as a result, was a catalyst for change as per Moersch's (1995) philosophy of how technology should be embedded in the classroom.

As students came up with an example they were asked to take a photo and upload it to the Padlet link. The link was a visual on the electronic whiteboard, so all examples were visible to students (see Figure 6). As the lesson went on, students started finding similarities and differences between the images displayed on the smart board. Mid-way through the task, students were asked to stop and view all the examples on the Padlet.They were able to see connections and identify patterns that inspired them to create more examples. As Boaler & Dweck (2016) acknowledge using technology can assist students to make connections motivating them with their learning.

Once the session was over, students were required to access the Padlet for home learning and write a reflection on how they approached the task and identify what mathematics they learnt. The Padlet made the learning visible so that students could take the time to compare answers, make connections, collaborate with each other and reflect on their learning. The technology itself didn't enable the collaboration, it was a tool that promoted easy access to a variety of answers. It is an example of a task that has been modified and redefined through using technology as per the SAMR model (Puentedura, 2009). To extend this task further, use of Thinkers Keys (Attard, 2017) could build higher-order thinking. Having students post different thinkers keys responses would extend rich conversation.

Example C: code.org

The final tool used to promote curiosity was code.org. This resource encourages students to build coding skills to represent their learning. The danger with this resource is that the technology can become the focus, instead of the mathematics. This task requires teachers to know their technology and their maths to ensure students are able to get the most out of the task. Coding can be an intimidating idea for teachers who are not confident with technology. However, the implementation of the Digital Technologies curriculum in 2018 will require primary school teachers to integrate these skills (ACARA, 2017). Bolognese (2014) suggests that by 2020 there will be more than one million technology jobs that will not be able to be filled by computer science majors. This suggests there is a need to embed these practices into teaching and learning in the primary school years.

The task represented in Figure 7 required students to show their prior knowledge of fractions in various ways. One student chose code.org to represent how a circle can be broken into quarters. Figure 7 represents a screen shot of a video where this student coded the pen to draw a circle and break it down into quarters. In the student's reflection she outlined the relationship between fractions, angles and measurement. These connections motivated other students to create different types of fractions and find the connections between their designs. The geometric thinking behind

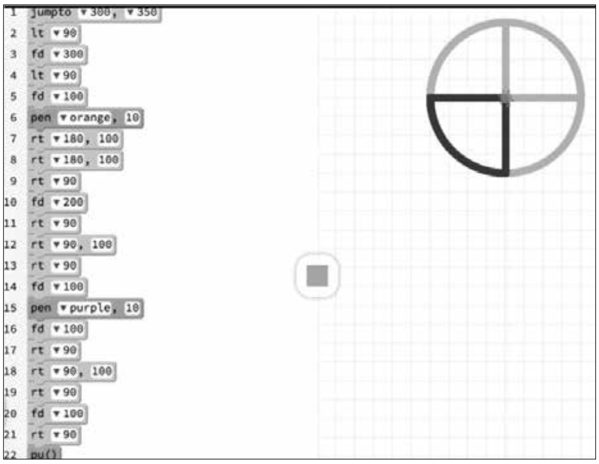

Figure 7. Coding and fractions.

instructing a computer to draw this design assisted in building the students' conceptual thinking and curiosity. This task is redefining mathematics as per the SAMR model (Puentedura, 2009) allowing students to engage in mathematics in a way people could not predict. Teaching students to code enables them to make connections between many mathematical elements, and to build their problem-solving skills. Upon reflecting on resources such as code.org, Bolognese (2012, p. 79) outlines that when electronic tools are used meaningfully, "students have a greater sense of ownership of the mathematics that they are learning, since the applications promote a sense of shared enterprise in the learning of mathematics". This also promotes students' reasoning skills as they reflect and provide feedback to each other.

Concluding thoughts

In a position paper published by the Australian Association of Mathematics Teachers (AAMT) (2009) it was argued that 21st Century learners need to be competent both in the mathematics and the technologies that enable the mathematics to be accessible. It is likely that schools may have to shift their focus to enable students to meet the mathematical needs of the future going beyond the key areas of content and process. This is where curiosity becomes a vital element in building mathematically sound and technologically able thinkers. Three applications have been discussed: Adobe Spark Plug Video, Padlet and Code.org. These applications demonstrate how technology and curiosity can work in partnership. Overall, "there is no one best way to integrate technology into curriculum. Rather, integration efforts should be creatively designed or structured for specific classroom contexts" (Koehler & Mishra, 2009, p. 62). However, as Attard and Northcote (2011) outline, a student is going to model his or her attitude towards mathematics on that displayed by his or her teacher. A curious mind is, at least in part, shaped by the classroom environment; it is incumbent on the teacher to help develop a culture of curiosity. The use of technology is one way in which that might be achieved.

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