6-2015

For the Technologically Challenged: Four Free Online Tools to Liven up a Mathematics Classroom

Maria T. Northcote
Avondale College of Higher Education, maria.northcote@avondale.edu.au

For the technologically challenged:

Four free online tools to liven up a mathematics classroom

Maria Northcote
Avondale College of Higher Education
<maria.northcote@avondale.edu.au>

Do you struggle to find meaningful ways to integrate technology into your mathematics lessons? Maria Northcote provides an insightful discussion on the purposeful use of technological tools and gives examples of four specific tools with ideas for integrating their use with the use of concrete manipulatives.

Introduction

> Mathematical ideas have evolved across all cultures over thousands of years, and are constantly developing. Digital technologies are facilitating this expansion of ideas and providing access to new tools for continuing mathematical exploration and invention. (Australian Curriculum Assessment and Reporting Authority [ACARA] 2013b)

Use of technology in the mathematics classroom has the potential to advance children's learning of mathematics and enhance their attitudes about mathematics. When used in conjunction with purposeful planning, teachers can use technological tools to reinforce their pedagogical intentions and to facilitate relevant learning activities for students. Students can increase their understanding of mathematical concepts by manipulating on-screen representations (Goodwin, 2008) and by engaging in the use of digital resources which are interactive and mathematically appropriate (Haldane, 2007; Higgins, Beauchamp & Miller, 2007; Kennewell & Beauchamp, 2007). As Attard and Curry explain: "One of the most significant influences on student engagement is the teacher's pedagogical practices, including the incorporation of technology into the teaching and learning of mathematics" (2012, p. 75). Bouta, Retalis and Paraskev (2011) reinforce the significance of a teacher's pedagogical skills in integrating the use of virtual tools into effective learning sessions: "careful design is necessary in order to use their full potential" (p. 501).

Digital resources

Online and digital resources have the capacity to "provide a motivating and engaging learning experience through which thinking capabilities and relationship skills can be enhanced" (Falloon, 2010, p. 626). Such resources can also form part of a collection of resources, experiences and activities (practical and virtual) by presenting multiple perspectives of a mathematical concept (Sfard, 2008). The benefits of using online resources in the mathematics classroom have been further explained by Kissane (2009) who identified five uses that internet resources offer mathematics teachers and learners, including: 1) interactive opportunity 2) reading interesting materials 3) reference materials 4) communication and 5) problem solving. However, a teacher's pedagogy should drive the technology, rather than technology being used for technology's sake.

In the context of this article, digital or technological tools (specifically, freely available online tools) are not intended to be used alone but in conjunction with purposefully designed learning activities and hands-on materials. The use of virtual manipulatives should be purposeful, systematic and carefully organised (Falloon, 2010; Swan & Marshall, 2010). Indeed, the overuse or segregated use of virtual tools may even cause conceptual problems in the way children understand complex mathematical concepts, if they are not meaningfully integrated with the use of practical applications and hands-on resources. Furthermore, while the tools described in this article can be used by teachers to facilitate opportunities for students to enhance their numeracy understanding and skills, there may be ways in which these tools can support children's development of literacy skills.

Examples of how each tool can be used in practical classroom situations have been interspersed throughout this article. While these tools are presented as examples of how to introduce technology into mathematics lessons and activities, they are not presented in a 'be all and end all' manner: instead, they are intended to be used in conjunction with a teacher's pedagogical intentions, and integrated into associated mathematical programs, lessons and activities. The tools presented here are not put forward as being better or worse than, or pedagogically superior or inferior to, concrete, hands-on or hand-held technological devices, but as alternatives or supplements that are convenient to access and duplicate within classroom groups of learners. It is intended that these tools may be used in circumstances when sets of classroom hands-on materials are not available, or when it is not possible to access some of the more traditional forms of these tools easily or quickly. In many cases, they offer additional interactive affordances that are not always possible in physical versions of these tools. In some cases, the use of online tools may also compensate for potential mechanical problems associated with the use of hand-held tools (such as the continual renewal of batteries or mechanical parts). Access to a substitution tool—such as an online stopwatch in place of a hand-held version of the tool—is presented in this article as one way to encourage experimentation and use of new technology in mathematics classrooms.

Hands-on and virtual tools

In their discussion of the value of hands-on and virtual manipulatives, Swan and Marshall (2010) reviewed Perry and Howard's research on mathematics manipulative materials (Perry & Howard, 1997). Combined, their work extends our understanding of how hands-on mathematics manipulative materials can incorporate the use of virtual manipulatives. For example, Attard and Curry (2012), in their exploratory study of engaging students in learning about mathematics concepts using *iPads,* found that these technological tools appeared to "have had a positive impact on the teaching and learning of mathematics for the participants involved…and increased student engagement by providing a resource that promoted interactivity, immediate feedback, challenge and fun" (p. 81). Some learning benefits of using tools in mathematics which present graphical displays in virtual contexts, have been found as far back as 2000 (Cannon, Heal, & Wellman) and 2002 (Moyer, Bolyard, & Spikell).

In more recent times, the potential offered by the use of virtual tools in mathematics classrooms to encourage collaboration and discussion among students has also been reported (Bouta et al., 2011). In their work on using virtual manipulatives in mathematics with children with special needs, Bouck and Flanagan (2010) explain the link between motivation and learning as follows:

> Students' interest in computers and the accompanying motivation can be captured with virtual manipulatives, and teachers can take advantage of their students' increasing ability to use this technology (p. 186).

Together, these researchers and educators provide a contextual backdrop of the issues impacting on mathematics classrooms. As a result, these issues have informed the creation of an evaluative guide that can be used to determine the appropriateness of an online tool for mathematics learning in primary schools.

Four tools

This article focuses specifically on the use of a handful of free online tools that can be used to liven up and support mathematics learning in lessons and activities that take place inside (that is, mathematics activities that take place within the walls of a classroom) or outside (that is, mathematics activities that take place beyond the walls of a classroom such as in a playground). The examples provided have been specifically drawn from the Foundation to Year 6 levels of the *Australian Curriculum*. Teachers are invited to evaluate each of the four tools outlined in this article according to the *Technological Tool Evaluation Guide*, presented later in this article. However, it is recognised that the value of the tools can only genuinely be realised by considering the practical context in which the teaching and learning occurs.

It is recognised that there is a growing collection of online tools that are clearly and specifically designed for use within mathematics classrooms, such as *Geogebra* (http://www.geogebra.org/), some apps available to use on hand-held tablets (for example, *Number Pieces*, *Geometry Pad* and *Geoboard*) and the tools offered through the National Library of Virtual Manipulatives by the Utah State University the US. Nevertheless, not all of the tools presented in this article have been specifically designed for mathematics teaching purposes. While tools such as the interactive number board, and virtual chance tools (such as virtual dice and virtual spinners) are examples of online tools that may have been purposefully designed for use in mathematics learning activities, the online stopwatch has not necessarily been created for such purposes. Even so, it can be used when students are learning about many aspects of the *Australian Curriculum*. Furthermore, a language-based tool such as the online game-creation tool, *Quizlet*, has not necessarily been created with mathematics in mind but may be used in mathematical teaching and learning contexts.

As well as recognising the functional uses of the four online tools presented in this article, teachers are also encouraged to evaluate them in terms of their capacity to engage and motivate students in primary mathematics classrooms. While this article primarily focuses on the value of using these tools as a way of introducing some purposeful technology into mathematics teaching and learning, there is also the possibility that the use of technology may enhance students' engagement with mathematics, an idea already put forward by a number of researchers and educators (Attard & Curry, 2012; Bouck & Flanagan, 2010; Bouta et al., 2011; Reimer & Moyer, 2005). To further contextualise engagement in a mathematics teaching environment, Attard's framework for engagement with mathematics in the primary classroom reminds us of the powerful role of motivation as well as the value of acknowledging students' views about mathematics (Attard, 2012a, 2012b). Specifically, Attard (2012b) explains the importance of integrating technology into student learning opportunities: "technology is embedded and used to enhance mathematical understanding through a student-centred approach to learning" (p. 13). As Attard has done in her work with Curry (Attard & Curry, 2012), this article uses Fredricks, Blumenfeld and Paris' (2004) approach to defining the multi-faceted concept of engagement as including:

1) cognitive engagement, incorporating "thoughtfulness and willingness to exert the effort necessary to comprehend complex ideas and master difficult skills" (p. 60);
2) behavioural engagement, involving active participation in academic and social activities; and
3) emotional engagement, which is seen as involving attitudes, reactions and a willingness to engage.

Consequently, in this article, the term engagement is intended to encompass the actions, thoughts and feelings that children experience through their involvement in mathematics activities.

What is a good tool in a mathematics classroom?

There are many ways to define a tool or resource in the mathematics classroom. While some learning contexts suit the use of hands-on tools, others are more suited to virtual use of online resources, and other contexts may be suited to the parallel use of both hands-on and virtual tools. While some researchers have used the term "mathematics tool" to describe linguistic devices (Collins-Browning, 2009) and communication journals (Amaral, 2010) used in mathematics, others consider mathematics tools to be technological devices (Attard & Northcote, 2012) or specifically designed tools for the purposes of teaching and learning mathematics (Arnold, 2012). Goodwin (2008) categorises technological tools according to whether or not the tool has the capacity to be instructive, manipulable or constructive. Furthermore, these types of tools could be further categorised into teacher-made, student-made and commercially available tools, or tools that have been tailored for a mathematics classroom and those that have not. In light of this vast range of tools available for mathematics teachers and students, this article recognises the value of using virtual manipulatives alongside or to support the use of hands-on manipulatives.

Whether or not a virtual or online tool is a 'real tool' is debatable. Whereas a hand-held tool such as a stopwatch may be considered more 'real' to a digital immigrant, a digital native (Prensky, 2001) child in a current Australian classroom may view an online stopwatch to be more 'real' than a hand-held stopwatch stored in a school cupboard. Pedagogically, whether or not these online tools are labelled as 'real' or not when compared to traditionally hand-held mechanical tools, is possibly not as important as how they are used, how accessible they are, how functional they are, and how useful they are for teachers and learners in practical mathematical contexts.

Consequently, a 'good' technological tool in the mathematics classroom can be defined according to the learning or teaching purpose. The use of technology for technology's sake will not necessarily enhance students' mathematical learning. Nevertheless, with the expansion of freely available, interactive online tools and resources that has occurred over the last few decades, there are now multiple opportunities for teachers and students of mathematics to use these tools in purposeful, targeted ways. Focused use of these tools has the capacity to engage students in the mathematics classroom and to enhance enjoyment, motivation and relevance (Falloon, 2010; Kennewell & Beauchamp, 2007). They should be used in pedagogically sound ways to enhance learning through the use of modern digital technology that is familiar to most primary-school-aged children (Reimer & Moyer, 2005), the digital natives of this century (Prensky, 2001).

Evaluation of tools for use in mathematics learning

For the purposes of this article, the criteria for an effective and motivating technological tool that is suitable for use in a mathematics learning context in a primary school, has been informed by Attard's *Framework of Engagement for Mathematics in the Primary Classroom* (Attard, 2012a, 2012b) and Swan and Marshall's discussion of both hands-on and virtual manipulatives (2010). Furthermore, the emphases in the recently published *Australian Curriculum* (ACARA, 2013b) on the general capabilities of literacy and Information and Communication Technology (ICT) have provided additional input to the development of the *Technological Tool Evaluation Guide* used to evaluate the four online technological tools described in this article in relation to:

- mathematics and English (the content);
- learners and teachers (the people);
- possible learning environments (the context); and
- the tools themselves (the technology).

This guide offers classroom teachers a structured approach to evaluating the capacity of online tools according to how they would enhance the content being taught, the people involved in teaching and learning, the context of the teaching and learning, and the technology available in their mathematics classrooms. As well as proposing this guide as an instrument to evaluate the tools presented in this article, it may also be used to evaluate a range of other online, virtual or technological tools that have the capacity to enrich mathematics teaching and learning situations.

The tools

The four technological tools described below have been especially selected for their efficient and effortless nature (Reys et al., 2012) to ensure their use is both incidental but pedagogically purposeful within a mathematics learning context. After considering their descriptions and some suggested uses, teachers are encouraged to evaluate each of the tools, using the *Technological Tool Evaluation Guide*, according to the tool's capability to engage teachers and students with relevant content within the context of primary school mathematics.

Tool no. 1: Online stopwatch

Most students will have access at some stage of their young lives to mobile stopwatch devices, some of which may be hand-held mechanical devices or digital tools, including wrist watches, tablets (such as *iPads*), and mobile phones. These tools are typically visible and accessible by individuals in everyday life.

Table 1: Technological tool evaluation guide

Dimension	Evaluation criteria Use of the tool	Descriptors of criteria
Content	...in mathematics	• clearly suitable to mathematics learning and teaching • promotes active engagement with mathematics hands-on resources and manipulation of ideas and resources • helps obtain exact results, where appropriate (e.g., stopwatch) • does not only focus on mathematics problems or questions that require polarised (right or wrong) responses • clearly relates to Content Descriptions and strands in the *Australian Curriculum*
	...in English	• offers opportunities to integrate numeracy and literacy • use of mathematics vocabulary is facilitated • use of oral language is facilitated • provides opportunities to use problem solving language
	...to develop numeracy and literacy skills	• realistic use of numeracy and numeracy skills is promoted • assists with the solving of authentic numeracy and literacy problems
People	...by the student	• tool use can be initiated by students • can be used by either primary school aged students as well as their teachers • caters for diverse learners • encourages students to develop their own views
	...with other students	• tool can be used by pairs or groups of students • mathematics conversations may occur while tool is being used • tool can facilitate collaborative problem solving
	...by the teacher	• motivating for the teacher to use • easy access, distribution and management • can be used in mathematics and other subjects
Context	...in the classroom context (within the walls of a classroom)	• suitable for use in a mathematics learning context by primary school aged children • can be used inside the classroom
	...outside the classroom (beyond the walls of a classroom)	• can be used outside the classroom • convenient access via mobile devices • incidental use is encouraged
	...with other materials	• can be initiated by the use of hands-on manipulatives • can be supplemented by the use of hands-on manipulatives • does not disregard the value of hands-on manipulatives • can extend understanding gained by hands-on manipulatives
Technology	...as a learning technology	• promotes active engagement with mathematics hands-on resources • encourages active participation by students with the tool • technology use is embedded in mathematics activities • an element of choice is incorporated into the tool
	...with other ICT	• uses desktop or mobile technology • can be used on large (e.g., interactive whiteboards), medium sized (e.g., computers) or small screens (e.g., mobile devices) • accessed online
	...to facilitate realistic and convenient use of technology	• free of charge • offers repeated use • registration or membership not required • no need for downloading or installing software

Alternatively, access to an online stopwatch on an interactive whiteboard or a digital projector provides full class access to such a device which, when required, can also be used as a timer for full class activities. Use of interactive whiteboards to manipulate online tools has been associated with learning engagement and resource management in primary mathematics classrooms (Mildenhall, Swan, Northcote, & Marshall, 2008). While the availability, distribution and management of hand-held stopwatch devices may present resource problems in the context of a busy classroom, the duplicability offered by online versions of tools such as stopwatches can enhance student access and enable multiple users of the same device. Availability of online tools from a full class or individual learner perspective also has pedagogical value. For example, the use of an online stopwatch on a large screen can illustrate how a technological timing device can be used incidentally to check time estimates, to track the time taken to play mathematics games and races, and to time the period between events (for example, the time between recess and lunch time). Classes of children who all have individual access to such online tools on internet-connected tablets have the freedom to manipulate these devices according to their own learning needs and styles.

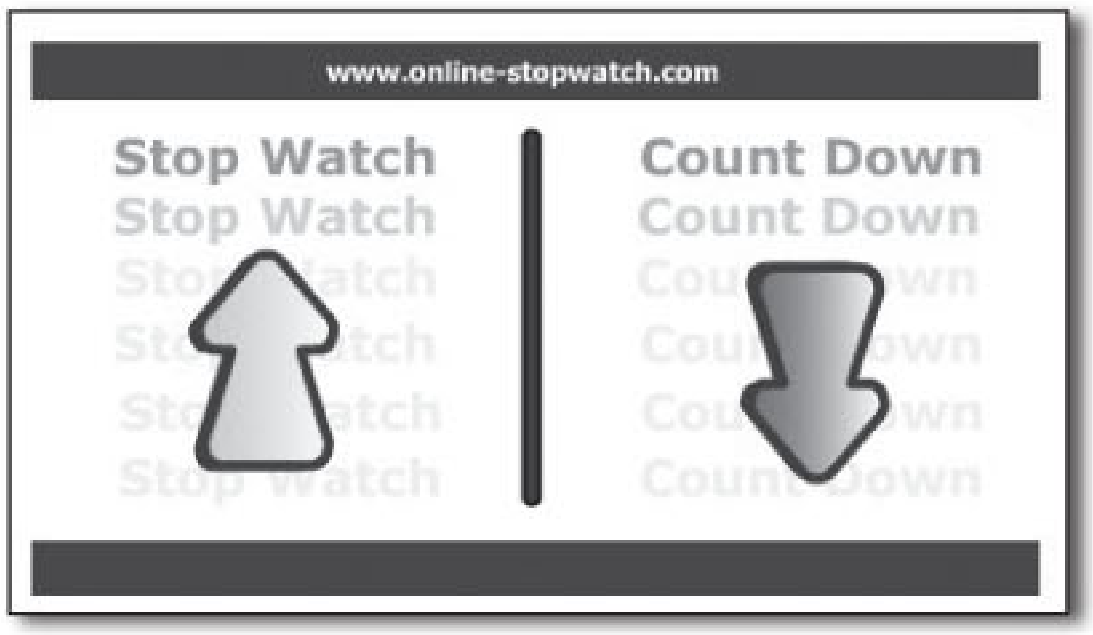

Figure 1: Online stopwatch: http://www.online-stopwatch.com/

From Year 1 onwards, according to the *Australian Curriculum*, children are expected to "explain time durations" (Year 1 Achievement Standard), "investigate the relationship between units of time" (Year 3, ACMMG062) "convert between units of time" (Year 4, ACMMG085) and "solve problems involving time duration" (Year 4 Achievement Standard). The use of an online stopwatch, which is easily accessible and used by students of all ages, can put students in control of their own learning and engage them in meaningful and incidental use of time devices during purposeful activities.

Furthermore, online stopwatches can be used to enhance collaborative learning opportunities. If accessed via mobile devices (e.g., *iPads*), online stopwatches can facilitate activities that focus on developing concepts such as the difference between seconds and minutes as students "investigate the relationship between units of time" (Year 3, ACMMG062; ACARA, 2013a). Groups of students may investigate problems such as: "How can we time our movements around the classroom? How are activities that take longer than 60 seconds timed and how are these measurements recorded? How do we time our recess and lunch breaks?" Students could be placed in groups of 3-4, each with a tablet device on which they can access a stopwatch and a recording application (such as *Notepad*). When such an activity begins with a set of inquiry-focused questions, students are presented with numerous opportunities to investigate, question and engage with practical activities that support their conceptual development of different units of time. As Attard and Curry (2012) found: "The *iPads* allowed the teacher to introduce a wider range of teaching strategies that included group work and a rotation of tasks within each lesson as opposed to whole-class, worksheet based lessons" (p. 81). While manual, hand-held stopwatches could also be used in such activities, and records of time-based experiments could be documented on either paper-based or digital resources, the use of an online stopwatch on a mobile internet-connected device allows students to use a single device to access a measuring tool and record their measuring results.

Tool no. 2: Virtual chance tools

The *Australian Curriculum: Mathematics* outlines a range of Content Descriptions in the content strand of Statistics and Probability, that describes what primary school students should learn about chance and probability in their everyday lives.The topic of Chance is explored from Year 1 onwards, as described in the *Australian Curriculum*. For example, in Year 3, students are provided with opportunities to "conduct chance experiments, identify and describe possible outcomes and recognise variation in results" (Year 3, ACMSP067) and Year 6 students "conduct chance experiments with both small and large numbers of trials using appropriate digital technologies" (Year 6, ACMSP145; ACARA, 2013c). While the use of hands-on devices (such as dice and spinners) are ideal for individual and small group use in mathematics games and activities—to facilitate turn-taking and prediction activities—enlarged virtual chance tools can also be used to illustrate the processes and outcomes associated with probability of events to a whole class. Once children have an understanding of how to use physical chance tools (such as plastic die and gameboard spinners), their understanding of such tools may be extended to the use of virtual tools which simulate the actions of the physical tools.

Virtual online chance tools can be used to initiate conversations about the possible number of combinations of outcomes that may occur for particular events. For example, virtual dice can be used to "conduct repeated trials of chance experiments" (ACMSP067; ACARA, 2013c). Virtual spinners can assist with common everyday events such as allocating students to groups for team activities. Whereas the physical versions of chance tools are difficult to modify, these free-of-charge and freely accessible online devices can be easily modified to increase or decrease the complexity of probability, or to enable students to experiment with the different parameters associated with chance activities including the number of sides on a die, the number of segments on a spinner and the labels on dice sides. The flexible size and appearance of online dice and spinners can further engage students in mathematics activities as they can modify the tools to suit their own aesthetic preferences and their own learning levels, thus providing them with greater control over their own learning contexts.

The use of virtual chance tools, due to their customisability and flexibility, can provide students with opportunities to devise their own probability experiments that can be initiated by inquiry questions such as "How many times will this virtual die land on 5 when I throw it 20 times compared to when I throw this plastic die 20 times?"

Use of multiple virtual and physical tools can stimulate students with a range of possibilities for creating problems to be solved by other children or by groups of children. Such mathematics activities, while assisting in children's conceptual

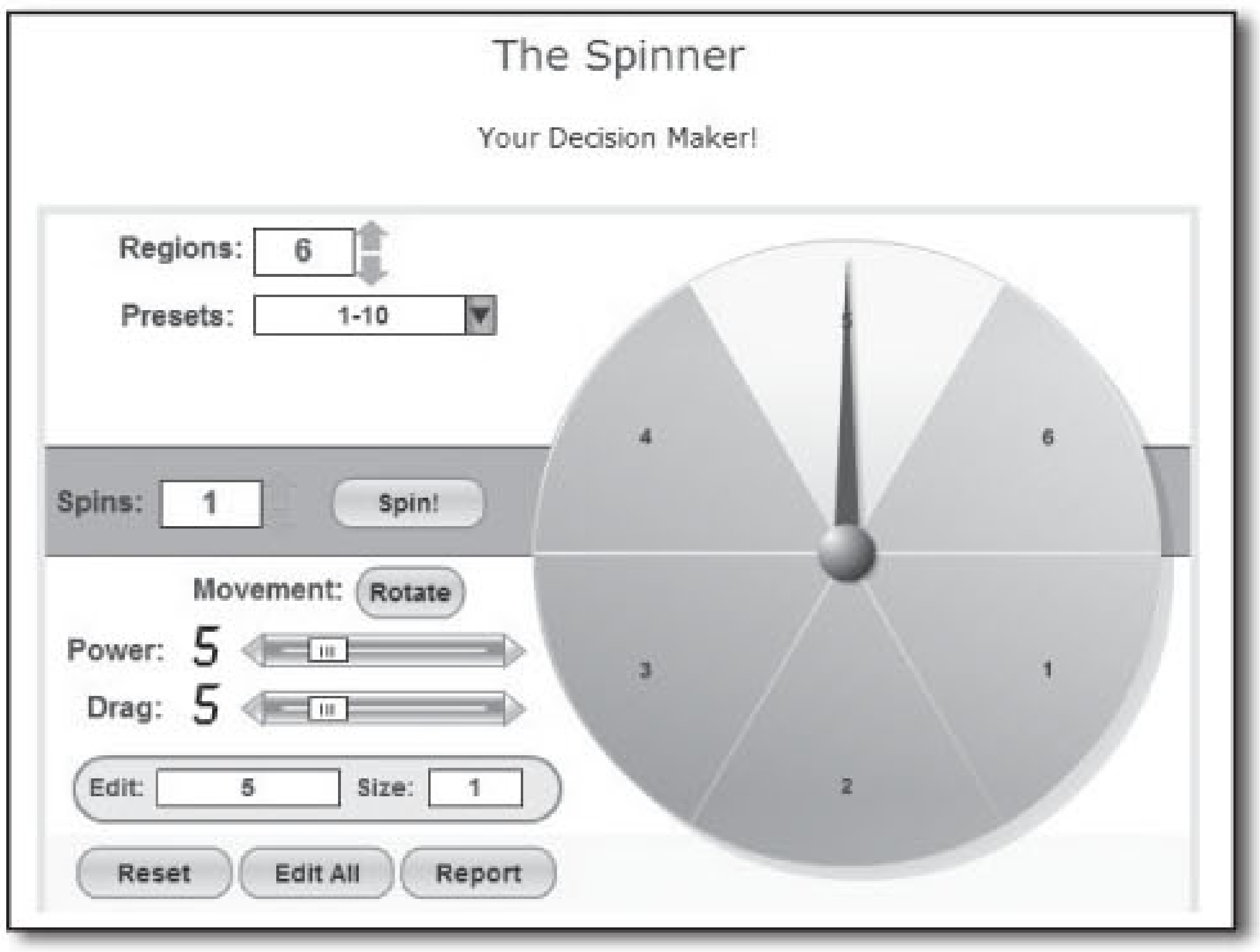

Figure 2: Virtual spinner: http://www.mathsisfun.com/data/spinner.php

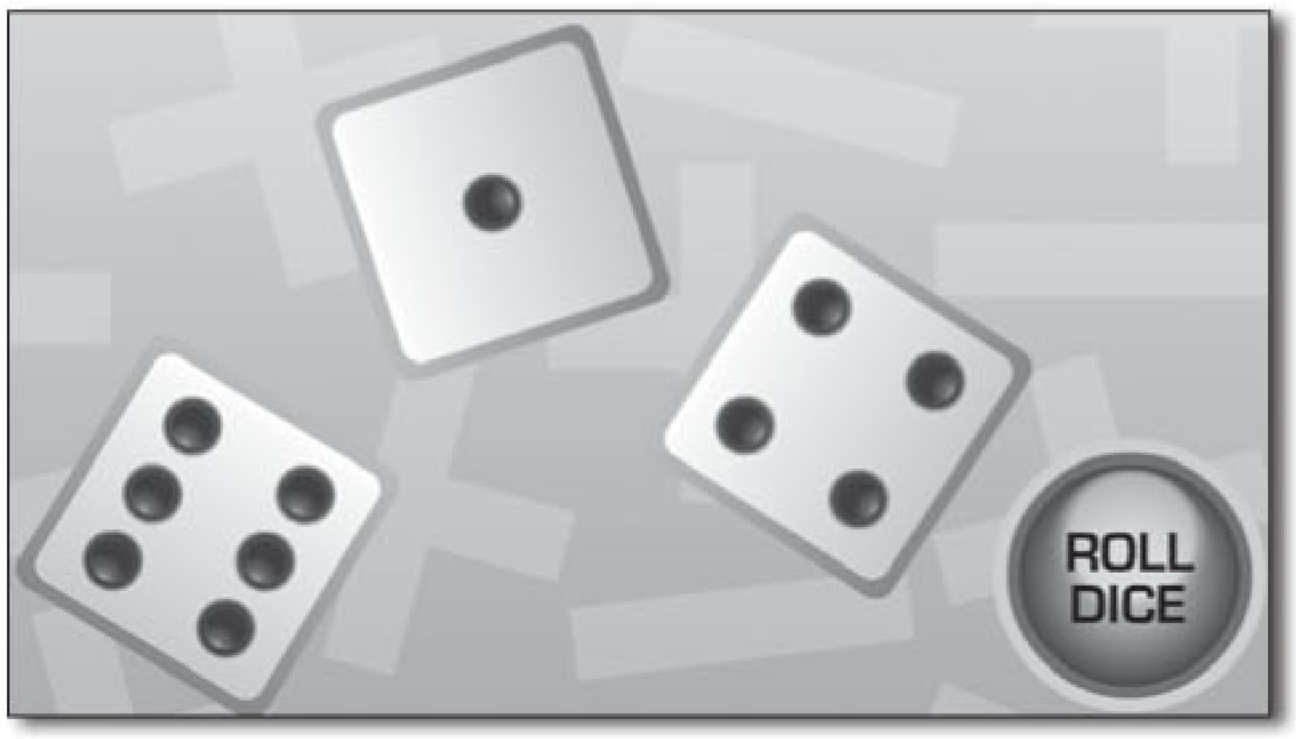

Figure 3: Virtual dice: http://www.curriculumbits.com/mathematics/virtual-dice/

development of understanding how to "conduct chance experiments, identify and describe possible outcomes and recognise variation in results" (Year 3, ACMSP067; ACARA, 2013c), can also facilitate the development of communication skills as they explain their problem to others and record their results. Possibilities presented by the use of varied mathematical tools can enhance collaboration and engagement (cognitive, affective and behavioural) as reported by Bouta, Retalis and Paraskev (2011) in their investigation of student engagement in a virtual environment: "the 3D virtual environment actively engages the students' interest and leads to richer interaction between them. This in turn results in a higher level of student engagement in the collaborative learning process" (p. 501).

When engaging in learning about probability and chance in Year 6 with larger numbers of chance trials, for example, children can easily use virtual chance tools to "conduct chance experiments with both small and large numbers of trials using appropriate digital technologies"

(Year 6, ACMSP145; ACARA, 2013c). If children choose to extend their investigations after school hours, during which time their access to physical chance tools may be restricted, easy access to online tools such as virtual spinners and virtual die can facilitate their extra-curricula work. As such, the use of virtual mathematics chance tools may present opportunities to engage students cognitively and socially, and to increase their interest in investigating mathematical concepts and sharing them with others.

Tool no. 3: Interactive number board

One of the major content strands of the *Australian Curriculum*: *Mathematics* is Number and Algebra. This strand incorporates wide-ranging and comprehensive topics such as place value, whole number, number patterns, addition, subtraction, multiplication and division (ACARA, 2013c). While this article does not claim that an online version of a number board is preferable to a physical version of this device (for example, in wooden or plastic form), a virtual version of a number board offers different learning opportunities for children when they are learning about number concepts.

An interactive online number board can be used as a natural extension to using a wooden or plastic number board that children and teachers can modify to explore and demonstrate number patterns, sequencing and place value. Because of their size and expense, mathematics classrooms typically tend to be equipped with one or two of the hands-on variety of number boards. However, once children are familiar with the three-dimensional, hands-on version of a number board, the interactive number board can provide individual children with multiple, alternative and extended opportunities to engage in number and pattern activities—colour coding even and odd numbers, exploring multiples and factors, identifying a fractional part of a collection, and practising skip counting. Because the use of online interactive number boards enables more than one small group of children to use the tools at any one time, individual children's progress can be tracked for assessment purposes, especially when work samples are captured.

As children develop abilities to "describe number patterns formed by skip counting and patterns with objects" (ACMNA018; ACARA,

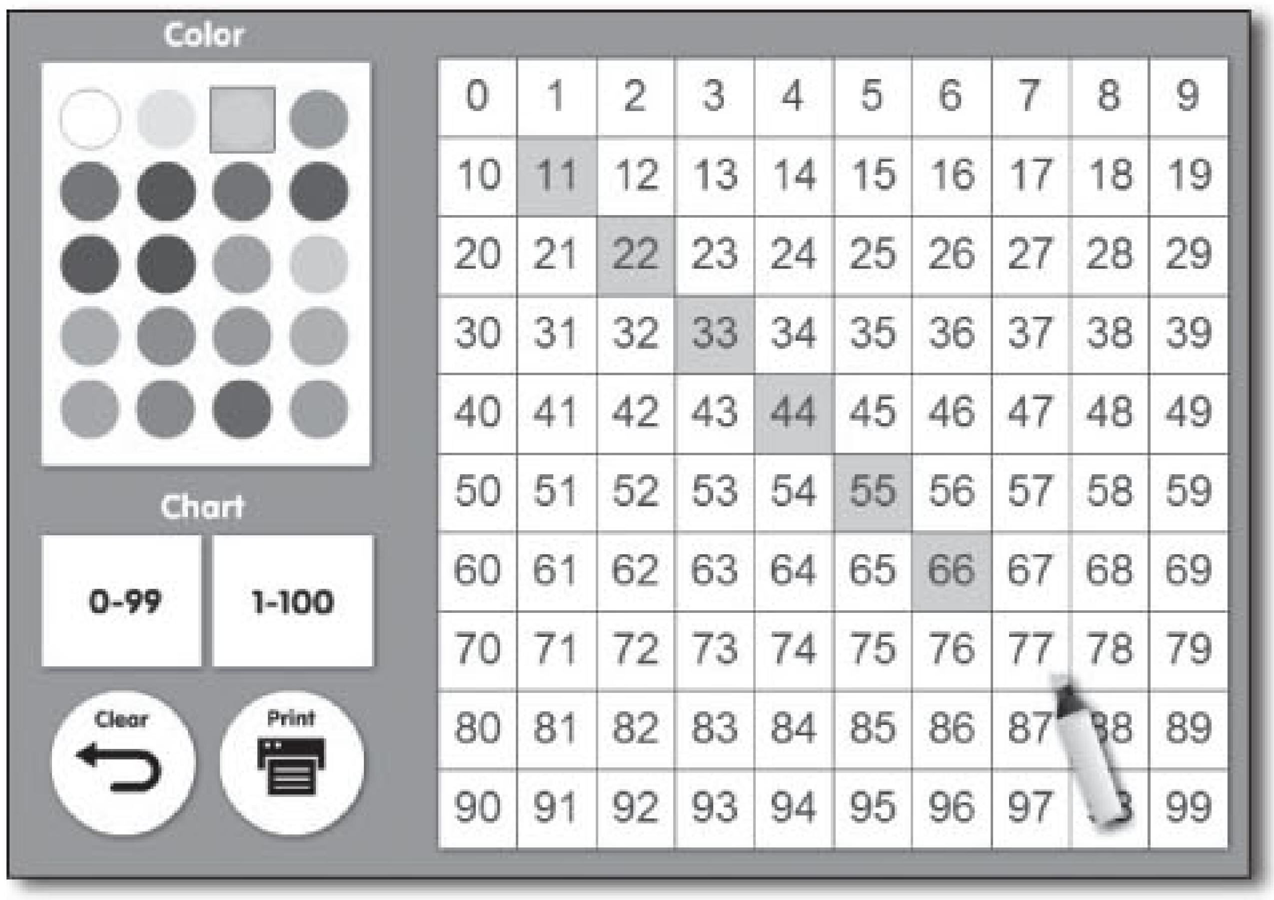

Figure 4: Interactive number board: http://www.abcya.com/interactive_100_number_chart.htm

2013c), the use of a virtual number board can be seen as the next step in their conceptual understanding as they progress through to the use of concrete to representational to abstract thought in association with number sequences; a progression also noted by Moyer and Bolyard (2002) who recommend using virtual representations of mathematics processes to facilitate development of mathematical thinking from visual to abstract. While a hands-on version of a number board may also facilitate such thinking, the virtual number board enables customisation of skip counting sequences, record-keeping by children and teachers (saving and printing), and the capacity to allocate varied colours to depict different number sequences. The use of a virtual number board may provide a supplemental or alternative view of how to sequence numbers for children who experience difficulties understanding such a concept. In fact, Bouck and Flanagan (2010) consider the use of virtual manipulatives with students with disabilities to be "best practice", recommending that "special educators need to consider manipulatives as a means of helping their students learn mathematics and should be open to the use of virtual manipulatives" (p. 186).

Tool no. 4: Quizlet

With the online game-creation tool, *Quizlet* (http://quizlet.com/), teachers and students can quickly create content-specific games on any topic, or access games made by other *Quizlet* users. Of course, as with any mathematical games, the game itself does not teach children, but the way it is integrated into purposeful and pedagogically sound learning activities increases its capacity to assist learning. When designed well, mathematical games give children the chance to engage in "sustained attention, high-level thinking and collective as well as individual effort" (Booker, Bond, Sparrow, & Swan, 2009, p. 28). This is especially the case if mathematical games are presented in classrooms for both individual and group use. The online tool *Quizlet* provides teachers especially with a tool that can be used to produce customised, timely resources for use in their mathematics classrooms.

Typical games that can be made using *Quizlet* include virtual flash cards, multiple choice questions, study games and drag-and-drop matching games. By providing the game user with direct control of the game pieces on the screen, students can quickly engage with the activity presented to them. On-screen instructions are typically short and succinct to ensure direct communication of what is expected of the user, thus facilitating self-directed learning. Although primarily used by students and teachers of arts and language-related courses, *Quizlet* can also be used to create mathematics activities and games. While children's engagement in *Quizlet* games would not necessarily be encouraged at the beginning of a learning sequence (for example, when Year 3 children are grappling with the concept of odd and even numbers—ACMNA051), these type of online games are useful to reinforce concepts taught, to emphasise links between concepts, and to revise the appropriate use of mathematical language.

By using *Quizlet*, teachers can create a set of 'matches' in which questions are matched with answers, or definitions are matched with words or digits (see Table 2: Ten matches made using the online game, Quizlet). For example, number words (five, seventeen) can be matched with numerals (5, 17).

In the game in Table 2, Numbers 1 to 20, a set of ten matches were made.Voice-overs can also be incorporated into the sets of matches. The matches created can then be integrated into a variety of games including flash cards and scatter games (see Figure 5).

After the matches were created (see Table 2), the 'Scatter' game type was selected (see Figure 6) which triggers the creation of the game.

Table 2: Ten 'matches' made using the online game, Quizlet

two	2	eleven	11
five	5	sixteen	16
seven	7	seventeen	17
nine	9	eighteen	18
ten	10	twenty	20

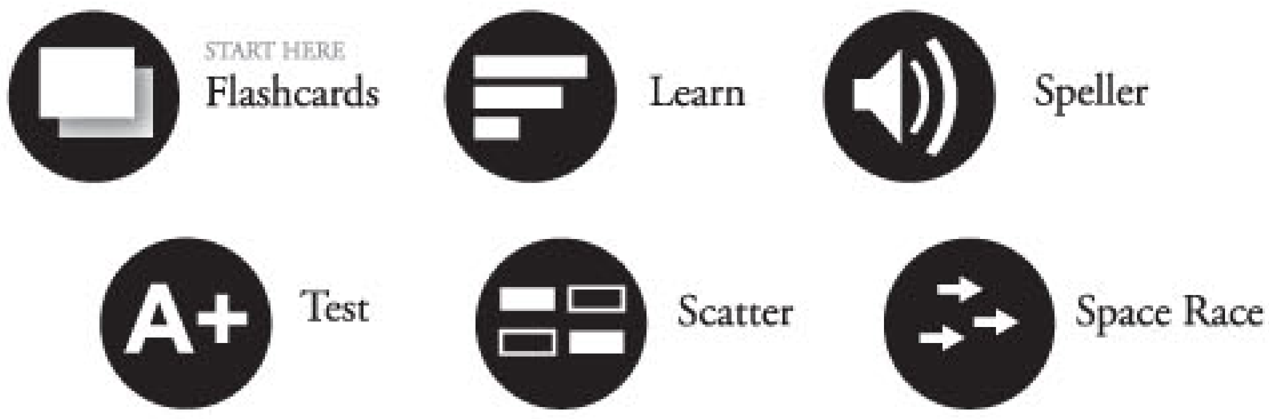

Figure 5: Game options provided when creating a Quizlet game: http://quizlet.com/

Selection of this game type automatically generates a URL (website address) that teachers can share with students. Game users are then faced with the challenge of making all of the numbers disappear from the screen by dragging and dropping matching halves. When learners drag a numeral to a word match (for example, when the numeral 5 is dragged to the word five), both instances of the number disappear. Conversely, learners can drag words to number matches (for example, when the word twenty is dragged to the numeral 20). Learners can play the game multiple times in an attempt to beat their personal best score. Feedback is instant and the game enables individual engagement, without the competitive pressure of team games. If students are currently learning another language, *Quizlet* provides game creators with over 50 languages to choose from.

A mobile app version of *Quizlet* is also available for use on phones and tablets.

Figure 6: A scatter game, created using Quizlet, at: http://quizlet.com/

While the example of *Quizlet* utilises a mixture of both literacy and numeracy skills, the game options within *Quizlet* lend themselves to a single focus on topics related to mathematics or literacy, or an integration of the two. Further possibilities for incorporating *Quizlet* into mathematics lessons may include:

- matching definitions of shapes with numbers of shape sides;
- learning basic number facts;
- number sequencing;
- sorting even and odd numbers;
- listening to recognise the names of large numbers; and
- skip counting.

Special note regarding the use of *Quizlet* by teachers: the free version of *Quizlet* was used in the preparation of the examples provided in this article. When registering for a *Quizlet* account, teachers may be offered to upgrade to *Teacher Quizlet* at the cost of $25 per year. Unless the teacher wishes to use *Quizlet* extensively, the author recommends clicking on the "Maybe later. Continue using free *Quizlet*" link at the base of the registration screen which will allow free use of the tool.

Using the Technological Tool Evaluation Guide

Each of the four technological tools outlined in this article can be evaluated using the *Technological Tool Evaluation Guide* (see Table 1 earlier). Teachers may decide to use this Guide on a purely qualitative basis; that is, use the descriptor criteria to examine various aspects and potential uses of the technological tools. On the other hand, teachers may decide to evaluate individual technological or online tools by giving each of the dimensions (content, people, context and technology) a star rating such as a scale from one star (not useful for my context) to five stars (highly useful for my context). A grid such as the following may be a useful way for teachers to record their evaluative comments or ratings about particular online tools. Overall, however, despite the suggested criteria outlined in the *Technological Tool Evaluation Guide* (see Table 1), it is the pedagogical context in which the tool will be used that should drive the way in which it is evaluated.

While the advantages of such tools can be explained in terms of their easy access (Goodwin, 2008), nil cost, flexibility, customisability, motivational value and even "unlimited supply" (Kissane, 2009, p. 137), these attributes may also point to some of their limitations. Just as Swan and Marshall remind us: "simply placing one's hands on the manipulative materials will not magically impart mathematical understanding" (2010). So it is with online tools. The use of online tools will not necessarily result in mathematics learning without purposeful planning and the facilitation of relevant learning activities. Concern has been expressed by some educators about the over-use of virtual manipulatives (Swan & Marshall, 2010) and the over-use of online resources that focus on the right-wrong nature of mathematics to the detriment of the richer side of mathematics. The highly engaging nature of some of these resources may prove distracting for some children and, because they are so easy to access, teachers and students alike may favour them in a busy classroom context over their valuable, hands-on counterparts. Furthermore, because some of these tools can be customised in a variety of ways (colour, size, font, style, etc.), some users may become sidetracked by the endless opportunities offered by tweaking the resources to suit their personal preferences.

Table 3: Suggested evaluation grid

Evaluation criteria					
Tool	Content	People	Context	Technology	OVERALL
Online stopwatch					
Online dice and spinner					
Number board					
Quizlet game maker					

Whereas the convenience, flexibility and capacity to motivate engagement are clear advantages of these online tools (depending on how they are used in the context of practical classroom teaching) they can offer students the chance to manipulate mathematical ideas across a range of contexts, and provide opportunities to integrate literacy and numeracy skills. Whereas some tools lend themselves more to individual use to encourage personal understanding and reflection, others are more appropriate for use in small or large groups of learners to encourage collaborative learning and dialogue.

Conclusion

While there is no doubt as to the value of young children using hands-on, concrete tools, there is also a place for technological tools or virtual manipulatives in the modern primary mathematics classroom (Goodwin, 2008; Kissane, 2009; Reys et al., 2012; Swan & Marshall, 2010). This is especially the case when technological online tools are used to support the use of hands-on mathematics manipulatives within carefully planned mathematics programs, lessons and activities. The four online tools presented in this article provide students with a variety of learning opportunities to engage them in mathematically-focused activities and games, which have the potential to extend students' understanding of mathematical concepts in a virtual environment. Many of these tools can be manipulated by students as well as teachers and offer potential integration with literacy. However, it is always timely to consider Cotton's (2006) reminder that a learning resource cannot teach children: good teachers do that. No matter how full of potential these tools appear to be, it is their application within a well-planned, pedagogically purposeful mathematics activity that will determine their genuine value or otherwise.

Notwithstanding some of the limitations of online resources, the use of such tools can liven up a mathematics classroom by introducing purposeful, engaging tools that enhance teaching and learning processes. The tools offered for consideration in this article represent a small selection of such tools and they have been presented as flexible, convenient supplements to good classroom practice. The affordance that online tools offer in terms of their use on large and small screens alike, ensure they are suitable for use by the whole class, small groups and individual learners. They have the potential to further highlight for students the relevance of mathematics in their lives and the ever-present links between literacy, numeracy and technology.

References

Amaral, S. S. (2010). *Children's discursive representations of their mathematical thinking: an action research study.* University of Manitoba, Manitoba.

Arnold, K. (2012). Tools of the trade. *Australian Primary Mathematics Classroom, 17*(2), 10–15.

Attard, C. (2012a). Applying a framework for engagement with mathematics in the primary classroom. *Australian Primary Mathematics Classroom, 17*(4), 22–27.

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

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.), *Mathematics education: Expanding horizons (Proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia)* (pp. 75–82). Singapore: MERGA.

Attard, C. & Northcote, M. (2012). Mathematics on the move: Using mobile technologies to support student learning (Part 2). *Australian Primary Mathematics Classroom, 17*(1), 29–32.

Australian Curriculum Assessment and Reporting Authority. (2013a). Australian Curriculum. Retrieved 4 April, 2014, from http://www.australiancurriculum.edu.au/

Australian Curriculum Assessment and Reporting Authority. (2013b). *Australian Curriculum: Mathematics.* Retrieved 4 April, 2014, from http://www.australian-curriculum.edu.au/Mathematics/Rationale

Australian Curriculum Assessment and Reporting Authority. (2013c). *Australian Curriculum: Mathematics - Foundation to Year 10 Curriculum.* Retrieved 4 April, 2014, from http://www.australiancurriculum.edu.au/mathematics/Curriculum/F-10

Booker, G., Bond, D., Sparrow, L. & Swan, P. (2009). *Teaching primary mathematics* (4th ed.). Frenchs Forest, NSW: Pearson.

Bouck, E. C. & Flanagan, S. M. (2010). Virtual manipulatives: What they are and how teachers can use them. *Intervention in School and Clinic, 45*(3), 186–191.

Bouta, H., Retalis, S. & Paraskev, F. (2011). Utilising a collaborative macro-script to enhance student engagement: A mixed method study in a 3D virtual environment. *Computers & Education, 58*(1), 501–517.

Cannon, L., Heal, R. & Wellman, R. (2000). Serendipity in interactive mathematics: Virtual (electronic) manipulatives for learning elementary mathematics. In C. Crawford & D. Willis (Eds.), P*roceedings of the Society for Information Technology and Teachers Education International Conference 2000* (pp. 1083–1088). Chesapeake, VA: AACE.

Collins-Browning, A. R. (2009). *The Language of Mathematics: Virginia Standards of Learning Mathematical Pictionary for Grades K-3.* (Master of Science), East Tennessee State University, East Tennessee. Retrieved from http://dc.etsu.edu/etd/1874/

Cotton, T. (2006). Mummy how heavy are mushrooms". *Mathematics Teaching, 194*, 37–40.

Falloon, G. (2010). Learning objects and the development of students' key competencies: A New Zealand school experience. *Australasian Journal of Educational Technology, 26*(5), 626–642.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–110.

Goodwin, K. (2008). The impact of interactive multimedia on kindergarten students' representations of fractions. *Issues in Educational Research, 18*(2), 103–117.

Haldane, M. (2007). Interactivity and the digital whiteboard: Weaving the fabric of learning. *Learning, Media and Technology, 32*(3), 257–270.

Higgins, S., Beauchamp, G. & Miller, D. (2007). Reviewing the literature on interactive whiteboards. *Learning, Media and Technology, 32*(3), 213–225.

Kennewell, S. & Beauchamp, G. (2007). The features of interactive whiteboards and their influence on learning. *Learning, Media and Technology, 32*(3), 227–241.

Kissane, B. (2009). What does the internet offer for mathematics students? In C. Hurst, M. Kemp, B. Kissane, L. Sparrow & T. Spencer (Eds.), *Mathematics it's mine: Proceedings of the 22nd Biennial Conference of The Australian Association of Mathematics Teachers* (pp. 135–145): The Australian Association of Mathematics Teachers.

Mildenhall, P., Swan, P., Northcote, M. & Marshall, L. (2008). Virtual manipulatives on the interactive white board: A preliminary investigation. *Australian Primary Mathematics Classroom, 13*(1), 9–14.

Moyer, P. S., Bolyard, J. J. & Spikell, M. A. (2002). What are virtual manipulatives? *Teaching Children Mathematics, 8*(6), 372–377.

Perry, B. & Howard, P. (1997). Manipulatives in primary mathematics: Implications for teaching and learning. *Australian Primary Mathematics Classroom, 2*(2), 25–30.

Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon, 9*(5), 1–6.

Reimer, K. & Moyer, P. S. (2005). Third-graders learn about fractions using virtual manipulatives: A classroom study. *Journal of Computers in Mathematics and Science Teaching, 24*(1), 5–25.

Reys, R. E., Lindquist, M. M., Lambdin, D. V., Smith, N. L., Rogers, A., Falle, J., . . . Bennett, S. (2012). *Helping children learn mathematics.* Milton, Qld: John Wiley & Sons.

Sfard, A. (2008). *Thinking as communicating: Human development, the growth of discourses and mathematizing (Learning in doing: Social, cognitive and computational perspectives).* New York: Cambridge University Press.

Swan, P. & Marshall, L. (2010). Revisiting mathematics manipulative materials. *Australian Primary Mathematics Classroom, 15*(2), 13–19.