Technology and Mathematics: Supporting Students Learning and Engagement in Mathematics in Today’s Elementary Classrooms Through the Use of iPads

By

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Abstract

This research study was conducted using a qualitative research approach involving a comprehensive review on existing research and relevant research and semi-structured interviews with three elementary teachers. This study investigated how three teachers are effectively using technology, specifically iPads, to teach the mathematics curriculum to support students learning in today’s elementary school classrooms. The findings were organized into seven key themes and numerous sub-themes that serve as responses to the main research question and subsequent research questions. One of the key conclusions from this study is that it is vital that all teachers, new and experienced, are learning the tools and skills they need to effectively integrate technology into their classrooms, given the many benefits of technology integration for both teaching and learning.

Key Words: Technology, Technology Integration, iPads, Mathematics, 21st Century Learning
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Chapter 1: Introduction

1.0 Introduction to the Research Study

There is no question that we are more dependent on technology in today’s society than ever before. Technology is everywhere, entwined in almost every aspect of our lives. It affects how we live on a daily basis – how we socialize, connect, learn (Wainwright, 2013). Today’s classrooms in North America have changed dramatically since even as little as ten years ago. Many classrooms today are now equipped with laptops, tablets (i.e. iPads), interactive display boards, digital and video cameras, document cameras, and more (Schwartz & Pollishuke, 2013). The rapid developments and advancements in technology are creating new opportunities for teaching and learning, which teachers should be embracing (Gulbahar, 2007). Research suggests that when technology is used effectively, it can enable ways of teaching that are much better matched to how children learn, as opposed to the resources of traditional classrooms (Keengwe & Onchwari, 2011; Morgan, 2014; Poole & Evans, 2009; Roschelle, Pea, Oadley, Gordin, & Means, 2001). Through conducting a meta-analysis of over 1055 studies, Tamin, Bernard, Borokhovski, Abrami, & Schmid (2011) found that, “the average student in a classroom where technology is used will perform 12 percentile points higher than the average student in the traditional setting that does not use technology to enhance the learning process” (p. 17).

Technology has the potential to equip students with skills essential for life in a 21st century global society, allow students to be active users of information instead of passive recipients of information, and help teachers diagnose and address individual student needs (Moeller & Reitzes, 2011). In mathematics education specifically, technology can support students in exploring and identifying mathematical concepts and relationships, increase students’ access to information, and enhance interactions between students and with the teacher. Moreover, when
Technological tools are used strategically, they can support the learning of mathematical procedures and skills as well as the development of advanced mathematical proficiencies, such as problem solving, reasoning, and justifying (Gadanidis & Geiger, 2010; Kastberg & Leatham, 2005; Nelson, Christopher, & Mims, 2009; Pierce & Stacey, 2010; Suh & Moyer, 2007). However, integrating technology in a way that supports and maximizes students’ learning seems to be the issue many teachers are currently facing (Gilksman, 2013; Keengwe & Onchwhari, 2011; Polly, 2014). Many teachers feel uncomfortable integrating technology into their classrooms due to lack of experience and/or training and the lack of technical support available (Chen, Gallagher-Mackay, & Kidder, 2014). Other barriers to successful integration includes lack of network infrastructure and slow or unstable wireless Internet, out-of-date technology, time constraints, the cost of technology within school budgets, and the expense of maintaining technology (Chen et al., 2014; Moeller & Reitzes, 2011; Bingimlas, 2009; McKenna, 2012; Maher, 2013).

Research has indicated that a high percentage of students and elementary school teachers alike have some level of mathematics anxiety (Scarpello, 2010). Mathematics anxiety is defined as “feelings of tension and anxiety that interfere with the manipulation of numbers and solving of mathematical problems in a wide variety of ordinary life and academic situations” (Richardson & Suinn, 1972, p. 551). With only about 7% of Americans indicating that they do not experience math anxiety (Scarpello, 2007), teachers should be aware of the causes of math anxiety in order to attempt to reduce it. There are several practices teachers can employ to lessen math anxiety in their classrooms (Scarpello, 2010), and research suggests that the use of technology is an important one (Sun & Pyzdrowski, 2009). According to Hak (2014), “[technology] present students with a less intimidating environment, one that they may be more accustomed to or
interested in exploring; one that steers away from rote memorization and in fact promotes independent thinking and collaboration, all of which can ease student anxieties and increase student understanding of mathematical concepts” (p. 49).

As teachers are being increasingly encouraged to incorporate technology into their teaching methods, this research study examines literature on the effects of integrating technology into the classroom, and specifically in the mathematics classroom, as mathematics is traditionally taught using little to no technology. A focus on the use of iPads will be explored, as more and more schools are becoming equipped with iPads.

1.1 Purpose of the Study

The primary purpose of this study, moreover, is to investigate how teachers are effectively using technology, specifically iPads, to teach the mathematics curriculum to support students learning in today’s elementary school classrooms. By doing extensive research and by interviewing a small sample of teachers who actively use iPads in their classrooms to teach mathematics, it was my goal to learn how to best support teachers’ learning and use of iPads to teach mathematics and how they can best apply those learning experiences in their classrooms.

1.2 Research Questions

The main research question that guided this research study was: How are a small sample of elementary school teachers using iPads in their classrooms to support students learning and academic engagement in mathematics? To support this research question, subsequent questions were investigated, such as:

1. What factors and resources support teachers’ learning and use of iPads in their mathematics lessons?
2. How do teachers choose which iPad applications to use to best support students’ learning in mathematics? What criteria do they apply in these decisions?

3. What benefits of using iPads to teach mathematics do teachers observe for themselves and for students?

4. What are the challenges associated with using iPads to teach mathematics? How do teachers overcome or best deal with these challenges?

Through these research questions, it was my goal as a researcher and future teacher to gain a better understanding of how to best integrate technology, specifically iPads, into my mathematics lessons in an effective way, to improve my own teaching pedagogy and to share my findings with the broader education community. Through sharing my research findings, I hope that more teachers and schools can meaningfully integrate 21st century learning tools into instructional practice.

1.3 Background of the Researcher

As an elementary student myself, I enjoyed the mathematics subject area, most likely because I excelled in it. Throughout my years as a student, I was privileged to receive extra support in mathematics from my father, who is very proficient in the subject area. Although I enjoyed mathematics growing up, many of my peers did not, as they found it either boring or difficult. As a future teacher, it is important to me that I do my best to make mathematics more engaging and fun for all students, which in turn will hopefully help them succeed academically. As teachers are being increasingly encouraged to incorporate technology into their teaching methods, I developed a strong interest in exploring the effects of integrating technology into the classroom, specifically mathematics. Because many classrooms today are equipped with different technological devices, I am interested in investigating how these devices can be used to
their full potential to support students learning. As an individual who does not have much knowledge on using iPads in education, I concluded it would be beneficial for me to learn more about this device and how to effectively use it in my future classrooms, in a subject area that is traditionally taught using little to no technology.

1.4 Overview

This Masters of Teaching Research Paper (MTRP) contains five chapters. In chapter one, an introduction of the research study is provided, the purpose of the study is explained, the research questions are listed, and an explanation as to how I came to choosing this particular topic is included. Chapter two contains a review of the literature, in the areas of the role of technology in the classroom, effective technology integration, technology plans in the Toronto District School Board and Toronto Catholic District School Board, and the benefits and challenges associated with technology integration. Additionally, literature in the areas of technology and mathematics, iPads in the classroom, and iPads in mathematics education are explored. In chapter three, the methodology and procedures used in this study are described, including information about the sample participants and the data collection process. The limitations of this research are also discussed in this chapter. In chapter four, I report the research findings and their significance in light of the literature. The final chapter discusses implications and recommendations of this research, as well as my own reflections as a researcher and future educator. A list of references and appendixes follow at the end.
Chapter 2: Literature Review

2.0 Introduction

In this chapter, I review the literature in the areas of technology integration in education. More specifically, I review themes related to technology integration, specifically iPads, in elementary school mathematics. I start by reviewing the literature in the broad area of technology in education and I consider the role it has in the classroom in today’s society. I present research about what is being said on how to effectively integrate technology into the classroom. Next, I review research findings on the benefits and challenges associated with technology integration. From there, I focus on looking at current research regarding the role technology has in the elementary mathematics classroom. Finally, I focus on the use of iPads in the elementary mathematics classroom and its effects on the teaching and learning of mathematics.

2.1 The Role of Technology in the Classroom

"If we teach today's students as we taught yesterday's, we rob them of tomorrow" – John Dewey, 1915

Technology affects almost every aspect of our daily life – life at work, at home, and leisure. Rapid developments and advancements in technology creates new opportunities for teaching and learning, however many school systems are struggling to keep pace with these changes (Gilksman, 2013). Some of the commonly used technologies in education today are laptops, tablets (i.e. iPads), interactive display boards (i.e. smart boards and Promethean boards), digital and video cameras, document cameras, the Internet, and more (Schwartz & Pollishuke, 2013). There is a strong consensus in current literature and research studies pertaining to technology in education that there is a need to integrate technology into the classroom (Chen et al., 2014; Pilgrim, Bledsoe, & Reily, 2012; Prensky, 2012; Thiele, Mai, & Post, 2014). The
current generation of students is what Prensky (2012) refers to as “digital natives” (Prensky, 2012, p. 68). Digital natives have spent their entire lives surrounded by and using the technological tools of the digital age, and as a result, “think and process information fundamentally different from their predecessors” (Prensky, 2012, p. 68). Teachers who were not born into the digital world, referred to as “digital immigrants” by Prensky, must reconsider their methodology and content. Prensky (2012) states,

Teachers need to change how and what they teach, in ways that reflect their students current and future realities. Changing the ‘how’ means creating a pedagogy that works for today’s students. Changing the ‘what’ means creating a curriculum that is future-oriented and engaging to today’s students, while remaining useful and rigorous (p. 19).

Unfortunately, teachers do not have the power to change the curriculum, but they do have the power to teach the curriculum material in creative and meaningful ways that is valuable for today’s students. Various recent research studies and literature written within the last 5 to 10 years have indicated that when technology is used effectively in classrooms, it can facilitate ways of teaching that are much better matched to how children learn, as opposed to the resources of traditional classrooms (Keengwe & Onchwari, 2011; Morgan, 2014; Poole & Evans, 2009; Roschelle et al., 2001). Research has found that digital natives are more stimulated when using digital resources, as opposed to material in print format (Herther, 2009). Data from the University of California–Los Angeles’s Semel Institute for Neuroscience and Human Behavior discovered that the brain activity of digital natives increased while they navigated a web page as opposed to when they read similar material in print format (Herther 2009). In Maximizing Student Success with Differentiated Learning, Morgan (2014) states, “Since today’s students tend to be more engaged while using technology and may find traditional approaches less motivating, teaching effectively with digital resources should help teachers instruct in a manner that matches
the learning styles of their students” (p. 37). With devices such as the interactive white board, tablets and laptops, students can learn through various formats that align with auditory, kinesthetic, and visual learning styles (Morgan, 2014). Despite the known benefits of using technology in today’s classrooms, effectively integrating technology in a way that supports and maximizes students’ learning seems to be the issue many teachers are currently facing (Keengwe & Onchwari, 2011).

2.2 Effective Technology Integration

Bernie Poole (2009) developed prerequisites for successful implementation of a technology program, referred to as the "Ten Pillars of Successful Technology Integration.” According to Poole, every single one of the pillars needs to be in place for the successful implementation of technology for teaching and learning:

1. Leadership must provide active and committed support.
2. Everyone needs to buy in to the change that technology brings.
3. Invest in, and train, a core of teacher-technologists.
4. Recognize that technological change is fast—keeping up-to-date is challenging and essential.
5. All teachers must receive on-going training.
6. All teachers must receive technical support—ideally on-site and on demand.
7. Teachers must plan on integrating technologies in order to maintain currency and fluency in its application.
8. Parents and students must be actively involved in the evolutionary process.
9. There must be planned and systematic financial investment in technology-integrated teaching and learning.
10. Recognize that technology is for all, and that it involves all in the process of lifelong learning.

(Poole, 2009, p. 343).
Other scholars who have conducted research in the area of technology integration support Poole’s prerequisites. According to a study conducted by Summak, Samancioğlu, & Bağlibel, (2010), the way in which technology is used in a classroom is a critical measure of its success. Simply having technology in the classroom without proper planning and reflection is not sufficient – technology in itself does not support learning. Schacter and Fagnano (1999) explain that technology should not be used only because it makes learning easier and more efficient, as ease and efficiency do not lead to deep and meaningful learning. When technology is integrated effectively, it brings qualitative changes to education and is not merely used to continue the old way of teaching and learning (Su, 2009). Johnson, Maddux, & Lui (2000), who analyzed 102 cases where technology was integrated into the classroom curriculum, recommend focusing on three variables that can increase the chances of successful integration: “adequate software programs that allow students to create, manipulate, and produce; problem-based assignments; and constructivist learning environments” (Johnson et al., 2000, as cited in Su, 2009, p. 162).

Educators must devote thoughtful planning and attention both to the objective of the activity and to the needs of the students to develop successful lessons that incorporate technology. A teacher’s training, knowledge, and attitude toward technology use are central to effective technology integration (Protheroe, 2005). In addition, many studies have found that school administration, parent and community support is essential for technology integration to be successful (Guilfoyle, 2006; Strudler et al. 2003; Thompson, 2003).

Dr. Ruben R. PuenteDura developed the SAMR Model, a framework to support educators and instructional designers in creating optimal learning experiences using technology in education (Romrell, Kidder, & Wood, 2014). The main goal of the SAMR Model is to serve as a guide for effective technology integration. The SAMR model includes four levels of technology
integration: substitution, augmentation, modification, and redefinition. The goal for educators is to move through the different levels to find more meaningful uses of technology in teaching (Younie, Leask, & Burden, 2015). When planning learning activities, educators should aim for task redefinition, the stage at which technology offers a completely different learning experience that otherwise could not be possible (Younie, Leask, & Burden, 2015). Gorman (2015) has found that as educators become familiar with the SAMR Model, it allows them to reflect and evaluate their technology integration practice and implement technology more effectively.

### 2.3 Technology Plan in the Toronto School Boards (TDSB and TCDSB)

Both the Toronto District School Board (TDSB) and the Toronto Catholic District School Board (TCDSB) recognize the importance of using technology to engage students to enhance and enrich their learning. Both school boards clearly state what their current views on technology are and what their goals are for the future on their website (TDSB, 2014; TCDSB, 2014).

The TDSB is guided by Information and Communications Technologies Standards (ICT Standards), which is a framework for students, teachers, and administrators to use technology as a tool for teaching and learning. The TDSB ICT Standards document offers different methods of teaching The Ontario Curriculum so that the various learning styles of students may be addressed. Many schools in the TDSB have joined an online tool called the “Academic Workspace 3.0” (AW 3.0). The AW 3.0 is an online tool for communication, collaboration and information sharing among teachers, students and staff. In addition, the TDSB is a “Google Apps for Education” partner, providing students and staff with access to free online tools in a safe and secure TDSB Google account (TDSB, 2014). Although the TDSB has a technology plan in place, they are still working on integrating technology effectively into all schools. Currently, the board states that they are working to provide all schools with wireless connectivity, every teacher
The TCDSB seeks to transform education through the development of four key 21st century skills: Creativity, Collaboration, Communication and Critical Thinking. In 2013, the board developed a five-year learning plan that provides a framework for staff, students and their families to develop these 21st century learning skills and to effectively use technology for learning. The TCDSB's Department of 21st Century Learning provides professional development for the integration of technology in the classroom, through a framework called “Project NEXT,” which promotes the 21st Century Fluencies through a Catholic lens. The “Academic Information Communication and Technology Department” (AICT Department) provides professional development opportunities for all staff about the integration of technology in the classroom. Workshop topics include: SMART Board integration, iPad training and integration, Learning Management System training and implementation, Assistive Technology, e-Learning and Bring Your Own Device. On the TCDSB website, a list of recommended apps for iPads that encourage 21st Century Fluencies are available (TCDSB, 2014).

Currently, there is no public research available that evaluates whether the TDSB and TCDSB are achieving their stated goals and putting their beliefs into action.

2.4 Benefits Associated with Technology Integration

Many research findings have indicated that effective technology integration has countless benefits for teaching and learning. Numerous scholars have cited a wide range of benefits resulting from successful technology integration, including: increased student engagement (Avila & Wilson, 2011; Digedu, 2014; Hechter, Phyfe, & Vermette, 2012; Warschauer, 2008),
decreased disciplinary issues (Baldwin, 1999, as cited in Spektor-Levy & Granot-Gilat, 2012; Edutopia, 2008), assessment support (Nicol & Milligan, 2006), giving every student a voice (Brosnahan, 2012; Carpenter, 2015), making differentiating instruction for teachers easier (Hechter, Phyfe, & Vermette, 2012; Spektor-Levy & Granot-Gilat, 2012; Starr, 2011), promoting the development of 21st century skills (Edutopia, 2008; Rieti, 2014; Spektor-Levy & Granot-Gilat, 2012), and providing greater access to diverse and current learning materials (Chen, Gallagher-Mackay, & Kidder, 2014; Edutopia, 2008). In addition, researchers have indicated that technology helps to facilitate active learning (Hechter, Phyfe, & Vermette, 2012; Kovalchick & Dawson, 2004; Starr, 2011), inquiry-based learning (Donovan & Macklin, 1999, as cited in Balmeo, Nimo, Pagal, Puga, ArisDafQuiño, & Sanwen, 2014), and inclusive learning environments (Johanson, 1998, as cited in Balmeo et al., 2014). Furthermore, Roschelle et al. (2001) present cognitive research findings stating that technology can support four fundamental characteristics of learning: 1) active engagement, 2) participation in groups, 3) frequent interaction and feedback, and 4) connections to real-world contexts.

Today’s technological-advanced generation of students are more engaged while using technology and find traditional approaches less motivating (Morgan, 2014). Student engagement is an issue in many classrooms, but the use of technology can help to address this issue. Avila & Wilson (2011) explain, “Learning becomes a more active experience, stimulating students at a deeper level. Many education products employ the principles of gamification, which is the use of game mechanics in nonentertainment environments to change user behavior and drive engagement” (p. 9). When students are placed in the relatively passive role of receiving information through lectures or textbooks, they often have a difficult time applying what they have learned in the outside world (Roschelle et al., 2001). Providing students with the
opportunity to use technology in an interactive way is an excellent way to facilitate active learning (Kovalchick & Dawson, 2004). Active learning is defined by Kovalchick and Dawson (2004) as “learning that helps students to think critically, analyze, synthesize, and evaluate information, work efficiently and effectively in groups, and solve problems within a variety of different disciplines” (p. 3). In a multi-side case study examining literacy practices in 10 schools in the United States with one-to-one computing programs, Warschauer (2008) noted increased student engagement in wireless classrooms as students participated in more diverse writing activities, analysis of reading, and use of media-production software. Research has found that as students are more engaged and on task in school, less behavioral issues arise as well (Edutopia, 2008). In addition to increased engagement, Sivin-Kachala Bialo, and Rosso (2000) found that students developed more positive attitudes about themselves and towards learning through the use of technology.

Moreover, technology offers teachers effective ways to access each student’s learning style and assess student understanding in multiple ways (Edutopia, 2008). New technologies are leading to new ways of enhancing current assessment practices and offering innovative possibilities for assessment. There are many tools available to support self-assessment, in addition to tools that support the delivery of teacher and peer feedback. Nicol and Boyle (2003) provide an example and describe the use of a technology called a Classroom Communication System (CCS) that can be used to enhance feedback dialogue. They explain,

> With a CCS, students make responses to multiple-choice questions presented in class using handsets that send signals to wall-mounted sensors. Responses are collated, in real time and then displayed by digital projection to the student cohort as a bar chart. This bar chart provides almost immediate quantitative feedback on class responses and can be used to support classroom dialogue” (p. 7).
Technology is a new facilitator learning activities because it enables teachers to embed assessment into instruction more efficiently (Ferrara, 2013). Additionally, technology supports many of the data-collection, complex analysis, and individualized feedback and scaffolding features needed for the formative use of assessment (Brown, Hinze, & Pellegrino, 2008). It has also been cited that technology gives every student a voice (Brosnahan, 2012; Carpenter, 2015). Not only does technology assist nonverbal children communicate and help children with special needs express their desires and feelings (Brosnahan, 2012), it can also be used to direct students' social instincts toward academic discussion, and thus improve engagement and achievement for all (Carpenter, 2015).

Balmeo et al. (2011) elucidates, “well-employed use of technology in the classroom can allow teachers to tailor learning to student’s individual needs while freeing up classroom time, leaving teachers more time for projects, one-on-one coaching, and more creative activities” (p. 5). Many educational technology tools provide personalized instruction, allowing students to do work based on their individual needs, skill levels and interests (Avila & Wilson, 2011). Technology helps teachers create inclusive learning activities that enable all students, including those with disabilities, to participate (Johanson, 1998, as cited in Balmeo et al., 2014).

In a CBC News article released in September 2014, Ontario’s Education Minister Liz Sandals stressed that students will need both technology skills and the ability to think critically about what they’re doing with technology to succeed in today’s digital world. By integrating technology into the classroom, all students are provided with the opportunity to gain the tools and skills they require to live and flourish in our digital world (Edutopia, 2008). Learning with technology helps students develop important higher order skills such as the ability to collaborate, think critically, and be creative (Rieti, 2014). The use of technology does not only enhance
learning environments, but also prepares students for their future lives and careers (Wheeler, 2001).

2.5 Challenges Associated with Technology Integration

Research conducted over the past 20 years on technology integration in education sheds some light on why technology is not used more often, despite the numerous benefits for teaching and learning (Moeller & Reitzes, 2011). According to a recent survey of more than 1000 educators, Information Technology (IT) staff members, and students conducted by CDW Government LLC (2010), only 8 percent of teachers fully integrate technology into the classroom. Although many educators acknowledge the value of technology and are aware of the compelling reasons to use it to enhance teaching and learning, many educators experience various challenges during the process of adopting new technologies, which is why technology is not currently widely integrated into classrooms (Bingimlas, 2009).

There is a vast amount of research available on the challenges of technology integration and the majority of the research studies present similar findings. The main challenges associated with technology integration can be classified into two categories: teacher-level or school-level challenges. Teacher-level challenges include lack of teacher confidence, lack of teacher competence, and resistance to change and negative attitudes. School-level challenges include lack of time, lack of effective training, lack of accessibility, and lack of technical support (Bingimlas, 2009; Chen et al., 2014; Maher, 2013; McKenna, 2012; Moeller & Reitzes, 2011). Moeller & Reitzes (2011) explain that “in order to use technology effectively for educational purposes, teachers must not only be familiar with how to operate equipment, but also understand how these tools are effectively used in the subjects they teach and how to incorporate resources into classroom activities that accomplish important learning goals” (p. 14). In a survey conducted
by Walden University (2010), more than half of the teachers surveyed felt that their Teacher Education programs failed to prepare them in how to effectively teach with technology. According to Becta (2004), who conducted a small-scale survey with teachers and reviewed some of the available literature associated with teachers’ use of technology, a teacher’s level of confidence in using technology is the significant determinant of whether they will engage with and integrate technology in their classroom or not. A teacher’s lack of confidence is the main barrier to the uptake of technology by teachers in the classroom (Becta, 2004).

Cuban (2001) explains that as infrastructure matures and teachers’ beliefs about teaching and learning evolve, more and more teachers will change their practices and integrate technology into their classrooms. He argues that in order for this to happen, policymakers and practitioners must: a) make technology more readily available to students in each classroom; b) provide Internet access to all schools; c) invest in more online curriculum and distance learning; d) increase the technical support for teachers; and e) add more professional development opportunities for staff (Cuban, 2001). Similarly, Moeller & Reitzes (2011) have found that technology is most likely to be widely adopted by teachers and schools if it supports already existing practices, it is part of a school-wide initiative, and if teachers have access to ongoing professional development and support (Moeller & Reitzes, 2011). Further discussion and research will lead to a better understanding of how to overcome the technology integration challenges currently facing schools and districts (Center for Implementing Technology in Education, n.d.).

2.6 The Use of Technology to Support Mathematics Learning

The implementation of technology into a mathematics lesson can be an intimidating task for many teachers, but an essential one (Herron, 2010). Research studies have concluded that
Technology is an essential and valuable tool for teaching and learning mathematics effectively, for numerous reasons including reducing levels of mathematics anxiety, engaging students in their learning, making mathematical ideas tangible and creating individualized learning environments (Attard & Northcote, 2011; Kigger, Herro, & Prunty, 2012; National Council of Teachers of Mathematics, 2003; SRI International, 2007).

Research has indicated that a high percentage of students and elementary school teachers alike have some level of “mathematics anxiety” (Scarpello, 2010). Psychologists Richardson and Suinn (1972), who developed the first instrument designed specifically to measure mathematics anxiety – the Mathematics Anxiety Rating Scale (MARS) – define math anxiety as “feelings of tension and anxiety that interfere with the manipulation of numbers and solving of mathematical problems in a wide variety of ordinary life and academic situations” (Richardson & Suinn, 1972, p. 551). Sheila Tobias (1993), often referred to as a pioneer in the study of mathematics anxiety, explains that mathematics anxiety can cause one to forget and lose self-confidence (Tobias, 1993). This anxiety associated with math can begin as early as the fourth grade and usually increases in middle school and high school (Scarpello, 2010). Math anxiety is caused by two main factors: intrinsic, specifically the failure of cognition, or extrinsic, the negative emotion transmitted from others, such as peers, teachers and parents (Sun & Pyzdrowski, 2009). With only about 7% of Americans indicating that they do not experience math anxiety (Scarpello, 2007), teachers should be aware of the causes of math anxiety in order to attempt to reduce it. Teachers are a key element in reducing math anxiety, therefore they should work at actively employing effective teaching practices to lessen math anxiety in their classrooms (Scarpello, 2010). A review of the literature on this topic presents several strategies that can be implemented to reduce or overcome mathematics anxiety and one specific way mentioned frequently is the use
of technology in mathematics education (Sun & Pyzdrowski, 2009). Sun and Pyzdrowski (2009), both professors at West Virginia University, made conclusions on how technology can be used to overcome mathematics anxiety based on an analysis of literature. Online discussion boards present students with the opportunity to express their feelings and allows cooperative learning to occur. The use of websites through the Internet provides virtual manipulatives and hands-on activities, easy access to resources to quickly retrieve information, and presents multiple strategies that can be used when solving difficult problems, which can be helpful for students, parents and teachers. Technology used in these ways can strengthen student cognition, thus help to reduce mathematics anxiety (Sun & Pyzdrowski, 2009).

Technology is believed by many to be an engaging way to help students and teachers create an authentic learning environment in mathematics (Gard, 2014). Tuttle (2007) explains that when students use different technologies in the classroom, they become more engaged in learning which helps them to move from abstract ideas to hands-on applications. Polly (2014) claims that “while concrete manipulatives or pictorial drawings could be used to explore the mathematical content, using technology provides learners with the ability to quickly generate and manipulate mathematical representations, thus allowing them to concentrate more on examining the mathematical concepts, making and testing generalizations, and making connections between the representations and the mathematics that they explore” (Polly, 2014, p. 277). Integrating technology into the mathematics classroom also helps to make ideas more tangible. SRI International (2007) explains that although drawings on paper or on the chalkboard can make ideas tangible, they often fail to properly convey mathematical principles because they are static drawings. The example provided to support this statement is that many students think a triangle is an isosceles triangle if it looks like one and do not understand how to establish the property
formally. With a technology-based geometry tool, students can move a corner of a geometric construction of a triangle and observe how it behaves under transformations. Experimenting and playing with this tangible image can prepare students to understand the formal proof (SRI International, 2007). When technology makes abstract ideas tangible, researchers have found that teachers can more easily build upon students’ prior knowledge, emphasize the connections among mathematics concepts, make connections between abstract ideas and real-world settings, address common misunderstandings, and introduce more advanced ideas (Bransford, 2000; diSessa, 2000; Roschelle et al., 2001). Lastly, using technology for mathematical gaming is becoming more popular in schools today because it fosters individualized learning. According to Shin, Sutherland, Norris, & Soloway (2012), “mobile gaming creates an individualized learning environment that allows students to select their own learning paths based on their prior knowledge and learning progress. This flexible approach, linked to prior knowledge, leads to meaningful learning” (p. 468).

Although the use of technology is encouraged in the mathematics classroom, many researchers agree that teachers should have a well-balanced mathematics program that provides students with different methods to practice math (Gard, 2014; McKenna, 2012; Rieti, 2014; Technology for Teaching and Learning, 2011). Solid teacher pedagogy in mathematics must not be disregarded; technology as a teaching and learning tool is “a part of the whole,” according to Timothy Gard, a Toronto District School Board Educator (Gard, 2014, para. 9). Just like other subject areas, Strot (1999) states that the key to successful technology integration in mathematics is a thoughtful plan for learning. When technology is used without a plan, it provides only random skills practice, competition for equipment, and may be a distraction from learning (Strot, 1999). There is a strong consensus in current literature that when used properly, technology can

2.7 The Use of iPads in the Classroom

The iPad accounts for nearly 99.8% of all tablets used, with almost 20 million sold in the United States (Etherington, 2011, as cited in Powell, 2014). Apple’s iPad has attracted a lot of attention from the public since its release in 2010 and one area in which it has been adopted is the field of education. The iPad has many features that make it attractive to educators: its mobility, lightweight and small size, large multi-touch screen, sleek profile, and abundance of software tools (Henderson & Yeow, 2012). With iPads, students can interact with content in motivating, authentic, and effective ways (Bennett, 2011; Pilgrim et al., 2012).

With an iPad, users can download applications, also known as “apps,” for immediate use. Apps are created to serve specific, discrete functions, unlike traditional software programs. Many apps are available for free, but some cost a small fee. There are thousands of educational apps available, but the quality of these apps varies greatly. One of the greatest challenges associated with the adoption of iPads in the classroom that educators are facing is choosing the best apps to support learning (Brooks-Young, 2014). It is important that students are using iPads as a tool to enrich learning, as opposed to using them as toys. The iPad has significant potential in improving students learning through the use of apps (Murphy, 2011, as cited in Powell, 2014), but only if the apps are aligned to curriculum goals and standards (Finegan & Austin, 2002, as cited in Powell, 2014). It is vital that teachers are selecting apps with targeted content and appropriate learning outcomes for students with and without disabilities. With the number of apps available today, choosing appropriate apps can be an overwhelming and time consuming process for teachers (Powell, 2014).
Much of the current literature on the topic of iPads in education speaks about the challenge schools are facing with affording class sets of iPads, as one iPad costs more than $500.00 (Bennett, 2011). However, studies have shown that iPads in the classroom should not be dismissed if a class set cannot be afforded. Bennett (2011) explains, “Having a class set promotes traditional, whole-class instruction, but fewer iPads facilitate individualized and tailored instruction” (Bennett, 2011, p. 23). Students can use iPads in small groups or they can be used in centers – fewer iPads simply requires innovative thinking in terms of instructional design (Powell, 2014).

2.8 The Use of iPads in Mathematics

According to a CBC News article released in September 2014, new standardized testing numbers show elementary students are struggling with math in the province of Ontario (Rieti, 2014). In the article, Ontario’s Education Minister Liz Sandals, stated, “the Education Quality and Accountability Office (EQAO) numbers show students have good basic arithmetic skills, but struggle to explain their understanding of math questions” (Rieti, 2014, para. 9). At the end of August 2014, Sandals announced $150 million in funding for technology which will help pay for the board’s plan to give all students in Grade 4-12 an iPad in the next five years. Sandals believes in a well-balanced mathematics program, and that the effective use of technology may help with the dropping math scores (Rieti, 2014).

Although the use of iPads are becoming more popular in elementary school classrooms, it is difficult to find teaching ideas that promote deep mathematical understanding using the iPad (Attard, 2013). In two studies conducted, it was found that teachers are finding it more challenging to use iPads in interesting ways when teaching mathematics, in contrast to their use in other subjects. Many apps that are specifically designed for mathematics focus on a “drill and
practice” games approach, which basically just replaces the repetition of a standard worksheet or textbook page with some added animation (Attard, 2013; Attard & Curry, 2012). These apps are beneficial for keeping students engaged, but do not provide opportunities for students to develop their problem solving skills and deep mathematical thinking (Attard, 2013). However, in order to learn advanced mathematics, students must master basic arithmetic skills in the early stages of the learning experience (Hoon, Chong & Binti Ngah, 2010, as cited in Shin et al, 2012). It was found that “drill and practice” apps can help facilitate student learning of basic mathematics skills, thus should not be viewed as an ineffective learning tool in the elementary mathematics classroom (Shin et al., 2012).

Carefully selecting apps and designing activities using the iPad requires thoughtful planning by a teacher. It is important that teachers test apps prior to using them in class to ensure they are appropriate for the curriculum and specific student needs. Attard (2013) provides a brief list of the many things to think about when considering the integration of iPads into teaching and learning mathematics:

1. What specifically do you want students to learn (content and/or proficiencies)?
2. What types of activities/tasks help students learn this content? (Don't forget the importance of including concrete materials.)
3. What function of the iPad could you utilise to enhance teaching and learning? (If the iPad does not add anything to the lesson, then perhaps reconsider using it.)
4. How will you integrate the iPad into the lesson structure? Will the lesson begin with a whole class demonstration using projection onto an interactive whiteboard?
5. How many iPads will you need? (This often depends on how many you have available.)
6. Should each child have a device, or is it better for students to share a device? (Sharing promotes reasoning and supports the development of mathematical language.)
7. How will the students be grouped?
8. Will all students be engaged in exactly the same task using the iPads, or will there be a range of tasks that address the same mathematical content?

9. How will you know if students are engaging with the mathematics of the lesson?
   (Sometimes iPads can be distracting.)

10. How will you collect evidence of student learning?
    (Attard, 2013).

Attard and Northcote (2011) highlight examples of apps available for the iPad that can be downloaded by educators for various goals. To increase fluency in number operations and mathematical reasoning, Attard and Northcote (2011) reference Rocket Math, Geometry Test, Math Addicted, Basic Math and MathBoard Addition. Of these five applications, Rocket Math is the most engaging as it is designed as a game but still embeds mathematical questions at varying levels of difficulty. Attard and Northcote (2011) state that the other four applications are useful for having students practice computation, but offer little more than a worksheet in terms of their potential to engage and motivate students. To support a problem-solving and investigative approach to learning mathematics, Attard and Northcote (2011) mention Red Dragonfly Mathematics Challenge, KENKEN: Train Your Brain Lite, LetsTans Lite, Dice Puzzle and Sukoku. These are problem-solving, puzzle-based applications that are interactive and also provide opportunities to address proficiency strands of the Australian Curriculum. Lastly, to support students during mathematics investigations, Attard and Northcote (2011) cite World Fact Book, iBlueprint, iBrainstorm, Keynote, and Show Me. Show Me is of benefit to both students and teachers as it allows students to record their voices, while they draw and complete a mathematical problem. By capturing a student’s verbal reasoning and problem solving skills, teachers can more easily assess mathematical content and processes (Attard & Northcote, 2011).
2.9 Summary

In this literature review, I looked at research on the current role of technology in the classroom, what is being said regarding effective technology integration, and some of the benefits and challenges associated with technology integration. The use of technology to support mathematics learning was explored, since a high percentage of students suffer from mathematics anxiety. Lastly, I reviewed current literature about the use of iPads in education and how they are being used in the elementary mathematics classroom to support students learning.

Through this review of the literature, I learned that technology integration in education is a very hot topic right now and there is a lot of current research already done. With this said, I believe there is the need for further research in the areas of iPads in mathematics and how to best integrate them into mathematics lessons. Choosing appropriate and beneficial applications seems to be a challenge many teachers are facing. There are many factors to consider with the integration of iPads into teaching and learning mathematics, which should be further researched. This study explores the question “How are a small sample of elementary school teachers using iPad’s in their classrooms to support students learning and academic engagement in mathematics?” It investigates the methods and strategies some elementary school teachers are using to effectively integrate technology, specifically iPads, into the mathematics classroom and the indicators of learning these teachers observe when doing so. Additionally, this study will explore the challenges associated with using iPads to teach mathematics and how teachers can best overcome or deal with these challenges.
Chapter 3: Research Methodology

3.0 Introduction

In this chapter, I discuss the research methodology, including how the data was gathered and analyzed. I begin by articulating the research approach and procedures, and the instruments used for data collection. Next, I address all methodological decision-making pertaining to my research participants: sampling criteria, sampling recruitment and participant bios. I explain data analysis procedures and review the ethical considerations related to my study. I also discuss a range of methodological limitations, but then speak to the strengths of the methodology as well. Lastly, I conclude the chapter with a brief summary of key methodological decisions and my rationale for these decisions given the research purpose and questions.

3.1 Research Approach and Procedures

This research study was conducted using a qualitative research approach involving a comprehensive review on existing research and relevant research and semi-structured interviews with three elementary teachers. Qualitative research is conducted because a problem or issue needs to be explored. Creswell (2013) explains that to study the research problem, “qualitative researchers use an emerging qualitative approach to inquiry, the collection of data in a natural setting sensitive to the people and places under study, and data analysis that is both inductive and deductive and establishes patterns or themes” (Creswell, 2013, p. 44). Among the five qualitative approaches to inquiry (narrative study, phenomenology, grounded theory, ethnography, case study), narrative research is the most suitable approach for this study, given the research purpose and questions, and so I will draw on characteristics of this approach. Narrative researchers collect stories from individuals about their lived and told experiences, primarily through the method of interviews and documents. For this study, I will be personally collecting data by
conducting semi-structured interviews using open-ended questions with three teacher participants who are reflective of my participant sampling criteria. It is the goal of this study that these teacher’s experiences in the classroom will provide insights into the topic. I will be reflexive in the study, conveying my personal background to participants and why I am interested in the topic under investigation (Creswell, 2013).

3.2 Instruments of Data Collection

Given the parameters of the MTRP, the primary instrument of data collection used in this research study is the interview protocol (see Appendix B). Three semi-structured interviews were conducted and audiotaped, and then transcribed. Interviews can be placed on a continuum of structure, ranging from “unstructured” to “highly structured” with “semi-structured” in the middle. The difference between these different types of interviews is the idea of how much “control” the interviewer has over the interaction (Harrell & Bradley, 2009). In a semi-structured interview, the interviewer has a set of pre-planned questions to ask to the participants and an idea of the main topics that must be covered during the interview that attends to the research focus and questions. Although this structure is in place, the semi-structured interview format allows the conversation between interviewer and participants to vary, as participants have the opportunity to elaborate and even re-direct attention to areas previously unforeseen by the interviewer (Creswell, 2007). Semi-structured interviews are an excellent tool to understand how people make meaning of their experiences (Rabionet, 2011).

3.3 Participants

In this section, I review the sampling criteria I established for participant recruitment, and I review a range of possible avenues for participant recruitment. Moreover, I provide a brief introduction of each of the participants in the study.
3.3.1 Sampling Criteria

In order to inform the study and respond to the research questions, participants were selected based on the following specified criteria:

1. Full-time elementary teachers who have a minimum of 5 years elementary teaching experience. This criterion ensured that participants were well informed and experienced practitioners with many teaching experiences to inform their responses.

2. Full-time elementary teachers who have incorporated iPads into their mathematics teaching for at least 2 school years to teach different mathematics topics. This criterion is extremely important since the purpose of this study is to investigate how teachers can effectively use technology, specifically iPads, to teach the mathematics curriculum to support students learning in today’s elementary school classrooms. The criteria of 2 years was chosen to ensure participants had experience using iPads with more than 1 group of students.

3. Full-time elementary teachers who have demonstrated leadership and/or expertise in the area of technology integration in the classroom. Such leadership could be in the form of providing professional development for colleagues, having completed a graduate degree with this focus, or having written curriculum support materials. This criterion assures that participants have ample knowledge on the research subject, which in turn means their responses should inform the research study.

3.3.2 Participant Recruitment

Qualitative inquiry usually focuses on relatively small samples, selected purposefully, whereas quantitative methods typically depend on larger samples, selected randomly. With purposeful sampling, the goal is to select individuals and sites for study
that will purposefully inform an understanding of the research problem. There are
different types of sampling strategies that can be adopted to recruit participants, which
are each unique and serve different purposes (Patton, 1990; Creswell, 2013). Given the
small-scale nature of this study and the methodological parameters, the main sampling
methods that were adopted include purposeful and convenience sampling. Although
convenience sampling sometimes lacks intellectual credibility, it is the least costly
sampling method, in terms of time, effort and money (Marshall, 1996; Creswell, 2013).
As an individual who is currently immersed in a community of teacher colleagues, I am
able to conveniently rely on existing contacts and networks to recruit participants.

To recruit participants, I employed the following strategies until I found three
participants who met the sampling criteria:

1. I contacted elementary principals who work in schools with a demonstrated
commitment to technology integration, and provided them with an overview of my
research study. I provided the participant criteria and asked if they could distribute
my contact information to teachers they believed may fulfill the criteria. Interested
teachers could contact me to ensure that teachers were volunteering to participate
rather than feeling pressure or obligation to participate. I did not contact random
principals, but rather, I made a list of schools in Toronto and the Greater Toronto
Area that I had been informed have teachers who actively use technology as a tool to
support student learning.

2. I spoke with colleagues and instructors in the Master of Teaching Program to inquire
if they knew of anyone who fulfilled the sampling criteria. I asked them to kindly
forward on my contact information to their recommendations.
3. Using my Twitter account, I followed the 31 Ontario teacher Twitter Accounts recommended by Brian Aspinall on his website: http://brianaspinall.com/30-ontario-teacher-twitter-accounts-worth-following/. After following these accounts, I direct messaged each these educators to inquire if they would be interested in participating in the research study. For those who replied and were interested, I provided them with more detailed information regarding the study.

3.3.3 Participant Biographies

There were three participants interviewed for this study: Susan, Laura and Andrea. A brief biography for each participant is provided below and pseudonyms are used to maintain confidentiality.

Participant 1: Susan

At the time of the research, Susan had fifteen years of experience as a classroom teacher, teaching every grade level from kindergarten to grade eight, except for grade two and three. The previous year, Susan taught grade eight mathematics and science at a middle school in Ontario and was the Technology Coordinator in her school. She had access to laptops and iPads in her school, but the majority of students brought in their own device, as her school had a “Bring Your Own Device (BYOD)” program in place. The following year, Susan took on a new position as an Instructional Coach with a school board in Ontario. Susan supported four schools in meeting their own individual goals, such as teacher-related or school-related goals. In addition to being an Instructional Coach, Susan was also an Additional Qualifications (AQ) Instructor and PhD candidate. She had her Masters Degree in Education and her specialties were math, science, and
literacy across the curriculum. Susan had developed and delivered many workshops at both the school and board level about technology integration.

Participant 2: Laura

At the time of the research, Laura was a grade one teacher in the Ottawa Catholic District School Board (OCDSB) in Ontario. Laura had been teaching as an elementary school teacher for fifteen years. She had experience teaching in all elementary grade levels (kindergarten to grade six), however, she had spent most of her career teaching grade one. Laura had access to range of technology in her classroom, such as iPod touches, iPads, chromebooks, and a Smart Board. Laura supported other teachers in integrating technology into their classrooms by facilitating different professional development workshops and sharing her knowledge and ideas on an online blog.

Participant 3: Andrea

At the time of the research Andrea was a grade four teacher in the Peel District School Board (PDSB) in Ontario. Andrea had been teaching as an elementary school teacher for seven years. She had previously taught grade two, grade three, grade six, grade seven and grade eight. This year, Andrea had access to iPads, netbooks, Apple TV, a classroom computer, projector and document camera in her classroom.

3.4 Data Analysis

The first stage of the data analysis process was transcribing the interviews. Once completed, each transcript was coded individually using the research questions as an interpretive tool. Categories of data and themes within categories were identified through the coding process, and where appropriate, categories and themes were synthesized. During this process, “null data”
was also explored. It was important to examine and acknowledge the silences in the data – what the participants did not speak to – as this data was just as important as the data received from the participants, as it shed light on gaps or problems that might needed to be further researched. A later stage of analysis was the meaning-making process where the research findings were discussed.

Creswell (2013) explains that this analysis process is best represented in a spiral image, referred to as the “data analysis spiral,” where analysis starts at the bottom of the spiral and proceeds upwards in various stages until findings are presented through a written account. This process highlights an “iterative and systematic approach to data analysis that can help to ensure credible findings” (Kodish & Gittelsohn, 2011, p. 55).

3.5 Ethical Review Procedures

Ethics is a very important aspect of research and should be at the heart of a study from the early design stages until the end. According to Webster, Lewis, & Brown (2014), “good ethical qualitative research means being able to anticipate what might arise but also to respond to the unexpected, working in a thoughtful and reflective way” (p. 78). An ethical qualitative researcher is committed to reflecting upon what their research means for participants and how it may affect them, potentially deviating from prescribed rules to make the best ethical decisions (Webster et al., 2014).

This study has followed the ethical review approval procedures for the Master of Teaching Program at the Ontario Institute for Studies in Education. A letter of consent (Appendix A) was provided to the participants (who were recruited on a voluntary basis) and signed prior to the interview stage. The letter outlines an overview of the research study, speaks
briefly about the data collection process, addresses ethical implications, and specifies expectations of participation.

Prior to participation, it was made clear to each participant that there were no known risks to participation in the study. All participants were notified of their right to choose to decline to answer any interview question or withdraw from participation in the study at any stage of the research study. Each participant was assigned a pseudonym to protect his or her identity and personal interests. Participants were reminded prior to the interview that their identity would remain confidential and any identifying markers related to their students or school would be excluded. The participants were also made aware that the data would be stored safely on my password-protected computer with restricted access and destroyed 5 years after the interview. Participants were informed that the only other person beside myself who would have access to the raw data would be my course instructor Dr. Angela MacDonald-Vemic. Participants were given the opportunity to review the transcripts and to clarify or retract any statements before I conducted the data analysis. Careful review of the data, and adherence to ethical procedures for ensuring anonymity, made certain that the dignity, rights and welfare of all participants were protected.

3.6 Methodological Limitations and Strengths

In this section, I address the methodological limitations and strengths of this research study.

3.6.1 Limitations:

There are a couple notable limitations of this study, which confine the study design. Given the ethical parameters that the Master of Teaching Program has approval for, the MTRP could only involve interviews with teachers, limiting the scope of the research.
Consequently, I was unable to interview students or parents, who could have provided worthy insight about the research topic. It would be valuable to learn about how parents support the use of iPads at home with their children, and their views on the integration of technology in today’s classrooms. It would beneficial to have student voices represented in the data as well to gain a better understanding of how children describe the impact technology has on their learning.

Having the opportunity to collect data through other methods in addition to interviews, such as through surveys or classroom observations, would also be helpful in generating more data. Although the data would not be as detailed as responses received through interviews, conducting surveys would allow more teachers to be included in the study. Classroom observations would be helpful in this study as well as I would be able to witness and make notes on the ways teachers are employing different strategies in the classroom and how children are responding to technology integration. Observations could support the data from the interviews, but could also provide valuable data that the participants did not speak about.

Furthermore, the small sample size of the study is an additional limitation. Only three teachers were interviewed to gather data. A common limitation of qualitative research is that findings may only be unique to the few people included in the study (Anderson, 2010). Although the findings from these three teachers can inform the research topic, they cannot generalize the experience of teachers more broadly speaking.

3.6.2 Strengths:

By selecting semi-structured interviews as the primary instrument for data collection, I was able to gather much more detailed information from the three teacher participants than I
would have had I collected data through another form of collection (i.e. a survey). The interview method involved probing and clarification, which allowed for detailed retrospective accounts to be collected. Semi-structured interviews allow for questions to be guided/redirected by the researcher in real time (Anderson, 2010). The interviews provided the teacher participants with the opportunity to discuss their lived experiences and speak to what matters most to them about the importance of technology in the classroom and as a tool to teach mathematics.

3.7 Conclusion

This research study was conducted using a qualitative research approach involving a literature review and semi-structured interviews with three elementary teachers. Semi-structured interviews were chosen as the main instrument for data collection to allow the teacher participants to openly speak about their experiences with technology in their classrooms and its effect on children’s learning, particularly in math. The participant sampling criteria, sampling recruitment and participant bios are specified in this chapter, followed by the data analysis process. The analysis process used in this study is represented by Creswell’s “data analysis spiral.” Ethical considerations related to the study are explained, as well as the methodological limitations and strengths. Next, in chapter 4, I report the research findings of this study.
Chapter 4: Findings

4.0 Introduction

In this chapter, I report and discuss the research findings derived from semi-structured interviews with three elementary teachers. As discussed in chapter 3, this research study was conducted using a qualitative research approach involving a comprehensive review on existing and relevant research and semi-structured interviews. All three participants had a great amount of experience and knowledge to share regarding the research topic, which provided valuable insights and findings. After analyzing the interview transcripts in great detail, I felt that the findings were best organized into seven key themes and numerous sub-themes that serve as responses to my main research question and subsequent research questions. The themes that will guides this discussion are:

1. Participant’s learning and use of the iPad in their mathematics lessons is supported through collaboration with other educators via Twitter, Professional Development workshops, sharing at school meetings, and self-directed research.

2. The criteria that participants reported to select applications include cost, exposure to advertisements and recommendations and reviews from others in the field of education.

3. Participants prioritized the role of technology in instructional planning and used it not only for practicing math facts but also for meaningful and creative tasks in math.

4. Participants report many benefits for teachers of integrating iPads into their mathematics instruction.

5. Participants report many benefits for students when integrating iPads into their mathematics instruction.
6. Participants did not believe it was essential to have class sets of iPads because opportunities for sharing them help teachers differentiate math instruction.

7. The range of challenges these teachers identified included school level infrastructure, equity, teacher background experience, and the distractions technology can create.

The chapter is organized using bold headers for each key theme and italicized sub-headers for corresponding sub-themes. I conclude the chapter with a brief summary of key findings and a short preview of what is included in the final chapter, chapter five.

4.1 Participant’s learning and use of the iPad in their mathematics lessons is supported through collaboration with other educators via Twitter, Professional Development workshops, sharing at school meetings, and self-directed research.

4.1.1 Teachers learning through collaboration on Twitter

All three participants spoke very highly of Twitter and deemed it the most supportive resource for gaining new knowledge about technology integration and the use of iPads in the mathematics classroom. All three participants claimed that most of their learning had occurred through collaboration with other professionals in the education field on Twitter. Andrea explained that most of the activities and lessons she was doing at the time came from ideas she viewed on Twitter. Many teachers will showcase their math problems and the different open problem solving questions they are using in their classrooms or share helpful resources or applications, which Andrea appreciated. Laura made a very similar statement and credited Twitter as the resource responsible for all of the knowledge she had regarding technology integration and using iPads for teaching mathematics. Although Laura spoke mostly of learning through collaboration with other elementary teachers via Twitter, she also made a note that the
Support Consultant for mathematics in her school board has really adopted using Twitter as well to send out helpful resources for teachers, indicating that it is not only teachers using Twitter. Susan spoke about her love for “Twitter chats” which are conversations that occur between teachers almost every night on different topics related to education. Laura also spoke about these chats as her avenue for collaborating and sharing ideas with other grade one teachers and supporting and learning from each other by participating in projects that each other is running. Although a great resource, Susan believed that a lot of teachers do not engage with Twitter because they do not understand its educational value or do not have time, which she understood as there never seems to be enough time in a teacher’s day. With this said, Susan explained that if a teacher is interested in learning through Twitter chats, they do not have to be online and an active participant in the chat when it is happening live. If a teacher misses a chat, they can easily “hash tag” and search all of the archived chats. All three participants alluded to the notion that with Twitter, there is no need to “reinvent the wheel.” Laura explained that there are more people interested in collaborating online now than in the past, which she believed was changing education and how teachers are teaching. Laura stated, “I can’t speak more passionately about Twitter… Twitter changed how I teach. I wouldn’t be where I am today if it wasn’t for Twitter.” Similarly, Andrea’s strongest advice for teachers interested in integrating technology in their teaching was for them to use Twitter. It is well known that teachers need professional learning opportunities and ongoing support to improve their teaching practice (Darling-Hammond & Bransford, 2007; Jacobsen, 2006). According to Darling-Hammond & McLaughlin (2011), conventional professional development does not transform teaching, as teachers often have little or no choice in the type and timing of their professional development. As access to and use of the Internet increases in schools across the country, more opportunities for online, collaborative
professional development of teachers are being designed, allowing teachers to take advantage of online professional development opportunities and professional networks. In a hermeneutic study conducted by Darling-Hammond & McLaughlin (2011), it was found that online professional development provided opportunities for geographically dispersed teachers to collectively learn about collaborative mathematical problem solving in an online professional learning community. After joining and using Twitter regularly, McClintock (2010), a seventh grade teacher, encourages teachers to join Twitter to engage in self-directed professional development and build their personal learning networks (PLNs). A small-scale study in the United States of eight teachers' use of technology found that five of the eight teachers referred to online collaborative technologies as contributing to their professional development (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010). A growing number of educators around the country are using Twitter and other social networking sites to share best practices and find answers to important questions (Lu, 2011).

4.1.2 Teachers learning by attending Professional Development workshops

A major commonality between the three teachers interviewed was their belief about the importance of attending Professional Development (PD) workshops to learn from experts about technology integration. Many researchers have reported that there is a need for in-depth, ongoing professional development on integrating technology into the classroom (Center for Implementing Technology in Education, n.d.; Chen et al., 2014; Cuban, 2001; Maher, 2013). Education is constantly changing and teachers should continuously be developing and renovating their skills and knowledge. All three participants had attended many PD workshops during their teaching career and both Laura and Susan also facilitated some local workshops for teachers. Andrea pointed out that many teachers are not aware that there are workshops available strictly on the
topic of integrating iPads into the mathematics classroom, as opposed to workshops only on
technology integration in general. Andrea attended the EdTech Teacher iPad Summit in Boston a
year ago, which was a two-day interactive conference about the various ways to use iPads in
different subject areas. Andrea received information about different applications available that
had been evaluated by experts in education and left the conference with a list of “the best apps”
for every strand of the curriculum for elementary students. Andrea also spoke about a recent
conference called the EdSurge Conference that she heard about via Twitter and attended, which
provided her with the opportunity to learn from app and technology developers who presented
their apps and explained how they work and how stakeholders in education would benefit from
the apps. The conference was interactive and teachers were encouraged to play with the apps.

Laura explained that she felt blessed to work for a school board that continuously wants
to learn and improve education, so they offer summer learning sessions on technology for any
teachers interested. Susan believed that teachers can never have enough professional
development, but she noted that teachers are not given enough PD opportunities on how to
effectively use the iPad in the math classroom. In her words:

Every initiative that comes out, whether it’s a reading initiative or a math
initiative, teachers are given PD or workshops on it, but it seems like with
technology, it's kind of just thrown at teachers and they're to just go with it.

Andrea had a slightly different view and believed that there were various opportunities
available for teachers right now as she observed that “math is a push with the ministry, as well as
using tech, so there’s always things out there.” According to Andrea, it is about finding what’s
available and jumping at any chance you find for professional development on technology. One
of Bernie Poole’s Ten Pillars of Successful Technology Integration is that “all teachers must
receive on-going training” (Poole, 2009, p. 343). Both new and experienced teachers experience
challenges each year, such as new instructional methods, advancements in technology, student learning needs and changes in subject content, which is why engaging in effective professional development is crucial for teachers. Teachers who do not experience effective professional development do not improve their skills, ultimately affecting student learning (Mizell, 2010). According to Miles et al., (2004), the average percentage most districts spent on professional development in 2004 was only 1% to 3%.

4.1.3 Teachers learning through sharing ideas and knowledge at staff meetings

Susan believed that more time should be devoted to teacher sharing at weekly or monthly staff meetings, even as little as half of an hour. She spoke to how busy teachers are and the limited amount of time they have in a given day, which most teachers would agree with. Teacher sharing can be as simple as teachers speaking about how they are using iPads and different applications in their classrooms and how it is benefiting their teaching and their students’ learning. Poole (2009) argues that it is important that everyone buys into the change that technology brings. Professional development is most relevant when teachers and school leaders are able to work together to analyze and discuss what they are learning and implementing in their classrooms and engage in an ongoing cycle of improvement and growth. Mizell (2010) explains, “As members of a team hone their skills, other educators may begin to adopt these new best practices, and success can spread throughout the school and even from school to school” (p. 12). Through the exchange of knowledge and ideas at staff meetings, more teachers may understand the importance of technology integration and feel more comfortable making changes in their current teaching practices.
4.1.4 Teachers are learning by conducting self-directed research

Andrea, Laura and Susan all demonstrated self-directed research through their commitment to learning via Twitter. Susan, however, also spoke about other resources that can support teachers’ learning and use of the iPad in their mathematics lesson. Because of her self-motivation to want to learn more, for example, she frequently read educational articles and subscribed to magazines pertaining to educational technology or browsed Google for new information on technology integration or reviews on applications. These resources have all been beneficial ways for her to gain new knowledge about technology integration.

4.2 The criteria that participants reported to select applications include cost, exposure to advertisements and recommendations and reviews from others in the field of education.

All three participants acknowledged the fact that there are countless applications available, which make choosing good quality applications for use in the mathematics classroom difficult for many teachers. This finding is supported by research conducted by Brooks-Young (2014) who noted that one of the greatest challenges associated with the adoption of iPads in the classroom that educators are facing is choosing the best apps to support learning (Brooks-Young, 2014). Current literature states that there are thousands of educational applications available, but the quality of these applications varies greatly. Andrea explained that if she did a simple search for multiplication apps, for example, hundreds would pop up, making choosing applications not such an easy process. It is for this reason that using iPads to teach and learn math may not be more common. She explained that many teachers, including herself, ponder on questions such as, “Well what applications are good? What do I want to use? Do I have the time to sit down and download a bunch to figure it out?” Powell (2014) reported that with the number of apps
available today, choosing appropriate apps can be an overwhelming and time consuming process for teachers (Powell, 2014). It is for this reason that all three participants rely on using specific criteria when choosing applications to use with their students.

A major finding was that all three participants use free applications in their classrooms, which many teachers may assume are not strong applications because they may think they include little educational value and thus should not be used. This belief is combatted by all three participants who spoke strongly about using specific free applications in their classrooms to support students’ learning in mathematics. Some applications that were discussed by the participants were Virtual Math Manipulatives, Prodigy, Explain Everything, Educreations, Show Me, Book Creator, Maths Toolbox, Dragon Shapes, Number Pieces, Popplet and Padlet. It is important to note that these applications are not all “math specific” applications. There are many broad or “multi-purpose” applications that can be used in any subject area, including the mathematics classroom, which the participants believed had numerous benefits for teaching and learning mathematics. All three participants stressed the significance of not only searching for and using math-specific applications, but instead using applications that allow students to record their thinking when solving math problems and document their learning process. This major criterion will be discussed in further detail in the next key theme (4.3).

When choosing applications, Andrea and Laura both explained that recommendations and reviews from other teachers certainly informed their choices. This ties back to the importance of collaborating with other educators, whether online or through professional development opportunities. Although there are numerous good quality free applications, many free applications present challenges for teachers and students. Andrea explained that the hardest thing she finds with finding free apps is finding apps with unlimited access. She found that many
free apps will only provide limited access to the application and ask for payment to receive unlimited access, which can be expensive when wanting to download applications onto a class set of iPads. Andrea shared,

If you are buying thirty copies of it, you do get a volume purchasing discount, but it still eats out part of the budget. If I can find something similar for free, I’m much more likely to choose the free one.

With small school budgets for technology, the price of applications is a major factor for most teachers when choosing applications to use. Laura spoke passionately about “Free app Fridays” which is a website that posts the top apps that have gone free on the app store each week, accompanied with reviews and recommendations. Laura consequently waited until Fridays to download apps. Both Andrea and Laura reported that one major issue with free apps is that they are usually accompanied by advertisements. Although irritating, older students can usually deal with advertisements, but younger students have difficulty deciphering between advertisements and application features. Laura explained that primary students occasionally accidently click somewhere where they should not have which can cause issues. For this reason she advised that it is important for primary teachers to check for advertisements and to try to avoid apps if they are heavily advertised. All three participants also spoke about their criteria of checking an application to see how easy it is to use. If an application is too difficult for students to use on their own, it will cause unnecessary challenges in the classroom, which can be avoided by only using age-appropriate applications. As a primary teacher, Laura believed fewer steps are essential for young students to use an application successfully.

A common practice used by all three participants for choosing applications was testing them prior to using. This practice is supported by current research by Attard (2013) who discussed the importance of teachers testing apps prior to using them in class to ensure they are
appropriate for the curriculum and specific student needs. All three participants indicated that students should be a part of this process, which was not discovered in the literature review. Susan stated “I'll test an app out myself or I'll even have the students test it out at times and ask them which one they find better.” Andrea spoke about students’ excitement to test out new apps and said “If they can figure out how to play it, or use it, then it’s probably a good one.” It was a common belief amongst participants that teachers and students need to play and experiment with apps.

4.3 Participants prioritized the role of technology in instructional planning and used it not only for practicing math facts but also for meaningful and creative tasks in math.

4.3.1 Technology use has to be purposeful

A common theme across the interviews was that technology use has to be purposeful in order for it to be used effectively. Susan expressed her philosophy about technology in the classroom very clear:

My philosophy is that technology in the classroom has to be purposeful. It can’t just be for the sake of doing it and you know checking it off a checklist. When teachers think “well I need to do it so I’m going to check it off cause the kids have done research on the internet,” um, to me, that’s not really done purposefully in terms of what kids can do with technology.

Susan believed that many teachers use applications on devices as “busy work” which is not meaningful. She believed that teachers should be referring to the goals of their lesson when choosing applications to use or creating activities that incorporate the use of the iPad. Susan stressed the importance of thinking about the purpose for using technology and the lesson and long-range goals. Similarly, Protheroe (2005) recommended that educators must devote thoughtful planning and attention both to the objective of the activity and to the needs of the
students to develop successful lessons that incorporate technology. Susan believed that if technology does not support or enhance a lesson’s objective, it should not be used. Simply put, Susan stated, “If there is a better way to teach a concept and technology doesn’t fit, then don’t use the technology. Nobody says you have to use it everyday, every period. It should only be used if it fits.” Laura reinforced this idea by revealing that the device itself doesn’t matter, but rather it’s how you use the device that’s important. This is in line with research conducted by Summak, Samancıoğlu, and Bağlibel (2010) who noted that simply having technology in the classroom without proper planning and reflection is not sufficient – technology in itself does not support learning (Summak, Samancıoğlu, & Bağlibel, 2010). Teachers need to think about how technology can be used to its fullest potential and shift their mindset about the ways an iPad can be used for teaching and learning mathematics. Laura strongly believed that math can be learned in many different ways and students can show you they understand a math concept with the assistance of an iPad. The following sub-theme elaborates on this belief and the findings related to “drill and practice” applications versus “multi-purpose” applications.

4.3.2 “Drill and practice” math applications versus “multi-purpose” applications that provide students with the means to document their thinking and learning process when solving math problems

A common misconception when people think about the relationship between iPads and mathematics is that iPads can only be used to practice math facts and skills through applications referred to by many as math “drill and practice” applications. A central theme consistently emphasized by all three participants was that iPads should not be used solely for practicing math skills, but instead used more for the documentation of thinking and the learning process when solving mathematical problems. Susan shared her opinion that “drill and practice” apps should
not be disregarded and should be used from time to time as they serve as effective tools for reinforcing math skills, but teachers should also be thinking about what other applications and iPad features can be used to take the learning further. This opinion is supported by current research conducted regarding “drill and practice” applications. Shin et al. (2012) state that “drill and practice” apps can help facilitate student learning of basic mathematics skills (Shin et al., 2012). However, it has also been reported that many “drill and practice” game apps basically just replace the repetition of a standard worksheet or textbook page with some added animation (Attard, 2013; Attard & Curry, 2012). These apps are beneficial for keeping students engaged, but do not provide opportunities for students to develop their problem solving skills and deep mathematical thinking (Attard, 2013). All three participants indicated that there should be a balanced-approach between using math “drill and practice” apps and “multi-purpose” applications that promote more critical and creative thinking. According to Susan, “drill and practice” applications allow students to practice math skills in a fun and engaging way through a game-based approach. Many students drive on failure in these games and are motivated to succeed and thus must continue practicing their math facts. Andrea spoke about her students’ love for these games and their desire to play to compete and beat their own scores and the scores of their classmates. Andrea added that teachers can control many game-based applications and the games can be aligned with the Ontario Curriculum. Laura believed “drill and practice” applications are ideal for use at home because parents can facilitate them and they are more educational than many of the iPad games students currently engage in at home, making reference to games such as Candy Land.
Susan believed that many teachers are only using iPads for “drill and practice” applications because they do not know how to use the device for mathematics instruction in any other way. Laura believed, 

[Game-based applications] are fun for a little but that’s not what I see devices being used for. It should be for showing the process of how you’re learning something or producing a creative product that demonstrates the learning all the way through. You know, it’s not just to practice your math facts.

Laura spoke avidly about her opinion that teachers need to think about how technology can be used to its fullest potential and be open and willing to letting students be creative with the iPads. Susan posed the question, “What else can the students do with [the iPad] that they couldn’t do before?” She made reference to the SAMR model, which is a model designed to help educators incorporate technology into teaching and learning. Susan explained that math-based “drill and practice” apps mostly only target skills at the S (Substitution) level, whereas many activities that implement broad “multi-purpose” apps, such as the app Seesaw, are most likely targeting skills at the R (Redefinition) level.

All three participants spoke exhaustively and shared examples about using the iPad to document learning in math and then have opportunities for authentic reflection. Andrea spoke highly of an application called “Explain Everything” which she had students use when they were working through problem solving to record their thinking during the learning process and then to go back and listen to it. With Explain Everything, students can take a picture of their work in addition to recording themselves explaining their work, and then place it in their personal portfolio, which can be shared with the teacher and parents. Like Andrea, Shelly and Laura also spoke about using Explain Everything with students, along with other broad “multi-purpose” applications such as Educreations, Seesaw and Show Me. Through applications such as these, Laura noted that “students can really document the process of learning something. And
sometimes kids don’t realize how much they learn through the whole process and that’s where the big learning happens. It’s not what they produce at the end all the time.” Attard and Northcote (2011) highlight examples of apps available for the iPad that can be downloaded by teachers for various goals and included in this list are apps to support students during mathematical investigations that are not specifically mathematics based. The application “Show Me” is included in this list, which was mentioned by the participants in this study as well.

All three participants spoke about letting students be autonomous in their learning and letting them choose which learning tool they want to use to support their learning when solving a mathematics problem. Laura thought this simple pedagogical decision motivates and engages students because they get to pick the tools they want to use and have some control in their learning. Laura shared an example, saying,

Last year by Christmas, I was able to have my group going and grabbing an iPad, and saying, “wait a second, I got this!” and they’d take it and they’d grab whatever app they wanted. I taught them how to use about five or six apps that would explain and document their learning on their own.

All three participants also indicated that the documentation of the learning process also allows for richer discussions. Laura explained,

They learn so much more from that reflect piece and being able to reflect on it with something that came off of an iPad – the video, or the app, or listening to the kids voice, or their drawing – it’s so much more powerful than the kids standing up and saying “this is what I thought about it” and they have nothing to show.

There was a common agreement amongst all participants that iPads can and should be used in ways that require students to think creatively and not exclusively for “drill and practice” applications.
4.4 Participants report many benefits for teachers of integrating iPads into their mathematics instruction.

4.4.1 Technology helps to differentiate learning

A major reported finding from all three participants was that using iPads effectively allows for differentiated instruction and learning. Andrea discussed how some “drill and practice” applications support individualized instruction through the questions that are assigned. Many math game-based applications are designed to work based on the answers provided by students, which means they provide students with appropriate level mathematics questions. Students can be playing the same game but have different mathematics questions based on their specific needs. Laura explained that she addresses different needs in her classroom through grouping and using centers, with iPads at some centers. She reported, “What that little group needs over there might be a little bit different from what that little group needs over there.” Teachers can provide students with different tasks using the iPads according to their learning needs.

4.4.2 Technology helps to be responsive to students with special needs

All three participants indicated that technology can be very beneficial for students with special needs. Laura explained that having access to iPads can help students with special needs who can’t express themselves in a more traditional way still be involved in the learning. Andrea elucidated, “It gives them a lot of like avenues to help them, whether they use speech to text or listening software.” Susan believed that technology is a great tool for students with special needs to use because it can help them build skills that they might not be able to build with the technology assistance.
4.4.3 Technology provides access to many virtual manipulatives

Many elementary students benefit and require manipulatives to learn mathematics concepts in a hands-on manner. Although manipulatives can be helpful for learning math, certain manipulatives can be distracting for young children and cause classroom management issues or are expensive to purchase. Laura stated that she uses many different virtual manipulatives applications in her classroom on the iPads, such as a “geo board” application when teaching geometry. When speaking about virtual manipulatives and her example with the geo board application, Laura said, “I have a geo board app because geo boards are hard to come by and elastics in grade one is just like, you’re asking for trouble.” Teachers can download virtual manipulatives applications instead of having to buy class sets of manipulatives, which may not be affordable. According to Laura, there are a lot of great virtual manipulatives applications available that can be used on the iPads when teaching mathematics concepts. This is supported by Sun & Pyzdrowski (2009) who reported that the use of websites through the Internet provides virtual manipulatives and hands-on activities, easy access to resources to quickly retrieve information, and presents multiple strategies that can be used when solving difficult problems, which can be helpful for students, parents and teachers.

4.4.4 Teachers use iPads to help with tracking student work and assessment

In addition to students using the iPads to learn mathematics, all three participants spoke about using the iPads for assessment purposes. Susan indicated that when she herself uses an iPad in the classroom, it is usually for tracking and assessing students and helping them improve in their learning. Susan stated that she tries to focus on the skills and processes in the mathematics curriculum when assessing students. Laura also used the iPad for tracking students
and explained that her current goal was to find a tracking method that connects easily with Google, since her school board is very Google-driven. Laura expressed,

My goal this year is to figure out a way to be able to walk around with my iPad using my Google Forum and be able to click visually seeing like the actual learning happening. So you know when I see somebody achieve the concept of 1:1 correspondence with counting, I want to be able to just click on my iPad that they got it so that I remember that person had it and then it would track from the form into a sheet.

Laura elaborated saying, “It’s very helpful with math because sometimes the expectations are so specific that they’ve either got it or they don’t at that point and I can click through.” Andrea spoke highly of using digital portfolios for assessment purposes in mathematics, although portfolios can be used in any subject area. There are many digital portfolio applications available, but Andrea elaborated on an application she uses in her classroom called “Seesaw.” With Seesaw, students capture learning with photos and videos of their work and then upload the work to the portfolio where it is kept organized for themselves, the teacher and parents. Andrea finds having evidence of student work in digital portfolios is very helpful when determining report card grades and comments. Additionally, Andrea spoke about different mathematics applications she uses that provide direct feedback about student answers. Speaking about a math game called “Prodigy,” she explained, “You get a report of like every kid, every question, what they got right, what they got wrong, so you can kind of see where kids are struggling.” Many math applications can be useful resources for gaining a better understanding of who might be struggling with specific concepts and skills. Feedback from applications can help teachers determine concepts that students may need more instruction with. Technology offers teachers effective ways to access each student’s learning style and assess student understanding in multiple ways (Edutopia, 2008). For example, teachers can use the application “Show Me” to capture a student’s verbal reasoning and problem solving skills when completing a mathematical
problem, which allows for easier assessing of mathematical content and processes (Attard & Northcote, 2011).

4.4.5 Teachers use iPads to connect more easily with parents

A common theme across the interviews was the ability to involve parents in learning more easily through having iPads in the classroom. Through the use of digital portfolios, parents can view updates to their child’s portfolio and leave comments and feedback for their child or the teacher. Andrea noted, “There’s a parent version of the app where they can scan a QR code that I send home and it will leave them logged into their child’s portfolio so they can see all of their work within it.” Laura articulated, “We are more connected than ever being able to connect to the parents quickly.” Laura used her classroom blog to post classroom related material, which helps her student’s parents have a better understanding of what is going in each day in the classroom. She explained that she shares all of the iPad applications she uses in the classroom with parents to use with children at home. Susan stressed the importance of educating parents on the power of technology and getting them on board with the advantages of using technology for learning. This aligns with one of Poole’s prerequisites for successful implementation of a technology program: “Parents and students must be actively involved in the evolutionary process” (Poole, 2009, p. 343). Many studies have found that school administration, parent and community support is essential for technology integration to be successful (Guilfoyle, 2006; Strudler et al. 2003; Thompson, 2003). One of the TDSB’s goals in their technology plan is to provide all parents with electronic access to the school environment (TDSB, 2014).
4.5 Participants report many benefits for students of integrating iPads into their mathematics instruction.

4.5.1 Technology helps students self-correct

One specific benefit noted by Andrea of integrating iPads into the mathematics instruction is that it can provide students with richer opportunities to self-correct. Through using “multi-purpose” applications that document the learning process and using applications that provide direct feedback, students are able to more easily see their mistakes and make changes. When talking about self-correction, Andrea said,

So they can record, but then they can go back and listen to their thinking to see if they’ve made mistakes. There were constantly times last year when they would get to the end, they would listen to it, and go “oh wait, that’s not right” and they would correct themselves.

Andrea believed using iPads in an effective way that documents solving a problem from beginning to end helps students catch their mistakes more easily. According to Nicol and Boyle (2003), there are many tools available to support self-assessment, in addition to tools that support the delivery of teacher and peer feedback. Nicol and Boyle (2003). Brown, Hinze, & Pellegrino (2008) found that technology supports individualized feedback and scaffolding features needed for the formative use of assessment.

4.5.2 Technology gives every student a voice

A shared belief amongst participants was that technology provides every student with a voice. Susan believed that technology provides students who may not be confident enough to speak and share ideas in class to still be a part of the learning process by being able to share their ideas online. Susan stated,
[With iPads] every student gets a voice. So when you're assigning a question where you need an answer or an opinion, on an iPad, every student is responsible for giving me a response or their thoughts or their opinions on the concept of whatever it is that they are learning. So, it gives every kid a voice and I get to see that and assess that way and it helps with my assessing practices.

Andrea made a similar comment, saying, “For the kids especially that don’t like talking in front, they are generally very comfortable recording their voices so then it’s played up there, and other kids can ask them questions and discuss it.” All three participants eluded that the iPad is an excellent resource to make sure all students’ ideas are captured, especially shy students whose voices are sometimes dismissed in discussions. This is supported by many scholars in the field of education, such as Carpenter (2015) and Hubbard (2012). Not only does technology assist nonverbal children communicate and help children with special needs express their desires and feelings (Hubbard, 2012), it can also be used to direct students’ social instincts toward academic discussion, and thus improve engagement and achievement for all (Carpenter, 2015).

4.5.3 Technology promotes critical thinking

Andrea and Susan spoke about the notion that using iPads in the mathematics classroom can help students develop important skills, specifically the skill of critical thinking, and not only mathematics specific skills. Andrea believed that when students are using the iPads in mathematics, there is a lot more self-reflection and critical thinking happening. Andrea captured this belief by sharing,

Getting them to look at it [their work], listening to it, understanding it, like seeing it on the iPad or pulling in the manipulatives, they were able to think a little bit deeper and think a little bit more critically about their work versus doing it on a paper and handing it in.

By being able to return to their documented work, students can reflect on their learning and have deeper thinking discussions with their peers. All three participants spoke about the
significance of providing students with the freedom to choose how they want to solve a problem, which promotes critical thinking and creativity. This is supported by Rieti (2014) who shared that learning with technology helps students develop important higher order skills such as the ability to collaborate, think critically, and be creative (Rieti, 2014). Students need to learn these skills in school in order to flourish in today’s digital world (Edutopia, 2008; Wheeler, 2001).

4.5.4 Technology allows for instantaneous access to a wealth of information and global communication

A common theme across the interviews was the benefit of having instantaneous access to a wealth of information and being able to connect globally with other classrooms. Roschelle et al., (2001) cite research indicating that technology can support each of the four fundamental characteristics of learning: 1) active engagement, 2) participation in groups, 3) frequent interaction and feedback, and 4) connections to real-world contexts (Roschelle et al., 2001). With an Internet connection and access to technology, students have access to much more information than the past. Laura stated, “The fact that you can have access to information instantly to answer those burning questions they have right in the moment, that’s mind-blowing.” The teacher no longer needs to have the answers to all questions posed by students, as the teacher and students can use the Internet as a learning resource and discover answers together. Technology provides greater access to diverse and current learning materials, in comparison to traditional resources (Chen, Gallagher-Mackay, & Kidder, 2014). Moreover, students can use iPads to effortlessly connect with other places around the world. Andrea believes this global communication available with iPads “expands [students] horizons and expands their audience.” Laura provided an example of her class investigating an inquiry question with another class from Vancouver via Skype. Through a simple conversation, Laura explained that the concept of time got brought up
and students were trying to figure out why the time was different in both locations. All three participants indicated that students love sharing ideas and solving problems with other classes around the world, as this makes learning more fun and engaging.

4.5.5 Technology fosters a desire to engage in math

Participants reported a positive response and increased student engagement from students when using iPads in their mathematics classroom. This was also reported by Sivin-Kachala Bialo, and Rosso (2000) in current literature who noted that students developed more positive attitudes about themselves and towards learning through the use of technology. All three participants made similar statements about how much students enjoy using the iPads, even for mathematics activities. Through using iPads in her mathematics program, Andrea noticed a change in mindset about mathematics from some of her students. She explained, “It was just a huge outcome that they wanted to practice math, when on the first day, a lot of them said they didn’t like math.” Andrea spoke about how excited her students get when she downloads new applications or when students get to do math tasks on the iPads. She stated,

The biggest outcome that I could say beyond their actual academic abilities is their desire to want to practice math, where, I’m like not exaggerating at all when I say every single day last year they wanted to stay in and use the iPads to play like the different math apps.

Laura shared that she thinks many teachers feel math is too cut and dry and not creative and stick to teaching math traditionally, which is not very engaging for students. By incorporating the use of the iPad into mathematics lessons, all three teachers claimed that learning is more personalized, meaningful, and thus engaging for students.
4.6 Participants did not believe it was essential to have class sets of iPads because opportunities for sharing them help teachers differentiate math instruction.

A major reported finding by all three participants was their belief that teachers do not require a class set of iPads to effectively integrate iPads into their mathematics programs. This finding is supported by current studies that have shown that iPads in the classroom should not be dismissed if a class set cannot be afforded. Bennett (2011) explains, “Having a class set promotes traditional, whole-class instruction, but fewer iPads facilitate individualized and tailored instruction” (Bennett, 2011, p. 23). A common concern with integrating technology into the classroom is having limited access to it, or more specifically, not having enough devices to have a “1:1” classroom – a classroom where each student has his/her own device. According to Powell (2014), students can use iPads in small groups or they can be used in centers – fewer iPads simply requires innovative thinking in terms of instructional design (Powell, 2014). All three participants spoke about using iPads in small groups or at centers, which promotes collaboration and teamwork amongst students and provides teachers with the opportunity to differentiate instruction and address different learning needs. In the context of how best to use iPads, Susan explained, “It's not just about students using the iPads 1:1... that's great, but I think you need to balance out the collaboration. You could have two or three kids working on the iPad together to solve a problem.” Similarly, Laura shared, “We’re trying to get teachers to not do 1:1 so it’s easier to differentiate teaching.” In Laura’s classroom, she specified, “It’s unusual that we will all be doing the same thing at the same time.” Laura, along with Andrea and Susan, spoke about setting the iPad up at a center for a specific purpose and having small groups rotate through the centers. This allows for all students to have access to the iPads at some point, but just at different times. Teachers should not dismiss using iPads in their classrooms if they only have a
few, but instead embrace the small amount and group students according to their needs and share
the iPads through a rotation system.

4.7 The range of challenges these teachers identified included school level infrastructure,
equity, teacher background experience, and the distractions technology can create.

4.7.1 Using iPads in math can lead to off-task behaviour due to common distractions caused by
the iPad

Andrea and Laura both reported distractions the iPad cause can when trying to use it to
teach mathematics in school. With social media being a very prominent aspect of many students
lives, predominately junior students, students can be easily tempted to use social media
applications or websites when on the iPads instead of doing their mathematics work. Andrea,
speaking about junior students, noted,

You can see the temptation and then you can see the distraction because all they
[students] want to do is know what’s on there. They will use it [the iPad] the way
that it’s meant to, but they will easily get distracted. They will be on task and all
of a sudden it [iMessage] would pop up, and then they jump into their iMessage
and then they go back to reading, and then they go back to their iMessage, and
they’d be in conversations.

Andrea stressed the importance of making expectations with students clear and keeping a
close eye on students while they are on the iPads to make sure they are trying to ignore social
media distractions. Laura spoke about iPads being distracting for children since they are typically
used for games at home, instead of educational applications or tasks. She reported that off-task
behaviour on the iPads most often happens during mathematics tasks. Laura stated,

The occasional kids of course are going to go off and not do what they’re
supposed to be doing and sometimes that comes with math, right? If I were to say
when they are doing something that they are not supposed to be doing, it happens
in math and that’s the difficult part and it comes a lot from the whole mindset of
math.
4.7.2 Bandwidth and wireless Internet issues create a challenge when using iPads

Integrating iPads effectively into mathematics lessons can only be successful with a good bandwidth and wireless Internet connection. A common theme across the interviews was that one of the challenges with trying to implement iPads into the classroom is bandwidth and wireless Internet connection issues. In a recent document titled *Digital Learning in Ontario Schools: The ‘new normal’* (Chen et al., 2014) unstable wireless Internet is listed as one of the reported challenges associated with technology integration. Susan expressed her frustration with this challenge by sharing the example,

Okay, so I have the iPads but the kids can't get on. They can't get onto Wi-Fi. Or you know they can't log onto a desktop without it taking forever. Or the computers aren’t working. Or the login information isn’t working. So then your whole period is wasted.

When speaking about Wi-Fi issues in schools, Laura stated that she feels lucky to have wireless Internet in her school, as she knows this is not the case in other schools. Although Wi-Fi issues are a current challenge in some schools, Laura noticed that her school board is slowly making improvements in wireless Internet connections, compared to previous years. In addition to bandwidth and wireless Internet issues, Andrea reported slow technology as one of the challenges associated with using iPads to teach mathematics. Andrea talked about how slow the netbooks are in her classroom and how painful and frustrating it is to have to wait for the technology to load. Slow technology could be due to the fact that the devices are old, need to be cleaned, or a poor wireless Internet connection.

4.7.3 Limited access to technology due to small school budgets is a challenge for some schools

Although all three participants reported that they have access to a large amount and range of technology in their school, they all still spoke about the challenge some schools face of having
limited or no access to technology. Because iPads are costly, some schools do not have enough money in their budget to purchase them. This challenge is discussed in Digital Learning in Ontario Schools: The ‘new normal’ (Chen et al., 2014) and many other research articles (Becta, 2004; Bingimlas, 2009; McKenna, 2012). Susan stated, “They’re expensive, right? So it takes time to buy a lot,” referring to iPads. Andrea explained that in her school, the parent council raises money to help make additional technology purchases than what the school purchases with its budget. Susan expressed her frustration with this challenge stating, “I think if the government really wants to help us, or the ministry wants to help us, give us some money that we need.” She believed that the government does not provide schools with enough funding for technology, especially when they are pushing technology integration and making comments about how teachers need to prepare students for the 21st century. It is hard to integrate technology effectively into the classroom without funding to purchase enough devices or fix associated issues.

4.7.4 The expensiveness of technology can cause equity issues amongst students

Equity was cited as a challenge and spoken about by all three participants. Because iPads are expensive, not all families can afford to purchase one. Although teachers should not be assigning work to be done on an iPad at home, students who have access to an iPad at home have an advantage of being able to practice their math skills at home using the applications used in class. Susan explained, “The kids that can afford it, those kids who have that advantage, they can go home and continue working at home. It goes beyond those 4 walls of classroom kind of concept.” Moreover, Andrea explained that children who do not have access to Internet at home are also at a disadvantage. Laura noted that the school board that she works for provides Internet
sticks to students who don’t have access to Wi-Fi at home and require it for their schoolwork, but this is not that case with every school board.

4.7.5 Many teachers are unaware of how to use technology effectively for teaching mathematics or believe it should be taught traditionally

A major reported finding was that many teachers do not know how to use or effectively integrate iPads into their mathematics instruction. Although all three participants are experts at technology integration themselves, they noted that many teachers do not feel comfortable using technology to teach mathematics or believe mathematics should be taught using traditional methods. This is supported in a recent study where principals reported that some teachers felt uncomfortable integrating technology into their classrooms due to lack of experience and/or training and the lack of technical support available (Chen et al., 2014). In this study, Laura said,

Some people feel that they were brought up you know memorizing their math facts and math is based on your knowledge of facts and numbers and essentially number sense and we learned it the rote way. Like, very dry, very basic. And you learned it, so that should be how everybody else should learn it.

Similarly, Andrea shared, “I think a big part of it is the way a lot of teachers were taught… the practice seems necessary, doing it over and over. That’s how we learned, that’s how it should be.” Susan explained that these teachers need to understand that using technology to teach mathematics is much more engaging for students than traditional methods and teaching methods should change as time changes. Laura’s belief is that,

People aren’t creative when it comes to math and they don’t see the value of using more open ended or creative methods of teaching math. They feel that people are going to be missing the basics of math and I don’t know if that’s the right answer anymore in today’s world.

Teachers need to educate themselves on how to integrate technology into the classroom or change their mindset on how mathematics can be taught. The current generation of students is
what Prensky (2012) refers to as “digital natives” (Prensky, 2012, p. 68). Digital natives have spent their entire lives surrounded by and using the technological tools of the digital age, and as a result, “think and process information fundamentally different from their predecessors” (Prensky, 2012, p. 68). Teachers who were not born into the digital world, referred to as “digital immigrants” by Prensky, must reconsider their methodology and content (Prensky, 2012).

4.8 Conclusion

Throughout this chapter, major findings were discussed that were informed from the responses of the three participants interviewed. All three participants were extremely well informed about the research topic and their different experiences in education allowed for rich findings. There were many findings that all three participants spoke about and had similar opinions on, but some findings were only informed by one or two of the participants. In total, findings were divided into seven main themes and a variety of sub-themes. Many of the findings from this study serve to reinforce the case being made by other scholars that effective technology integration has many benefits for teaching and learning; thus, teachers need to actively alter their teaching methods to incorporate technology. The findings from this study more clearly address the specific factors and resources that can support teachers’ learning and use of iPads in their mathematics lessons. Although integrating technology into the classroom can be a daunting task for some teachers, the findings from this study suggest that teachers can be supported through collaboration with other educators via Twitter, Professional Development workshops, sharing at school meetings, and self-directed research. This study has offered findings indicating that using iPads to teach mathematics has benefits for both students and teachers. Teachers should be delighted to read that technology can help teachers to differentiate learning, be responsive to students with special needs, provide access to resources such as virtual manipulatives, track
student work and assess, and connect more easily with parents. Furthermore, this study has found that it is not essential to have class sets of iPads because opportunities for sharing them help teachers to differentiate math instruction. In chapter five, I will speak to the significance of the findings for myself as a beginning teacher and for the educational research community more broadly. A description of the implications and recommendations for the educational community will be included, and areas for further research will be identified.
Chapter 5: Implications

5.0 Introduction

In this chapter, I present a brief overview of the key findings of this study, as reported in chapter 4. I discuss the significance of these findings for the educational research community, as well as for myself as a beginning teacher. Based on what I have learned through my review on existing relevant research and my findings from the three semi-structured interviews, I identify a range of recommendations to benefit students, teachers, parents, administration, school boards, teacher education programs and the Ontario Ministry of Education. Next, I discuss important areas requiring further research attention and conclude the chapter with some final closing comments.

5.1 Overview of Key Findings and Significance

This research study provided many key findings that are significant to the area of educational research regarding technology integration. Through analyzing the findings, which yielded a wealth of information about how three teachers are effectively integrating iPads into their mathematics programs, several themes were developed. There are many connections between the themes developed and the literature reviewed and presented in chapter 2.

In summary, there are a variety of resources available to support a teacher’s learning and the use of the iPad in their mathematics programs. The participant’s reported that their learning and use of the iPad in their mathematics lessons is supported through collaboration with other educators via Twitter, Professional Development workshops, staff sharing of ideas at school meetings, and self-directed research. All three participants spoke very highly of Twitter and deemed it the most supportive resource for gaining new knowledge about technology integration.
Professional development workshops also provide rich opportunities to receive on-going training and learn important knowledge and skills regarding technology integration. There are iPad specific workshops available that are beneficial for teachers looking to effectively use iPads in their classrooms. Through the exchange of knowledge and ideas at staff meetings as well, more teachers may feel more comfortable making changes in their current teaching practices.

All three participants acknowledged the fact that there are countless applications available, which make choosing good quality applications for use in the mathematics classroom difficult for many teachers. It is for this reason that all three participants rely on using specific criteria when choosing applications to use with their students. The criteria that participants reported to select applications include cost, exposure to advertisements and recommendations and reviews from others in the field of education. The belief that free applications have little educational value or aren’t good apps is combatted by all three participants who speak strongly about using specific free applications in their classrooms to support students’ learning in mathematics. Some of these applications include Explain Everything, Educreations, Seesaw and Show Me.

Participants prioritized the role of technology in instructional planning and not solely relying on it for practicing math facts but also for meaningful and creative tasks in math. Teachers need to think about how technology can be used to its fullest potential and shift their mindset about the ways an iPad can be used for teaching and learning mathematics. There was a common agreement amongst all participants that iPads can and should be used in ways that require students to think creatively and not exclusively for “drill and practice” applications. Students should be given opportunities to use the iPad and a variety of “multi-purpose” applications to document their thinking and learning in mathematics.
This study provided insight to the many benefits of integrating iPads into mathematics instruction for both teachers and students. In short, technology helps teachers differentiate learning, be responsive to students with special needs, have access to countless resources such as virtual manipulatives, track student work and assess students, and connect more easily with parents. In addition, technology helps students self-correct, gives every student a voice, promotes critical thinking, allows for instantaneous access to a wealth of information and global communication, and fosters a desire to engage in mathematics. Of course with benefits come challenges as well, which were discussed by the participants. The participants identified a range of challenges that they’ve experienced when integrating iPads into your math instruction which include school level infrastructure, equity, teacher background experience, and the distractions technology can create.

Many of the findings from this study serve to reinforce the case being made by other scholars that effective technology integration has many benefits for teaching and learning; thus, teachers need to actively alter their teaching methods to incorporate technology. This study has found that using iPads to teach mathematics has benefits for both students and teachers. Technology can help teachers to differentiate learning, be responsive to students with special needs, provide access to resources such as virtual manipulatives, track student work and assess, and connect more easily with parents. In an ideal world it would be best to have an iPad available for every student (1:1), but this is rarely the case in publically funded schools. A major reported finding important for educators to be aware of is that teachers do not require a class set of iPads to support students learning in mathematics. iPads can be shared by students in small groups or placed in centers, which can help teachers address different learning needs in the classroom.
5.2 Implications

5.2.1 The Educational Research Community

Detailed and meaningful insights were gained from the three participants about how they are effectively using iPads in their classrooms to support student learning. As confirmed in many studies, including this study, there are numerous benefits with effective technology integration and challenges that can be overcome. The research findings from this study have implications for a range of educational stakeholders: the Ontario Ministry of Education, school boards, principals, teachers, students and parents. A range of recommendations for these various stakeholders in education are provided below in section 5.3. If schools are going to be responsive to students’ needs and interests, it is important that research continues to be conducted regarding the potential of technology integration in today’s classrooms and the recommendations from this study are genuinely considered by the education community.

5.2.2 Professional Identity and Practice

This research project has provided me with an opportunity to grow as both a teacher and researcher. Moving forward in my teaching career, my practice will certainly be informed by my research findings, but also through having the opportunity to develop my research skills. I have grown to value the active and ongoing relationship between research and practice and have developed a research-supported teaching pedagogy that will support my teaching.

Although I was aware of the importance of integrating technology into today’s classrooms before this research study, my research findings have allowed me to better understand the imperative need to provide students with opportunities to use digital tools as part of their educational experiences. As Morgan (2014) explains, “Since today's students tend to be
more engaged while using technology and may find traditional approaches less motivating, teaching effectively with digital resources should help teachers instruct in a manner that matches the learning styles of their students” (p. 37). By incorporating technology into my teaching meaningfully and purposefully, I will be able to access each student’s learning style and assess student understanding in multiple ways. Moreover, integrating technology will allow for benefits such as: decreased behavioral issues due to increased student engagement, assessment support, allowing every student to have a voice, making differentiating instruction easier, promoting the development of important 21\textsuperscript{st} century skills, connecting with parents more easily and providing greater access to diverse and current learning materials. In addition, my research findings have indicated that technology will help to facilitate active learning, inquiry-based learning, and inclusive learning environments.

I have learned a range of strategies, tools and applications that can be used with iPads to engage students in mathematics, a subject traditionally taught using little to no technology. I will use online virtual math manipulatives and “multi-purpose” applications such as Prodigy, Explain Everything, Educreations, Show Me, Book Creator, Maths Toolbox, Dragon Shapes, Number Pieces, Popplet and Padlet to facilitate critical thinking and problem solving. When teaching mathematics, students will use a combination of “drill and practice” math applications (to reinforce math skills) and “multi-purpose” applications (to document their thinking and learning process when solving math problems). In my classroom, iPads be will be used in ways that require students to think creatively and not exclusively for “drill and practice” applications.

I will actively modify my teaching practice to effectively integrate technology into my classroom to benefit teaching and learning. I have learned that simply having technology in the classroom without proper planning and reflection does not support learning. It is for this reason
that I will devote thoughtful planning and attention both to the objective of the activity and to the needs of the students to develop successful lessons that incorporate technology. I plan on becoming more familiar with Dr. Ruben R. Puentedura’s SAMR model and will plan learning activities, when appropriate, that fall under the fourth category in his model: task redefinition. By integrating technology into my classroom effectively, I hope to alleviate any mathematics anxiety caused by cognitive factors that my students may experience when beginning the school year.

5.3 Recommendations

Based on what I have learned from this study, I have identified a range of recommendations for various stakeholders in education: students, new and experienced teachers, parents, administration, school boards, teacher education programs and the Ontario Ministry of Education. The recommendations are as follows:

1. In Teacher Education programs, all Teacher Candidates should be required to take a full-year technology integration course. In this course, teacher candidates should be taught specific strategies and practical considerations for implementing technology into the classroom successfully, such as the SAMR model, which would assist teachers with using technology more purposefully and meaningfully. This course should highlight the variety of “multi-purpose” applications that can be used in the mathematics classroom for students to record their thinking when solving math problems and document their entire learning process, such as Explain Everything, Educreations, Seesaw and Show Me. Teacher candidates should also be taught how technology can assist teachers with differentiating math instruction, such as through a centers-approach.
2. All Teacher Candidates should have at least one teaching practicum where they get to work with and be mentored by an Associate Teacher who is passionate about technology integration and actively integrates technology into their classroom. This will allow the Teacher Candidate to put theory and knowledge (from the technology integration course recommended in recommendation 1) into practice. This will help deal with the reported challenge of teachers not feeling comfortable integrating technology into their classrooms due to lack of experience and/or training because they will have experience and mentoring prior to having their own classrooms.

3. In the Math Methods course in Teacher Education programs, time should be devoted to teaching Teacher Candidates how technology can be used in the mathematics classroom to engage students and enrich their mathematics learning experience. A focus in the curriculum should be on informing Teacher Candidates about virtual manipulatives, as well as “drill and practice” applications and “multi-purpose” applications and the appropriate times to use both based on the learning goals. Since mathematics is traditionally taught using little to no technology, it is critical that Teacher Candidates are taught today’s best practices based on research findings.

4. Professors in Teacher Education programs should be modeling how technology can be used effectively in instructional practice through using it themselves in some of their lessons to allow Teacher Candidates to become more familiar with different technological tools and experience firsthand the benefits of learning with technology.

5. With the vast amount of research stating that technology can enhance learning when used effectively, all schools should be purchasing a few iPads or tablets for every classroom. A class set of iPads (1:1) is not necessary, as stated in the research findings, yet it is ideal if
each classroom has access to a small amount of devices to share. To enable these expensive purchases, it is suggested that schools look into reconfiguring their budgets or fundraising options. It is recommended that schools also conduct research to find agencies that loan devices, such as the Ottawa Network for Education (ONFE), the network Laura contacted to borrow iPods from for a year for her classroom. Another recommendation is for schools to reach out to parents and the local community (via a school website, a newsletter, a newspaper posting, etc.) to collect used tablets from donors.

6. School boards should adopt a “Bring Your Own Device” or better known as a “BYOD” model to allow students to learn with personalized technology and to more easily allow students to have access to technological devices. With BYOD programs, school boards can integrate cost-effective technology into their educational programs (Getting Started with BYOD, 2014). To develop a successful BYOD program, extensive planning, communication and ongoing evaluation of these programs is needed by teachers and school boards. Although there are some challenges associated with BYOD, there is an abundance of current literature outlining strategies teachers can use to mitigate these challenges. For example, for students who cannot afford a personal device, schools can apply their technology budget to purchasing a set of devices for loaning, parents can be asked to donate used devices when they purchase new ones, or students can share devices with one another if need be (Getting Started with BYOD, 2014). When adopting a BYOD program, it is recommended that school boards provide teachers with a professional development workshop on how to plan and implement a successful BYOD program.

7. Since the research has found that through the exchange of knowledge and ideas at staff
meetings more teachers understand the importance of technology integration and feel more comfortable making changes in their current teaching practices, school administration must promote collaboration between staff members and whole-school initiatives regarding technology integration. Administration must devote more time at staff meetings for teachers to share applications, programs and/or tools that have worked in their classrooms. Administration should also look into creating and providing time during the week for Professional Learning Communities (PLC’s) to meet, share expertise, and work collaboratively to build knowledge with one another.

8. Since many researchers have reported that there is a need for in-depth, ongoing professional development on integrating technology into the classroom, school boards should discuss making more workshops mandatory for teachers to attend, as opposed to allowing attendance to be optional. Some workshop topic recommendations include: iPad training and integration, SMART Board training and integration, Assistive Technology, e-Learning and Bring Your Own Device. Teachers can stay informed about these workshops through a board-wide or school-wide e-mail message. Teachers can stay informed about optional workshops in the province through reading education-related Twitter posts.

9. Since research is finding that Twitter can be a useful tool for resource-sharing among teachers, then it is important that schools and boards make a concerted effort in professional development to introduce teachers to this technologically and give them opportunities to sign up and begin using the technology as part of the curriculum.

10. To keep parents informed about how technology is being used in the classroom to benefit students’ learning, teachers can collaborate and communicate with parents regularly
through an online medium, such a classroom blog, digital portfolio or Twitter account. It is important for parents to understand why and how technology is being used in today’s classrooms.

5.4 Areas for Further Research

Although this research study provided many valuable insights about how teachers can effectively use technology, specifically iPads, for teaching and learning mathematics, there are still some areas requiring further research attention. One of the specific findings from this research study is that technology fosters a desire in students to engage in math. This is not a surprising finding as many scholars have cited the correlation between technology use and increased engagement (Avila & Wilson, 2011; Digedu, 2014; Hechter, Phyfe, & Vermette, 2012; Warschauer, 2008). However, there is limited research conducted looking at whether student engagement is truly only due to the integration of technology into the classroom, or whether it is due to other factors as well such as the specific content being taught or the inquiry based learning that the technology affords. A detailed study looking specifically at student engagement and technology is an area for further research. A second avenue needed for further research is researching what the best methods are to shift teachers’ negative attitudes about technology integration, to ensure all teachers are supporting students in their learning. With the endless known benefits of integrating technology into today’s classrooms, it is imperative that all teachers are actively trying to change their teaching methods to include meaningful and purposeful integration of technology.

5.5 Concluding Comments

As educators, it is important to stay current with educational research and to participate in ongoing professional development to ensure we are incorporating the best practices and teaching
methods to support students’ learning. Given the many known benefits of technology integration for both teaching and learning, as discussed in this paper, it is vital that all teachers, new and experienced, are learning the tools and skills they need to effectively integrate technology into their classrooms. If our education system is indeed equitable, all students should have the opportunity to learn with technology. It is important for educators to remember that the use of technology does not only enhance learning environments, but it also prepares students for their future lives and careers in the 21st century. Learning with technology helps students develop important higher order skills such as the ability to collaborate, think critically, and be creative (Rieti, 2014). Based on my research, I firmly believe that all students can excel in thoughtfully planned digital classrooms that focus on opportunities for collaboration, creativity, and critical thinking. Through this qualitative research study, I learned a range of instructional strategies and practical considerations for effectively integrating technology, specifically iPads, into the elementary mathematics classroom to engage students and enrich their learning experience. In my future classrooms, I will use online virtual math manipulatives and “multi-purpose” applications such as Prodigy, Explain Everything, Educreations, Show Me, Book Creator, Maths Toolbox, Dragon Shapes, Number Pieces, Popplet and Padlet to facilitate critical thinking and problem solving. When teaching mathematics, students will use a combination of “drill and practice” math applications (to reinforce math skills) and “multi-purpose” applications (to document their thinking and learning process when solving math problems). I will devote thoughtful planning and attention both to the objective of the activity and to the needs of the students to develop successful lessons that incorporate technology. Without question, my research findings will certainly improve my own teaching pedagogy as a beginning teacher moving forward in my career, but I hope they will also inspire more teachers and schools to
meaningfully integrate 21st century learning tools into instructional practice. As John Dewey said, "If we teach today's students as we taught yesterday's, we rob them of tomorrow."
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Appendix A: Letter of Consent

Date:

Dear ______________________________,

My name is Stephanie Delorme and I am a student in the Master of Teaching Program at the Ontario Institute for Studies in Education at the University of Toronto (OISE/UT). A component of this degree program involves conducting a small-scale qualitative research study. My research will focus on how teachers integrate the use of iPads to teach elementary math. I am interested in interviewing teachers who actively incorporate iPads into their mathematics lesson plans to teach different mathematics topics. I am hoping to interview teachers who demonstrate leadership and/or expertise in the area of technology integration in the elementary classroom. I think that your knowledge and experience will provide insights into this topic.

Your participation in this research will involve one 45-60 minute interview, which will be transcribed and audio-recorded. I would be grateful if you would allow me to interview you at a place and time convenient for you, outside of school time. The contents of this interview will be used for my research project, which will include a final paper, as well as informal presentations to my classmates and/or potentially at a research conference or publication. You will be assigned a pseudonym to maintain your anonymity and I will not use your name or any other content that might identify you in my written work, oral presentations, or publications. This information will remain confidential. This data will be stored on my password-protected computer and the only person who will have access to the research data will be my course instructor Dr. Angela MacDonald-Vemic. You are free to change your mind about your participation at any time, and to withdraw even after you have consented to participate. You may also choose to decline to answer any specific question. I will destroy the audio recording after the paper has been presented and/or published, which may take up to a maximum of five years after the data has been collected. There are no known risks or benefits to participation, and I will share with you a copy of the transcript to ensure accuracy.

Please sign this consent form, if you agree to be interviewed. The second copy is for your records. I am very grateful for your participation.

Sincerely,
Stephanie Delorme
613-809-1740
Stephanie.delorme@mail.utoronto.ca

Course Instructor’s Name: Angela MacDonald-Vemic
Contact Info: angela.macdonald@utoronto.ca
Consent Form

I acknowledge that the topic of this interview has been explained to me and that any questions that I have asked have been answered to my satisfaction. I understand that I can withdraw from this research study at any time without penalty.

I have read the letter provided to me by Stephanie Delorme and agree to participate in an interview for the purposes described. I agree to have the interview audio-recorded.

Signature: ________________________________________

Name: (printed) _______________________________________________

Date: ______________________________________
Appendix B: Interview Protocol/Questions

Introductory Script:
Hello __________. My name is Stephanie Delorme and I am a Master of Teaching Student at the Ontario Institute of Studies in Education at the University of Toronto. I would like to begin by thanking you for participating in this interview. The data collected in this interview will assist my research for my Masters of Teaching Research Project (MTRP).

The aim of this research is to learn how teachers can effectively use technology, specifically iPads, to teach the elementary mathematics curriculum to support students learning in today’s elementary school classrooms. I am interested in interviewing teachers who actively incorporate iPads into their mathematics lesson plans to teach different mathematics topics.

I will be asking you a series of approximately 20 questions, focused on this research goal. The interview should take approximately 45-60 minutes to complete. I want to remind you that your identity will remain confidential and any identifying markers related to your students or school will be excluded. You will be assigned a pseudonym to protect your identity and personal interests. I would also like to remind you that you are free to change your mind about your participation at any time during this interview and you have the right to choose to decline to answer any specific question.

Finally, I would like to record this interview – do I have your consent to do so? Do you have any questions before we begin?

Section 1: Background Information
1. What grade are you currently teaching?
2. How many years have you been teaching as an elementary school teacher?
3. What grade(s) have you previously taught in your teaching career?
4. What type of technology do you have access to in your school and for use in your classroom? How often do you use this technology in your classroom?
5. What personal, professional, and educational experiences have informed your interest in technology integration for learning, and helped prepare you for this work?
   Probes: areas of study, PD taken, preferred learning style, personal interest, etc.

Section 2: Teacher Practices
6. What is your view on the role of technology in today’s classrooms?
   a. What are some of the benefits that you believe technology integration can have for student learning?
   b. What are some of the limitations?
7. In your experience, what are some prerequisites that need to be in place in order for successful implementation of technology into instructional practice to occur? Why are these important?

8. When it comes to the use of iPads specifically, what do you think is the potential of iPads in facilitating student learning in math and why?

9. In your view, what are some of the reasons why using iPads to teach and learn math is not more common?

10. What are some of the specific ways that you integrate iPads into your math lessons and why?

11. When you use iPads, does each student typically receive one or do they share? If they share, how do you coordinate this and why?

12. Can you tell me more about which applications, if any, you use on the iPads for teaching math? What criteria do you apply in these decisions? Why do you use these apps? What are some of the benefits you have observed from using them?

13. How do your students respond to your use of iPads in teaching math? What outcomes have you observed?
   a. What indicators of learning do you observe when integrating iPads into your math instruction?
   b. What indicators of engagement do you observe when integrating iPads into your math instruction?

14. Can you please give me an example of a math lesson you conducted using iPads?
   a. What was the lesson (grade, strand)?
   b. What were your learning goals?
   c. What opportunities for learning did you create?
   d. How did you integrate iPads into lesson and why?
   e. How did students respond to this lesson? What indicators of learning did you observe?

15. What are some of the policies or rules for handling, using, and sharing iPads that you have in place? How do students do in respecting these?

16. What factors or resources support your learning and the use of the iPad in your math lessons?

17. How, if at all, do you use the iPads to teach (and not only learn) math? E.g. do you use them for planning, to track student work, or for assessment purposes? What are some of the benefits you’ve observed they have for teaching math?

Section 3: Challenges and Next Steps

18. What challenges have you experienced when integrating iPads into your math instruction? How did you respond to these challenges? How might the education further support you in meeting these challenges?

19. What advice, if any, do you have for beginning teachers who are committed to integrating technology into their classrooms, specifically into their math lessons?

20. Do you have any further information you would like to share?

Closing Script:

Thank you very much for your time and participation in this study.