Alleviating Math Anxiety through the Integration of Technology in Elementary School

By:

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A research paper submitted in conformity with the requirements
For the degree of Master of Teaching
Department of Curriculum, Teaching and Learning
Ontario Institute for Studies in Education of the University of Toronto

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Abstract

The aim of this research study was to investigate the outcomes, successes, challenges and strategies of integrating technology in mathematics. The main research question that guided this study was: How is a sample of elementary teachers integrating technology in their mathematics instruction and what outcomes do they observe for student mathematics engagement? Data was collected through semi-structured with two elementary school teachers who frequently integrate technology in their mathematics program. Findings suggest that the most important factor influencing teachers’ use of technology in mathematics appears to be their knowledge of how to use the technology and how they believe it will support student learning for the particular lesson. With all the positive aspects technology brings to mathematics, students with math anxiety experience more of a hands on, visual and dynamic approach to learning, where both participants felt that may lower their students’ level of anxiety. The implications of these findings suggest that teachers need more education and professional development in the area of technology integration in general, and the various benefits associated in mathematics.

Key words: Mathematics, Technology, Math engagement, Math anxiety
# TABLE OF CONTENTS

## Abstract

## Chapter 1: Introduction

1.0 Research Context

1.1 Research Problem

1.2 Purpose of the Study

1.3 Research Questions

1.4 Background of the Researcher/Reflexive Positioning Statement

1.5 Overview/Preview of Whole

## Chapter 2: Literature Review

2.0 Introduction to the chapter

2.1 Math Anxiety

2.1.1 Math anxiety in students

2.1.2 Math anxiety in teachers

2.1.3 Causes of math anxiety

2.1.4 Strategies to reduce math anxiety

2.2 Technology in the Classroom

2.2.1 Use of technology in the classroom

2.2.2 Factors hindering inclusion of technology

2.2.3 Technology to support math learning and teaching

2.3 Technology to Reduce Math Anxiety

2.4 Conclusion

## Chapter 3: Research Methodology

3.0 Introduction to the Chapter

3.1 Research Approach and Procedures

3.2 Instruments of Data Collection

3.3 Participants

3.3.1 Sampling criteria

3.3.2 Participant recruitment

3.3.3 Participant biographies

3.4 Data Analysis

3.5 Ethical Review Procedures

3.6 Methodological Limitations and Strengths

3.7 Conclusion

## Chapter 4: Research Findings

4.0 Introduction to the Chapter

4.1 Educators’ Past Personal and Professional Encounters with Technology Helped Shape their Current View on the Benefits of Technology Integration

4.1.1 Participants indicated the importance of access to past professional development in their current ability to integrate technology into mathematics
4.1.2 Participants indicated the importance of their past self learning in their current ability to integrate technology into mathematics 40
4.1.3 Participants indicated the importance of past support in the school community in their ability to integrate technology into mathematics 42

4.2 Educators Utilize a Variety of Curriculum and Material Supports within their School Environment when Integrating Technology into the Mathematics Classroom 43
4.2.1 Participants identified current school support as a factor that supports their ability to integrate technology into mathematics 43
4.2.2 Participants identified reliable access to technology in the school as a factor that supports their ability to integrate technology into mathematics 44

4.3 Educators Identified the Potential Positive Impact on Learning that Technology Integration in Mathematics has on Students with Math Anxiety 46
4.3.1 Participants indicated that integrating technology in mathematics can individualize the learning process 46
4.3.2 Participants indicated that integrating technology in mathematics can foster inquiry and experimentation in the learning process 48
4.3.3 Participants indicated that integrating technology in mathematics can make the learning process multimodal 49

4.4 Educators Indicated the Personal and Academic Benefits of Incorporating Technology in Math Instruction for Both the Teaching and Learning Process 51
4.4.1 Participants signified a relationship between technology integration in mathematics and student engagement in the subject 51
4.4.2 Participants signified a relationship between technology integration in mathematics and the enhancement of teacher pedagogy in the subject 52

4.5 Conclusion to the Chapter 54

Chapter 5: Implications 55
5.0 Introduction to the Chapter 55
5.1 Overview of Key Findings and their Significance 55
5.2 Implications 57
5.2.1 Broad: The educational research community 57
5.2.2 Narrow: Your professional identity and practice 59

5.3 Recommendations 60
5.3.1 Ontario Ministry of Education 60
5.3.2 Ontario school boards 60
5.3.3 Teachers 61

5.4 Areas for Further Research 61
5.5 Concluding Comments 62
References 64
Appendices 70
Appendix A: Letter of Consent 70
Appendix B: Interview Protocol/Questions 72
Chapter 1: Introduction

1.0 Research Context

“We need technology in every classroom and in every student and teacher’s hand, because it is the pen and paper of our time, and it is the lens through which we experience much of our world.”

– David Warlick (2006, p. 1)

Ontario’s public education system is acknowledged to be one of the best in the world (Ontario Ministry of Education, 2014a). Since the beginning of public education, the influence of education on children remains consistent, to teach to read, write and engage in arithmetic. Business and political leaders are increasingly asking schools to develop skills in students such as problem solving, critical thinking, communication, collaboration and self-management, and these skills are all related to 21st century learning (National Research Council, 2012). With such a change in the past fifteen years in the way we work, communicate, interact, shop, listen to music, find information, and so much more, the way we teach and learn literacy and numeracy is also in need for change (Ontario Ministry of Education, 2014b).

One particular way the education system can continue to keep elementary achievement growth and graduate rates on the rise is to adapt teaching and learning methods to what students are most engaged with. With the integration of technology into the classroom, the overall benefits include greater peer interaction, student engagement and collaboration, an easy way to collect classroom feedback, improves communication and extends the place and time of learning (Kiger, Herro, & Prunty, 2012; Ontario Ministry of Education, 2014b). Lecture-based forms of instruction or “one-size-fits-all” approaches do not connect the students’ real world experiences
to the subject. This is particularly apparent in the mathematics curriculum where there is more rote memorization and individual mastery of material (Dede, 2014).

There are a number of students learning mathematics in the early years who suffer from math anxiety, which has been around since the mid-1900’s (Chernoff & Stone, 2014). Common teaching techniques that cause math anxiety include assigning the same work for everyone, teaching from the textbook, and insisting there is only one correct answer to a question or one correct strategy to answer a question (Furner & Duffy, 2002). Given that the integration of technology into classrooms can enrich students learning and result in a positive learning environment that integrates students’ interests into the curriculum, this research study investigates teacher’s perceptions of math anxiety in elementary students, and how they integrate technology to enhance mathematics engagement.

1.1 Research Problem

Despite the current research on 21st century learning practices, many teachers are still not comfortable or do not have enough training with integrating technology into their classroom (Aksan & Eryilmaz, 2011; Christensen, 2002; Glazer, Hannafin, Polly & Rich, 2009; NCTM, 2011; Polly, 2014). Successful technology integration is dependent on positive teacher attitudes towards technology (Christensen, 2002; NCTM, 2011; Polly, 2014). Although teacher education is pertinent to the better education of students, Glazer et al. (2009) identified insufficient human and physical resources to be key factors for technology integration. This leaves schools with resources ahead of schools with less resources; therefore the way children are being educated through technology integration at one school can be completely different then at another school due to the lack of resources.
Although math anxiety has been around for some time and has an abundance of research to suggest strategies to alleviate it, our society is still suffering from students who experience math anxiety on a daily basis (Chernoff & Stone, 2014; Furner & Duffy, 2002). While math anxiety in students continues to be a barrier to mathematics achievement, it is also a barrier for beginning teachers or long term teachers who themselves struggle with math anxiety (Beilock & Willingham, 2014; Chernoff & Stone, 2014, Furner & Berman, 2003; Isiksal, 2010). In this study, I am particularly interested in learning how teachers integrate technology to assist the students who suffer from math anxiety to learn math in a different, inclusive way.

1.2 Purpose of the Study

The purpose of this study is to explore how teachers use technology to engage students in mathematical practice. This study is focusing on elementary mathematics, as this is where all students are grouped together and learning the same content, unless specifically stated on an individual education plan (IEP). With the rise of research specifically focusing on math anxiety, this study will focus on integrating technology into the mathematics curriculum to assist the students who suffer from math anxiety and assist them in learning in a different way.

I was also interested in investigating how teachers learned how to work and implement technology, and to hear what overall outcomes they see with regard to mathematics engagement from students who experience math anxiety. It is my hope to report and share the practices of a sample of elementary teachers who integrate technology into mathematics and how these practices can inform instructional practice of other teachers. These findings will also inform my own practice as a beginner teacher to help me fulfill my commitment to administering the most up to date teaching and learning strategies that will best support all students in the classroom environment.
1.3 Research Questions

The primary question guiding this study is: How is a sample of elementary teachers integrating technology in their mathematics instruction and what outcomes do they observe for student mathematics engagement?

The sub-questions to further guide this inquiry include:

• How did these teachers learn to integrate technology in mathematics instruction?
• What factors and resources support teachers in their work integrating technology in math?
• What do these teachers believe is the potential of technology integration for alleviating math anxiety in students?

1.4 Background of the Researcher/Reflexive Positioning Statement

Through my own math experiences in elementary and high school, I believe I have limited my own career choices due to the fact that I did not like math and felt I was not good at it. I do not specifically want to say that I had math anxiety, but I do know that I enjoyed completing math tasks at home, while in school I hated math. Math was always a scary subject for me because you are either right or wrong, and receiving the bad mark on the test that you studied so hard for and thought you understood always brought me down. Although I may not have had the feelings that students with math anxiety experience, I want to know more about helping those students in particular, but also all students in general.

Having personally been affected by the negative aspects of learning math, I entered my first practicum in a six/seven split class with the fear of teaching math. My associate teacher assisted me throughout the way and I felt confident teaching math in this particular classroom. For much of the lessons, I integrated technology to make the experience of learning math fun and engaging. Everyday the students were so excited for 1:00 pm when I was teaching math because
we were learning as a group, rather than me teaching them. I began reading more into the topic of integrating technology into the math curriculum and I came to the area of math anxiety. According to Furner and Duffy (2002), about 7% of Americans have positive feelings about math and 93% who have a problem with math. This is clearly a problem that is on the rise and is now seeing more emphasis with the integration of teachers college changing to two years to provide more assistance to teacher candidates.

With the integration of technology into the classroom, I observed first hand in my practicum the amount of technology that was incorporated into classrooms with younger teachers, who themselves engaged in technology on a daily basis. This is where I wanted to further study the impact teachers observe in their classrooms when integrating technology and where or how they learned to incorporate it. Through my experiences as a student, student teacher and based on what I have learned through the literature, it is important to have a strong mathematical foundation for future careers and life. Not only that, I want to study how teachers are reaching the students who have math anxiety and to learn how technology is assisting them in excelling in their development.

1.5 Overview/Preview of Whole

This research project is organized into five chapters. To respond to the research questions, I conducted a qualitative research study using purposeful sampling to interview two elementary teachers about their teaching practices and how they integrate technology into their mathematics curriculum.

Chapter one includes the introduction and the purpose of this study, the research questions and how this topic is related to myself as a student and educator. In Chapter two, I review the literature in the areas of math anxiety, what technology integration looks like, how it
is effective on student learning in the math classroom and how it may alleviate math anxiety in students. Chapter three elaborates on the research design and includes the methodology and procedure used in this study. The information will include the participants, data collection instruments and limitations of the study. In Chapter four, I report my research findings and discuss their significance in light of the existing research literature. Lastly, in Chapter five I identify the implications of the research findings for my own teacher identity and practice, and for the educational research community more broadly. References and a list of appendixes are found at the end of this paper.
Chapter 2: Literature Review

“Tell me mathematics, and I will forget; show me mathematics and I may remember; involve me…and I will understand mathematics”

- Furner & Berman, 2003, p. 173

2.0 Introduction

In this chapter I review the literature in the areas of math anxiety, technology integration and ways technology can support math learning and decrease math anxiety in students. There is an extensive amount of literature on this topic and ways in which math anxiety can be alleviated, prevented and ways it can be transmitted to students. Also, the ways in which students learn mathematics and the attitudes by those around them play a crucial role in their success. From there, I review the research on how technology is being integrated into the math classroom and finally, how it may help students with math anxiety feel more comfortable and willing to learn math. This study’s overall focus is on the integration of technology into the mathematics curriculum and how it can assist students with math anxiety in the 21st century.

2.1 Math Anxiety

Math anxiety has been defined over the years by many individuals and has been a topic that is consistently being studied. Furner and Berman (2003) define math anxiety as an “irrational dread of mathematics that interferes with manipulating numbers and solving mathematical problems within a variety of everyday life and academic situations” (p. 170). More recently, Chernoff and Stone (2014) define math anxiety as “a feeling of nervousness, unease, or tension that interferes with math performance” (p. 29). On the other hand, many researchers speculate that math anxiety may be related to simply being bad at math. Studies have determined that there is a strong relation between math anxiety and poor math performance, due to the fact
that a math anxious person is consuming their working memory with anxious thoughts while completing the task at hand (Beilock & Willingham, 2014; Maloney & Beilock, 2012).

There is a link between math anxiety and brain performance, which particularly displays that individuals are suffering from math anxiety. Research has indicated the relationship between math anxiety and the part of the brain responsible for reasoning, problem solving and emotions. When a math anxious individual is solving a problem, the area responsible for math reasoning in the brain is less active, while the area associated with negative emotions tends to be more active (National Council of Teachers of Mathematics 2013; Beilock & Willingham, 2014; Eden, Heine & Jacobs, 2013). Further, these studies also determined the higher an individuals math anxiety, the larger the increase in brain action associated with threat and the experience of fear. This specific observation was when highly anxious students “just anticipate doing math” (Beilock & Willingham, 2014, p. 30). These studies conclusions determine that every mathematical task an anxious student receives, they are being prompted to complete two tasks at once. First, they are to solve the mathematical problem; and second, they are to deal with their intrinsic and extrinsic worries about math.

It is difficult to assess and determine whether a young student has math anxiety. Although it is difficult, the importance of assessing students and supporting them to overcome math anxiety is extremely important. If this is not successful, the math anxiety that an individual faces may potentially limit future education, career paths and limit their ability to excel in modern society (Chernoff & Stone, 2014; Eden, Heine & Jacobs, 2013). According the National Council of Teachers of Mathematics (2013), there are two main assessments for math anxiety. Firstly, the Mathematics Anxiety Rating Scale (MARS) is commonly used to assess math anxiety in adolescents and adults. Secondly, the Scale for Early Mathematics Anxiety (SEMA) assesses
children between the ages of seven and nine. There is a high scale of importance in assessing math anxiety in young children because it has been tested to have a negative impact in being successful in math reasoning and problem solving (Beilock & Willingham, 2014). On the other hand, the National Council of Teachers of Mathematics (2013) disagrees with this specific impact as no research displaying this claim has been developed. The best practice to assist students would include continuous observations and assessments of the students who may display math anxiety, and can provide strategies to assist them in their zone of proximal development.

2.1.1 Math anxiety in students

Although there is little research determining what actually happens in the brain when young students experience math anxiety, there are observable traits that teachers can take note of over time. Chernoff and Stone’s (2014) study on math anxiety found that the main symptoms of math anxiety included a rise in heart rate, sweating, nausea, stomach discomfort, headaches, confusion, and panic. More observable symptoms that the teacher can assess are a lack of confidence, poor performance and math avoidance. Their study found that many students avoided studying math in a variety ways. The lack of confidence led to students going to the office to call home sick because they were not feeling well, which became a reoccurrence before math class. This example depicts a common avoidance strategy exhibited by some children with math anxiety.

Math anxiety may manifest differently in every student, leading to varying experiences. Eden, Heine and Jacobs (2013) studied the relationship between mathematics anxiety and performance. Their results suggested that a student’s performance does not deteriorate when he/she receives a simple arithmetic task. Performance suffers considerably when the student
receives a task with more difficult problems that draw on working memory. This model is referred to as transitory disruption of working memory (Ashcraft & Kirk, 2001).

While the task does play a contributing role in mathematics anxiety in students, Isiksal (2010) found test anxiety and mathematics anxiety to be highly correlated. There are two critical elements of mathematics anxiety that Isiksal (2010) reported. First, learning math anxiety (LMA) is related to the process of learning math, which can be affected by many variables, which will be explored further in the next section. Second, math evaluation anxiety (MEA) is directly related to testing situations (Isiksal, 2010). These findings are consistent with Ashcraft and Ridley (2005), when focusing on student’s mathematical anxiety and testing. There research furthers a specific correlation between a teacher’s negative attitude, classroom style and unsupportive relationships with the feelings of mathematics anxiety and to mathematics testing in students. This leads further to environmental and social factors affecting student’s mathematics anxiety, one specifically being their classroom teacher.

2.1.2 Math anxiety in teachers

As stated, a student’s confidence in math is a predictor and indicator of math anxiety. With that, it is essential to examine the teacher’s views of math as a whole. The term self-efficacy, “an individual’s judgment of his or her capability to organize and execute the courses of action required to attain designated types of performances” (Isiksal, 2010, p. 502) has a direct correlation with teacher efficacy, “beliefs in their ability to have a positive effect on student learning” (p. 502). When a teacher has high self and teacher efficacy, their beliefs strongly influence their effort in teaching, the choices they make and the degree of anxiety they experience (Isiksal, 2010). In his/her study, Isikal (2010) found that teachers were more likely to use more approaches for teaching and differed how they are implemented, providing more
attention to low achieving students, and adapting teaching practices to support all student’s needs. On the other hand, teachers with low self and teacher efficacy frequently doubted their capabilities and in turn, they would not complete (or changed their teaching practices) when it came to difficult tasks that they viewed as a personal threat. This threat that many teachers perceive is consistent in the majority of the research in relation to math teaching (Beilock & Willingham, 2014; Chernoff & Stone, 2014; Furner & Berman, 2003; Isiksal, 2010).

Teacher math anxiety can begin in teacher education programs where some teacher candidates come in with negative attitudes towards math and the teaching of the subject (Chernoff & Stone, 2014). As the Ontario Minister of Education described in 2013, much of the elementary teachers have a background in the arts, and less in math and science. This is one of the reasons why teacher education in Ontario has moved from one year to two, to assist teachers in their comfort level with teaching math (Alphonso & Morrow, 2013). This is due to the fact that an improvement in education must begin with a reform in teacher training (Furner & Berman, 2003).

The way in which teachers with high math anxiety educate students is extremely different than teachers with high self-efficacy and low anxiety. Teachers with higher levels of self-efficacy and lower levels of anxiety spend more time in the classroom devoted to more traditional teaching methods, including lecture style and individual seatwork focusing on skills instead of concepts (Isiksal, 2010; Chernoff & Stone, 2014). Less time observed in these classrooms were devoted to class discussions and problem solving. Teachers’ internally held beliefs (about their own math adequacy and skills) as well as their external beliefs (how they deliver math in their classroom) play a huge role in the way their students learn math in the classroom (Chernoff & Stone, 2014). With that, the strong correlation between math teachers and
student achievement is a recurring theme in the literature and will be explored more in how this factor may be a cause of math anxiety in students.

2.1.3 Causes of math anxiety

As with anything in life, there is never one reason as to why something is occurring. Specifically with math anxiety, there is no specific cause that research has been able to identify. Some factors that come into play in the development of math anxiety include the environment the child encounters (home and school), the gender of the teacher and their ability/techniques to teach math and the way in which the student learns best (Furner & Berman, 2003). As an educator, differentiated instruction is required to meet a wide range of students’ abilities and learning needs (Ontario Ministry of Education and Training, 2005). Poor mathematics instruction that goes against the 21st century pedagogy does not assist those students who already have trouble with math and need assistance. The quotation by Furner & Berman (2003) describes a students’ interpretation of learning math as, “tell me mathematics, and I will forget; show me mathematics and I may remember; involve me…and I will understand mathematics” (p. 173).

The way that teachers educate students in the math classroom has a lasting effect on the decisions they make in the future, as well as the effects that can lead to or heighten math anxiety. There are specific internal and external causes to math anxiety that will be further explored. External sources can be linked to the classroom and home environment, while internal is based more on how the student learns (Chernoff & Stone, 2014). Teaching techniques that have been observed to cause math anxiety include assigning the same work for everyone, strictly going through the textbook on a daily basis, providing written work everyday, insisting that there is only one correct way to complete a problem and assigning math problems as punishment for misbehaviour (Chernoff & Stone, 2014; Eden, Heine & Jacobs, 2013; Furner & Berman, 2003).
As most of the teaching techniques observed to cause math anxiety can be related to more traditional types of teaching, Chernoff and Stone (2014) determined common practices leading to increased anxiety that also had this emphasis. These include drill and practice teaching methods, emphasis on getting the “right” answer and using the “right” method, taking timed tests and memorizing formulas/rules. Although there has been progress in moving away from these methods of teaching and focusing more on the process and application of math in daily life, these teaching practices are still dominant in the math classroom (Chernoff & Stone, 2014). Additionally, female educators with math anxiety also carry over consequently to lowering girls’ math achievement (Beilock & Willingham, 2014). More recent research has also concluded this, but it is also beginning to note the extent that the same is beginning to also be true for boys (Beilock & Willingham, 2014; Eden, Heine & Jacobs, 2013; Murphy, 2000).

As the school environment and the way mathematics is taught is one of the main causes of anxiety in students, the home environment also plays a tremendous role. Furner and Berman (2003) studied the impacts that parental attitudes have on the student’s levels of anxiety, and there is a correlation. Parents who have negative attitudes toward math or limited experience tend to make anxiety in students increase. Socioeconomic status (SES) also plays a role, students with a low SES may not have sufficient exposure to the kind of education and experiences that promote positive feelings about math (Furner & Berman, 2003). This can relate to the use and contact with technology, that brings about fun ways to engage in math activities and games. These students may be disproportionately affected, as they may not have the same access to technology at home, and at school. Technology can be used as a tool to engage with math in an anxiety reducing way.
2.1.4 Strategies to reduce math anxiety

As there is no one cause of math anxiety, there is no specific solution to reduce it. Research about how to best support students with math anxiety is ongoing, as there are few techniques that teachers actually find useful in the classroom (Beilock & Willingham, 2014). As mentioned, there needs to be more professional development and teacher training to reduce and prevent math anxiety in students. This is due to the fact that teachers must engage in careful and reflective practices that ensure a relationship between each learner to the math material (Chernoff & Stone, 2014; Beilock & Willingham, 2014). Chernoff and Stone (2014) and Beilock and Willingham (2014) further stated that the first step is for teachers to be aware of their own levels of math anxieties to make appropriate adjustments in their teaching practices. This will also help in passing negative biases to the students, which as previously stated, is a cause of math anxiety. This can be first noted and changed throughout teacher education programs, where teacher candidates are entering the field with the negative beliefs about math and their inability to teach hard concepts.

One in-class strategy that teachers have used noted the effectiveness of is journal writing (National Council of Teachers of Mathematics, 2013). This is used when a specific situation is in the near future and it may seem to be a stressor for students. They receive the opportunity to write freely about their emotions for ten to fifteen minutes. Results from one study indicate that writing about math worries did improve the math test scores of students with math anxiety (Maloney & Beilock, 2012). Another area where students are engaging more in positive contributions to mathematics is through group work (National Council of Teachers of Mathematics, 2013). Students are able to observe that problems can be solved in a variety of ways and that each student has something to contribute to the group. During this, teachers are
also encouraged to emphasize the importance of mistakes and to relate math to their lives on a consistent basis. As an educator, we can consistently ask ourselves what ways we can motivate our students in learning math and how to increase engagement.

2.2 Technology in the Classroom

The 21st century classroom aims to create students who are critical thinkers and problem solvers, leaders and effective communicators. Educators are engaging their students in higher-order thinking and digging deeper in learning beyond rote learning (Saavedra & Opfer, 2012). The expectations for the education system are now shifting. According to OECD (2010), technology is a tool for improving both the teaching and learning process that opens new opportunities for inquiry and adapting needs to particular students. Technology also prepares students for the skills necessary to adapt to society and adult life. Finally, a digital divide may occur that will affect their capacity to fully integrate into the economy and society if they do not engage with technology and master these skills (OECD, 2012).

Information and communication technologies (ICT) can strengthen the teachers and students learning process in all levels of the curriculum (Khambari, Luan, & Ayub, 2010). It provides a range of tools, including digital cameras, the internet, databases, multimedia resources and access to a variety of specialized software (Ontario Ministry of Education, 2005). Technology in mathematics influences what and how it is taught. Some forms of technology that have been observed in elementary classrooms are handheld devices (iPads and cellphones), interactive whiteboards, web-based digital media and document cameras (Polly, 2014; National Council of Teachers of Mathematics, 2011). With the forms of technology now increasingly available in classrooms, teaching and learning is moving from the traditional views of learning to a more advanced and independently driven way of learning.
2.2.1 Use of technology in the classroom

Technology in the classroom has created a shift in education where students are now accessing their own information, ideas and interactions while also taking ownership of their knowledge (National Council of Teachers of Mathematics, 2011). Although technology integration in the elementary classroom supports student learning, the way the teacher engages students with the technology is important in the way that it assists student learning. The way technology is integrated also depends on the available ICT tools and knowledge of integration, which will be further explored. The SAMR model, developed by Ruben Puentedura, defines different forms of technology tools and the uses in the classroom (Green, 2014). The model stands for “Substitute”, a tool that acts as a direct substitute and creates no change; “Augmentation”, a tool that has functional improvements; “Modification”, a tool that allows for significant task re-design; “Redefinition”, a tool that is used for the creation of new tasks (Jude, Kajura & Birevu, 2014). Once again, the level of integration depends on the knowledge of the teacher and availability of the tools.

With Jude, Kajura and Birevu’s (2014) study, the SAMR model demonstrates “substitution” as the use of computers to replace writing. This does not promote any significant change to the function. “Augmentation” displays the use of computers to increase writings functionality as on a computer you are able to cut and paste and use spell check, as examples. These first two stages act as a enhancement role in the teaching and learning process, but can further be transformed as mentioned in the “Modification” and “Redefinition” stages. The “Modification” of a task allows for usage of spreadsheets, graphing, etc. while the “Redefinition” dimension allows for the creation of new tasks such as the creation of interactive videos and integrating websites, audio and much more. The findings to their research displayed that overall,
there is a lack of technology implementation, lack of knowledge of how to implement ICT tools, and the lack of policies to implement these tools. This is also consistent with Green’s (2014) findings as it suggests teachers need basic technology skills and comfort with these devices, as well as pedagogical practice to develop meaningful student-centered learning.

2.2.2 Factors hindering inclusion of technology

The two particular studies integrating the SAMR model both developed the same findings about teachers’ preparedness and comfort level integrating technology into the classroom, as well as the affordability of the particular devices (Green, 2014; Jude, Kajura & Birevu, 2014). The access each school has to technology is one crucial factor that is hindering the inclusion of technology. One particular study concluded that teachers who have more access to technology and some experience using it more frequently use technology than those who have less access and less experience (Miranda & Russell, 2011). In contrast, Staples, Pugach and Himes (2005) discuss particular schools and parents within those schools who wanted to prepare their children for the real world and therefore invested in digital technology. Therefore, it is apparent that school and school board location is a factor in whether technology can be purchased for the school, as well as the socioeconomic status of the parents/guardians.

The area of teachers’ attitudes towards technology and the integration into classrooms holds a lot of research and conclusions for improvements in the area. One major finding in this area is that the successful integration of technology is dependent on positive teacher attitudes toward technology (Christensen, 2002; Glazer, Hannafin, Polly & Rich, 2009; Miranda & Russell, 2011; Polly, 2014). Glazer et al. (2009) indicate three issues for technology integration, which include inadequate training, insufficient human and physical resources and the resistance to change. Although inadequate training and resources is consistent among researchers
(Christensen, 2002; Miranda & Russell, 2011; Polly, 2014), Staples, Pugach and Himes (2005) focus specifically on principles and leaders and their need to make effective decisions regarding how a school will invest in specific types of technology and how to connect the technology to the curriculum. While they believe professional development is a part of the process of integrating technology, the planning and considerations of how to connect it to the curriculum is most important. Further, their conclusion is that administrators and teachers need to invest real time and effort (with their own learning and resources) to keep up with technology and consistently finding ways it can serve the curriculum.

2.2.3 Technology to support math learning and teaching

With the focus on the teachers who are implementing technology into their classroom, the research previously stated throughout this literature review provides the ways it benefits students learning. When specifically focusing on the math classroom, there is not a lot of research conducted in the area of technology acting as a supportive role in mathematics learning. Polly (2014) concludes in her study that there needs to be more research on technology integration in one content area, rather than the overall curriculum. She delves into detail about the use of document cameras and whiteboards as a useful way to display student’s mathematical representations of their examples to the whole group, which allows for class time to analyze and discuss connections between students. Aksan and Eryilmaz (2011) concluded that many mathematics teachers believe that instructional technology materials are not useful for their teaching of math and these negative attitudes need to be replaced. They suggest further courses for teacher candidates entering the field to develop positive views about technology integration in mathematics.
On the other hand, the National Council of Teachers of Mathematics (2011) has a strong view on the integration of technology into the classroom on a daily basis. Technology is stated to support and advance mathematical thinking, sense making, problem solving and communication. These are all skills that the 21st century education system desires their students to engage in. Further, the use of technology allows teachers to develop student understanding, stimulate their interest, and increase their proficiency in mathematics (National Council of Teachers of Mathematics, 2011). The use of technology in mathematics also decreases the cognitive load by allowing students to focus more on mathematical reasoning, forming and evaluating, rather than consistently completing calculations (Polly, 2014). There are a variety of web-based tools that assist students in exploring different areas of math such as area and perimeter and visual base ten blocks (as examples). Polly (2014) concluded that grade eight students who used technology to develop higher level of mathematical skills (problem solving) scored a third of a grade higher than students who did not use technology. With that, there also needs to be more research related to mathematics-specific technology integration and how it supports student learning.

2.3 Technology to Reduce Math Anxiety

The current research regarding math anxiety and technology raises questions about how to best support students with math anxiety. This research paper investigated technology as one method to support these students as well as the rest of the class. Before exploring the benefits of technology in the math classroom, it is important to identify the aspects of how it can negatively impact both students and teachers. Through the previous research stated, it is apparent that both teachers and students suffer from math anxiety. It is also evident that many teachers do not feel comfortable incorporating technology into the classroom, as well as keeping in mind the students who may not have experience with technology. This may create even more anxiety for these
participants that are already suffering from anxiety. At the same time, with a technologically driven future in which employers want individuals to have problem solving, critical thinking and communication skills, with respect to the use of technology, the school system should be engaging these students with no experience in the classroom (National Research Council, 2012).

Learning math anxiety is one form of impact on students, which focuses on the way the student learns math (Isiksal, 2010). Exploring the more traditional forms of education does not assist students in learning math, but rather creates anxious students. Therefore, teachers need to explore different ways they can teach math in their classroom that supports a diverse group of students. Furner and Duffy (2002) also conclude integrating technology into the classroom and math curriculum helps reduce math anxiety in students. Technology helps take away the pressure and anxiety associated with worksheets and the traditional teaching practices in math and provide an avenue to explore and enjoy doing mathematics.

The incorporation of technology into the math curriculum also helps individualize and accommodate students needs, interests and learning styles (Polly, 2014). Further, students are encouraged to take a lead in their own learning and by doing so, they are able to ask questions and investigate for answers. The use of the internet provides opportunities for them to conduct the research and find solutions themselves. This also allows for collaboration among peers as they may look to understand concepts as a group or with their peers. As observed, the internet also allows for the pathway between the home and school environment, where parents/guardians can also be involved through classroom blogs or sites (such as Google classroom). Parents/guardians can then educate themselves on what is occurring in the classroom and ways they can best support their child.
Although to date there is an insufficient amount of research specifically linking technology to improving math anxiety, there are specific math activities that are conducted online to be proven to help those with math anxiety. Hackworth (1992) delves into the importance of including online discussions about math for students to have the opportunity to express their attitudes about mathematics and the different feelings they experience in regards to the material they are learning. Hackworth’s (1992) strategy has been proven to help relieve individual anxiety towards mathematics. Sun and Pyzdrowski (2009) further explore the idea of websites and software as it provides virtual manipulatives and hands on activities that are easily accessible by both students and teachers. These online activities allow for quick retrieval of information, to further inform student understanding about a particular concept. Sun and Pyzdrowski (2009) state the use of technology in mathematics enhances their learning as they are able to overcome the anxiety caused by cognitive factors that were previously stated. This is due to the fact that this form of a learning environment allows students to explore concepts rather than only arriving to the “right answer”, which is anxiety producing for some students.

2.4 Conclusion

In this literature review, I reviewed research on math anxiety, technology integration and ways technology can assist student’s mathematical learning and reduce math anxiety in students. This review elucidates the extent to which attention has been paid to math anxiety and technology integration. It raises questions about how technology is enhancing students learning in math and points to the need for further research in the areas of how technology can assist students with math anxiety. In light of this, the purpose of my research is to learn how teachers are using technology in their math instruction and to learn from them what outcomes they observe from students who experience math anxiety. Through the use of semi-structured
interviews with elementary educators in Ontario who integrate technology into their math program, I provide the most relevant information to better understand how the integration of technology can positively affect students with math anxiety.
Chapter 3: Research Methodology

3.0 Introduction

In this chapter, I explain the research methodology and identify the different decisions I have made and my rationale for those choices given my research topic. I begin with a discussion of the research approach and procedure followed by the main instrument of data collection. I then identify the participants in the study, the sampling criteria and procedures and provide some background information on the participants. I proceed to describe how I analyzed the data and any relevant ethical issues that have been addressed and considered throughout the study. Finally, I highlight and acknowledge some of the methodological strengths and limitations of this study.

3.1 Research Procedures

This study was conducted using a qualitative research study approach with semi-structured, face-to-face interviews with two elementary educators. It includes a review of the existing literature that is relevant and significant to the research questions and purpose. According to Creswell (2007), qualitative research involves an exploratory and naturalistic approach, attempting to make sense of and interpret the meanings people bring to the topic. Qualitative research is a form of inquiry, in which the researcher studies and collects data in natural settings that are sensitive to the people under study. A qualitative approach invokes reflexivity of the researcher, the voices of the participants and a final interpretation of the problem, which may extend to a call for action (Creswell, 2007).

Due to the fact that the point of this research is to explore and learn more about what current educators are conducting in their teaching practices, qualitative research is key to this investigation. The key to qualitative research is the ability to receive the complex, detailed
understanding of the issue through directly communicating with the participants and allowing them to share their stories (Creswell, 2007). Further, the relationship between the researcher and participant is displayed as the researcher is learning from the participants, de-emphasizing the power relationship.

As our world is in constant change, Merriam (2002) presents the multiple constructions of the world in which one form of research cannot measure. She further examines how qualitative researchers are interested in understanding the particular issue at that point in time and how the individuals experiencing the issue are interacting in their social world. It is integral that with qualitative research, the researcher understands the phenomenon from the perspective of the participant, rather than the researchers (Jones, 1995). This is an important aspect of the research, as it solely relies on the participant’s experiences in the classroom setting and their reflection upon their teaching practices.

Unlike quantitative research that focuses on numerical data, qualitative research relies on richly descriptive words and pictures to convey what the research has learned about the phenomenon (Merriam, 2002). Different forms of supportive documents are used for the findings of the study. Some include participant quotations, interviews, field notes, excerpts from video tapes, observations etc. (Merriam, 2002). Therefore, given my research purpose and the questions I explored, a qualitative study was an appropriate approach as it provides me with the ability to inquire into the lived experiences of a small sample of teachers who are integrating technology into mathematics. I want to answer the questions such as “how” and “why” to further understand the experiences rather than just simply answering the “what”, which is observable in quantitative studies (Jones, 1995).
3.2 Instruments of Data Collection

Qualitative studies are established by the purpose of the study and determining which sources will produce the best data to answer the research questions (Creswell, 2007; Merriam, 2002). Merriam (2002) states the three more common sources of data collection are through documents, observations, and interviews. She further discusses the use of multiple methods to improve the validity of the findings. For the purpose of this qualitative study, the primary instrument for data collection is the semi-structured interview protocol (see Appendix B). While an interview is thought of as standardized and questions are asked identically word for word, the semi-structured interview is more flexible and dynamic (Taylor, Bogdan, & DeVault, 2016). Although there generally is a set of pre-determined questions organized around the research questions, the semi-structured interview allows for other questions to arise and a dialogue is set between the interviewer and interviewee (DiCicco-Bloom & Crabtree, 2006).

The point of the semi-structured interview is to conduct face-to-face encounters in which the researcher is directed to the participants’ perspectives on their experiences and situations expressed in their own words (Taylor, Bogdan, & DeVault, 2016). Further, the interview is not identical to a question and answer exchange, but more like a conversation between equals. Although the semi-structured interview can be conducted in groups, the interview will be with each participant individually, allowing for the interviewee to delve into the social and personal experiences of the topic. I am interested in learning about the teacher’s experiences and practical application with integrating technology into mathematics and how it may help those students with math anxiety. A semi-structured interview with a sample of teachers executing technology in mathematics will therefore yield the most relevant information. This interview provided me with the opportunity to hear and go in depth about teachers lived experiences rather than
conducting a survey, which can just get an overview of the experience. I organized my interview protocol (Appendix B) into five sections to specifically learn from the teachers in the areas including, the participant’s background information, experiences with math anxiety, experiences with technology, technology and mathematics and next steps for teachers.

3.3 Participants

Next, I review the sampling criteria and how they relate back to the research questions. I also review the recruitment procedures, and finally, I provide a brief biography of each participant.

3.3.1 Sampling criteria

In this section I review the sampling criteria I established for participant recruitment. The following criteria will be applied to teacher participants:

1. Teachers will be teaching within the primary, junior and intermediate grade range in Ontario.
2. The teachers must have experience with teaching students with math anxiety.
3. The teachers will consistently integrate technology into their mathematics instruction.
4. The teachers must demonstrate some commitment and leadership with technology integration in the classroom or school community.
5. Teachers need to be teaching in a permanent position for at least five years.

In order to address the main research question, the teachers selected must integrate technology into mathematics and have experience teaching students with math anxiety in the past. This is due to the fact that I am interested in hearing their perspective on whether integrating technology into the mathematics curriculum has helped those students who experience math anxiety. For the purposes of this study, participants will need to be following the Ontario curriculum in order to keep the requirements of all teachers on the same level. As
math anxiety begins in the early years, it is important to interview teachers in the elementary classroom. Further, teachers need to be teaching in a permanent position for at least five years. This allows for the teachers to have their own class and apply their own teaching styles. Additionally, research has found that the comfort level of teachers after the first five years of teaching is higher, as the majority of teacher dropouts are in the first five years of teaching (Karsenti & Collin, 2013). Lastly, teachers need to demonstrate commitment to the integration of technology into the classroom so that I am able to learn about a breadth of their experience (rather than a single instance, for example).

3.3.2 Participant recruitment

The sample selection in qualitative research is stated to have a tremendous impact on the quality of the research (Coyne, 1997). The recruitment selection involved in this study is purposeful sampling, which follows the aim of the research and questions being answered. Purposeful sampling seeks out the most productive participants that are likely to provide a deeper understanding of the topic and address the purpose of the research (Johnson & Christensen, 2012; Marshall, 1996). One disadvantage to this form of selection is the accessibility of the potential participants.

Due to the particular parameters of this study, I utilized purposeful sampling, as well as convenience sampling. Due to the limitation of accessibility, I also include convenience sampling, as I selected most accessible participants who were willing to participate in the study (Johnson & Christensen, 2012; Marshall, 1996). Therefore, the sampling procedure is purposeful, as the participants need to meet the set criteria in order to provide the relevant data to the purpose of the study. Convenience sampling was also used through the many existing
connections I have made in my previous elementary school that I attended as a child, as well as completed my practice teaching in.

3.3.3 Participant biographies

The first participant, Rebecca, has been teaching since 2000, starting her first couple of years in Vancouver and then moved to Toronto, Ontario. She has been a mathematics specialist for the past three years, teaching mathematics to every Grade Six class. She has taught Grades Two through Six in her sixteen years of teaching. She has always been interested and engaging with technology, as her father was a principal and that is something he always advocated for. She has so much support in her school community for integrating technology and she finds it extremely helpful when using it in mathematics. Due to the fact that she is a mathematics specialist teacher in her school, she is consistently integrating technology into her own professional development, as well as student development and engagement.

The second participant, Joshua, has been teaching with the same board in the GTA for the past fifteen years in the elementary system. He has taught at a total of three different schools, and is currently teaching Grade Seven. In the past, he has taught Grades One and Five through Eight. He was also a Special Education Resource Teacher (SERT) for a short period. Technology was never something he used in the beginning because he knew nothing about it. A couple of years ago, his school gave him a SmartBoard for his classroom and he had no idea how to work it. He engaged in his own professional development by reading more about it in professional journals and magazines, as well as going to workshops. He now considers himself a very active user and engages the students in mathematics through various strategies, with technology being one form.
3.4 Data Analysis

The process of data collection and analysis are interrelated in qualitative research (Creswell, 2007). To analyze the data, the researcher engages in the process of moving around a spiral that includes different steps in the management of data. For example, researchers organize their data, reflecting on the major themes or significant statements to the topic being studied (Creswell, 2007; Johnson & Christensen, 2012). Merriam (2002) further describes the comparison process among data, specifically looking for common patterns throughout the information. The patterns are later given codes that are sorted into themes, and this is described as a “template approach” (DiCicco-Bloom & Crabtree, 2006, p. 318).

During my data collection and analysis, I drew on this procedure, specifically when transcribing interviews and coding the data as it purposefully related to the research question. I identified specific statements in the interviews and organized them into themes, while also identifying any discrepancies in the findings as well as null data (i.e. what the participants did not speak to).

3.5 Ethical Review Procedures

According to DiCicco-Bloom and Crabtree (2006), the interviewer’s task is to listen and encourage the interviewee to speak, while obtaining information. Further, they describe four ethical issues related to the interview process that are, reducing the risk of unanticipated harm, protecting the interviewee’s information, effectively informing interviewees about the nature of the study, and reducing the risk of exploitation. For the purpose of this study, there was a letter of consent (Appendix A) distributed by email to participants before meeting with them, and they both signed the letter before beginning the interview. The letter of consent further explained all the information relevant to the study and the ethical concerns for the participants. It is extremely
important to note there are no known risks to participation in this study and all participants’
identities remain confidential. Participants were made aware that they have the right to withdraw
from the study at any time and they also have the right to refuse to answer any question.

Anonymity of the interviewee is crucial in the interview process as the information being
shared may jeopardize their position in the particular system they work for (DiCicco-Bloom &
Crabtree, 2006). Due to this concern, participants and their schools were assigned a pseudonym.
Further, only my instructor, Angela Macdonald and myself, will access the raw data produced
from this study. The data collected from this study will also be kept on a password protected
laptop for up to five years before it will be destroyed. An important part in the qualitative
interview is to form the trusting relationship through rapport, a further ethical consideration.

3.6 Methodological Limitations and Strengths

As the qualitative method and semi-structured interviews will give the best results in
regards to the research purpose and question, there are some drawbacks and limitations to this
particular study. The results gained from the study cannot be generalized, as we are only able to
interview two to three educators. The strength in this area is that I was able to delve deeper into
the understanding of their daily experiences with integrating technology and the benefits they
observe with students who have math anxiety. I had the ability to engage in one-on-one
interaction where it was semi-structured, which allowed for the teachers voice and experiences to
be heard and further elaborated.

To further extend this study, it would be beneficial to interview students who feel they
have math anxiety to best determine teaching practices that they feel are beneficial to their
learning. In this particular area, researchers can find out more in regards to whether they believe
it is helping them achieve the best they can, rather than communicating to the teacher what they observe.

Lastly, the time frame in particular for this research study is limiting due to the program being focused on professional preparation. This leaves less space and time devoted to the development of a strong research study. In a typical masters program, there is more space and time provided to work on their research, whereas our program focuses more on practicum related experiences. The benefit to this program is through our practicum experiences, we are consistently meeting teachers who can potentially match our sampling criteria and be apart of the study.

3.7 Conclusion

In this chapter I explained the research methodology. I began with a discussion and analysis of the qualitative research approach and procedure and the significance to this particular study. I then described the instruments of data collection, identifying semi-structured interviews as the primary source of data collection and its benefits. Further, I identified the participants in the study, listing the criteria applied to all interviewees and providing an analysis of why those were selected. This included educators teaching in elementary school in Ontario, with experience teaching students with math anxiety and consistently integrating technology into their mathematics instruction. Further, these educators must have demonstrated some commitment and/or leadership with technology integration in the classroom or school community. I also described the recruitment procedures, which require purposeful sampling in order to achieve the best results for the study, as well as convenience sampling to assist in the overall scope of the research study. I continued by describing how I analyzed the data, examining individual interviews before looking for common statements and themes across the data. Ethical issues such
as consent, risks of participation, right to withdraw and data storage were explored and identified. Lastly, I discussed the methodological limitations of the study, as well as highlighting some of the important strengths. In the next chapter, I report on the findings of the research.
Chapter 4: Research Findings

4.0 Introduction

This chapter presents the findings that emerged through the data analysis of 2 semi-structured interviews that occurred during summer break. The analysis of the findings was based on my research question: How is a sample of elementary teachers integrating technology in their mathematics instruction and what outcomes do they observe for student mathematics engagement? The interviews examined past and current teaching practices with integrating technology in mathematics and the experiences of utilizing technology in math for both the teachers and students. The discussion will include connections between participants’ experiences and perceptions and the Chapter 2 literature review. The findings are organized into four main themes, including:

1. Educators’ past personal and professional encounters with technology helped shape their current view on the benefits of technology integration.

2. Educators utilize a variety of curriculum and material supports within their school environment when integrating technology into the mathematics classroom.

3. Educators identified the potential positive impact on learning that technology integration in mathematics has on students with math anxiety.

4. Educators indicated the personal and academic benefits of incorporating technology in math instruction for both the teaching and learning process.

Each theme presented will be further explored by subthemes, where I investigate what participants described and discuss the significance of each theme to the existing literature.
4.1 Educators’ Past Personal and Professional Encounters with Technology Helped Shape their Current View on the Benefits of Technology Integration

Both participants spoke to how they learned to integrate technology in the classroom, specifically in mathematics. Their past encounters with technology were significant influences on their current views regarding the benefits and transition to 21st century teaching practices. Specifically, participants highlighted the importance of access to past professional development as an area of growth in their current ability to integrate technology. They were extremely involved in self-learning through the process, gaining a deeper knowledge of how technology can assist students on a deeper level. Both participants also spoke about the level of support they received in their school environment, recognizing the positive impact their level of support had and continues to have on their ability to integrate technology in mathematics.

4.1.1 Participants indicated the importance of access to past professional development in their current ability to integrate technology into mathematics

Both participants specified the importance of access to past professional development and how it has enhanced their understanding of how technology integration supports student learning in mathematics. Participants explained their lack of technology related content in their teacher education program, and primarily relied on professional development in their knowledge of technology integration into the classroom. Rebecca explained that technology integration in math class was addressed in only one class of her entire Bachelor of Education program. Although she furthered her education by obtaining a Master of Education, she emphasized, “I don’t remember there being any emphasis on technology at that time.”

Joshua did not have any courses in his Bachelor of Education specific to technology. By his recollection, teacher training focused on using manipulatives to support mathematics
learning. Rather, Joshua recalled the vast amount of professional development opportunities that furthered his understanding for both how to use different forms of technology and how it can support teaching and learning in the classroom. Joshua noted, “when I started teaching, technology was never really a thing…I started really learning about it a couple of years ago through professional development in my school and through other organizations.” It is important to note that the ability to engage in these opportunities either in their pre-service teacher training or professional development courses and their ability to be motivated to learn how to integrate technology did not act as a barrier to their past personal encounters with technology.

Research indicates that a positive teacher attitude toward technology is vital to its successful integration in the classroom (Christensen, 2002; Glazer, Hannafin, Polly & Rich, 2009; Miranda & Russell, 2011; Polly, 2014). According to Glazer et al. (2009), inadequate training and resistance to change are two main factors affecting technology integration. Both Joshua and Rebecca did not experience a large amount of training in their education programs, but they did have a positive attitude to improving their teaching philosophy, and they believed learning about technology and the benefits of integration was one way to do so. By taking the initiative to learn more about this area, resistance to change was minimal since they looked at ways changes could be made in a manner that positively affects the levels of engagement students experience in mathematics learning.

4.1.2 Participants indicated the importance of their past self learning in their current ability to integrate technology into mathematics

Participants described that their current ability to integrate technology into mathematics was due to the fact that they spent much of their time engaging in self-learning. Specifically, they took the initiative to find their own resources that would support their learning. They were
willing to undergo trial and error and through this they gained much experience on what worked and what did not work. As Rebecca grew up in a home where her family was in the education system and were strong advocates for technology integration, she took it upon herself to learn more about how it can be integrated in her classroom. She found it to be somewhat of a challenge looking for her own resources, stating “I had to do it all by myself and I had to find all the resources myself. And I don’t like going for one resource, I like to collect many, many resources. It takes a lot of time to plan.”

Joshua also shared his process of self-learning as he stressed “I am not great at it like you kids, so I had a lot of learning myself.” He is aware that he is not an expert at it and learns from his students as they go. He indicated, “I am not afraid to show them I don’t know something; this is when we work through my struggles together and come up with solutions.” The support from his own students helped him in his own journey of learning, teaching him how to utilize some aspects of technology. His principal provided support in giving access to attend courses on how to work the SmartBoard in his classroom, where he became increasingly interested and was always looking for ways to integrate it into mathematics. He specifically stated how useful it was finding premade lessons and modifying them to fit his learning goals and the needs of his students.

Staples, Pugach and Himes (2005) investigated how effective decision-making regarding a school’s allocation of funds towards professional development opportunities is important, while also noting the need for teachers to invest their own time and effort into finding new ways technology can support the curriculum. Similarly, both Rebecca and Joshua spent their own time to learn about technology and how it can support their students and improve their mathematics learning and comfort levels.
4.1.3 Participants indicated the importance of past support in the school community in their ability to integrate technology into mathematics

Despite their belief that self-learning was an important form of their professional development of understanding, another major impact on the development of their knowledge was their support that they received from the school community. Both participants noted the importance of having access to technology to use in their classrooms and having a positive relationship with the technology team at their school.

Rebecca spoke to how fortunate she was in her schools in the past as they had reliable access to desktop computers, iPads and laptops. She indicated,

I always try to incorporate technology into the classroom and luckily I’ve worked at schools that had a lot of technology support and encourage us to use technology. And a lot of access to technology so that has been very helpful.

The supportive community helped foster motivation and was an important factor in her ability to incorporate technology as she had the support to assist her on a daily basis. She specifically had a technology team readily available on a daily basis to ask questions about what she needed to know more about. She stated, “I have people who are there to support me, in anything I could possibly want to do.”

Joshua also felt he had the support he needed in his school community as his principal supported him in receiving extra support when necessary. He admitted that although he had access to a SmartBoard in his classroom, he initially did not use it because he had no idea how to. He stated, “I realized how much whiteboard and chalkboard space it took up so I had to do something about not having that space anymore.” The support he received allowed him to learn more about how to use it and the many benefits it had to make mathematics more visual and
dynamic. Miranda and Russell’s (2011) study concluded that teachers who have more access to technology and some experience using it, will in turn use technology more frequently than those who have less access and less experience. This is apparent in both Rebecca and Joshua’s experiences, as once they had the technology they wanted to learn more to utilize it in the classroom.

4.2 Educators Utilize a Variety of Curriculum and Material Supports within their School Environment when Integrating Technology into the Mathematics Classroom

A key factor in the positive aspect in regards to integrating technology into participants’ mathematics classroom was the variety of support they received. Specifically, the amount of support they have in their school environment is a big influential factor for them in their ability to integrate technology into math. The access they have to resources in the environment acts as a key factor in the way they integrate technology. Furthermore, having reliable access to technology is a vital factor in how or how much technology can be used in the classroom.

4.2.1 Participants identified current school support as a factor that supports their ability to integrate technology into mathematics

As Rebecca stated, she had ongoing support from the tech team all through her time at her current school and if she wanted to implement anything in her classroom, they would be there to help. She also spoke to a workshop she recently attended focusing on coding. She believed that coding is like a language, and “it is going to be absolutely necessary and mandatory to be able to navigate and use and build.”

Joshua, on the other hand, has a school wide initiative focusing on technology integration as a learning goal. Within the school, the principal leads staff meetings about how to use technology effectively in the classroom and in their divisional meetings, they would go more in-
depth about how it would support their students. Within these divisional meetings, they would collectively look at professional journals and magazines, specifically *Professionally Speaking*, and look at the research behind what they were implementing. It was up to individual teachers to take the initiative to learn how to use the technology.

While technology integration in the elementary classroom supports student learning, research suggests the way the teacher engages students in the learning process with technology needs to be on the higher end of the Substitution, Augmentation, Modification & Redefinition (SAMR) model (Green, 2014). This is an area many schools are basing their current initiatives around, providing support to understand how to promote lesson plans in the higher end of the model. Educators need to strive to be able to allow for technology to not only act as a “substitute”, such as using computers to type instead of writing on paper, but further as a “modification” or “redefinition” (Green, 2014). This would act as a task that significantly re-designs the learning goal and is used for the creation of new tasks (Jude, Kajura & Birevu, 2014). As Rebecca stated, a teacher must always know their goal for instruction and how the technology is supporting that goal in a meaningful way. This is all dependent on the educator’s knowledge and the availability of the support to these educators and students to engage in these meaningful math tasks.

4.2.2 *Participants identified reliable access to technology in the school as a factor that supports their ability to integrate technology into mathematics*

Both participants noted the need for reliable access to be able to feel confident in their ability to integrate technology into mathematics. For Rebecca, she spoke to the importance of this, but she had the advantage of working in a school with both strong Wi-Fi connection and classroom laptops and iPads specifically for her class to use. She stated,
I have a lot of advantages. I am very privileged to have access to what I have access to. Um, so I was telling someone else that just access to strong Wi-Fi is just a basic need that I know a lot of schools have trouble with. And I am lucky to have the physical resources right at my fingertips for whenever I may need them.

Although she does not specifically deal with this first hand, she knows the impact these two areas has on her ability to integrate technology in her classroom.

Joshua, on the other hand, felt that the downside to using technology was the unreliable access, both Wi-Fi and having to sign out the iPads for his class. He described that there was a cart for the school, and each teacher would sign out the iPad cart for the period they needed to use it. There were times he went to sign it out and had to rearrange his plans because they were already signed out. Further, he stated that the access to Wi-Fi was sometimes unreliable, as it would cut out at times, specifically on the SmartBoard. Joshua stated, “I think the fact that sometimes its not always reliable makes it hard on the teacher in those situations.”

Miranda and Russell (2011) state that the amount of access each school has to technology can hinder the inclusion of technology by teachers. The study concluded that educators who have more access to technology use it more frequently than those who have less access. Access to reliable Wi-Fi and technology is something that many educators describe as the downfall to using it as a teaching tool as they consistently have to change their lesson in the face of technology failure (Miranda & Russell, 2011). Therefore, the existing research displayed the same pros and cons as both participants in this study, providing evidence consistent with existing research.
4.3 Educators Identified the Potential Positive Impact on Learning that Technology Integration in Mathematics has on Students with Math Anxiety

Participants spoke to the unique and positive impact that integrating technology into mathematics can have on learning for students with math anxiety. Specifically, participants agreed that technology in mathematics can help individualize the learning process, alleviating anxiety as there is no pressure on racing to get the correct answer. Further, they specified technology fosters inquiry and experimentation in ways that allow students to make mistakes and learn from them through trial and error. Furthermore, the use of technology in the mathematics classroom can make the learning process multimodal, not just the traditional pencil and paper tasks.

4.3.1 Participants indicated that integrating technology in mathematics can individualize the learning process

Both participants identified the technology they use in their mathematics classroom helps individualize and differentiate the learning process for students. Rebecca described the amount of time and effort she puts into making her math lessons engaging through integrating technology. She tends to find various resources online to support their learning and utilize the technology as much as possible on their classroom computers, laptops or personal devices that they bring to class. Some games she used in the classroom online are Prodigy and IXL Math, where students move along at their own pace and she receives updates on how well they are completing the tasks. Further, Rebecca stated,

I pull a lot of my resources, like majority of them, I’d say like 80-90% of them from the internet. And so that means that a lot of the like activities or games or lessons and stuff that the kids are doing are online, or they’re found online.
Rebecca has described that the reasoning behind her pedagogy to introduce and utilize technology is because of the way the students positively react to the math learning. She specifically recalled, “students ask me everyday about math and they never used to show an interest as they do now.”

Joshua really tried to understand his students through learning what they already know before providing new content because of the many misconceptions in math. Specifically, he indicated that creating that relationship with his students has allowed him to observe the interest of technology and helped him understand why utilizing it in math is so important. While he thought that the technology for individualizing the program is significant, he also believed there are some downsides. He described the ability to communicate the math learning was the barrier because they are so engaged in the clicking that they are forgetting how to verbally communicate it. As he explained,

I think the advantage is that it does create independent learners and the different programs help students individually because usually it can be geared to their level. I think a big disadvantage is just clicking to complete the task and not being able to explain what they are doing using the technology.

The potential risk of non-engagement is why he prefers to use the technology in the whole-class environment - so students can also have discussions about what is happening in real time. Lastly, he indicated that technology also allows for individual conferencing between the educator and student. He stated, “when they need assistance I am able to have that one on one time with them to work through the problems.” Joshua explained the benefit of this practice was that he could focus more of his time on assisting his students who struggle with math.
Polly (2014) supports the incorporation of technology into the math curriculum as it helps individualize and accommodate student needs, interests and learning styles, as both Rebecca and Joshua noted. Further, the National Council of Teachers of Mathematics (2011) strongly supports the integration of technology into the classroom on a daily basis due to the advance in mathematical thinking, sense making, problem solving and communication that occurs. Joshua described that he believed the downside was the lack of communication of their ideas due to the amount of clicking and attention being focused on the technology. This new finding contradicts existing research, as technology integration was a positive advance in students’ communication levels. Lastly, Polly (2014) found that they are able to take the lead in their learning and allow for collaboration in understanding concepts as a group or with their peers. This provides a connection between existing research findings and current findings, as collaboration is a key learning goal that is accomplished through the integration of technology into mathematics.

4.3.2 Participants indicated that integrating technology in mathematics can foster inquiry and experimentation in the learning process

Rebecca justified the importance of reflection in her teaching and learning process as an aid for assisting the students in their math understanding. She described herself as a reflective practitioner, “constantly reflecting on what went wrong or well with the technology integration.” She further believes that allowing access to students during mathematics fosters experimentation in the learning process that they would not encounter with pencil and paper tasks. She promoted technology in mathematics as “it is important that they have those skills going forward in life because they’re growing up in a world that is dependent on technology in the workforce and their daily lives.” For example, Rebecca used technology as a summative assessment for the measurement unit, connecting it to daily life and the role of a job as Architecture. Students were
to design their own athletic structure using SketchUp, an online application for three-dimensional designs. This engaged students in their own experimentation about what their structure would be, what it would contain and how they would use their measurements to communicate their understanding.

Joshua believed the advantages of utilizing technology in mathematics allowed for students to experience trial and error in their work, in which their errors were easy to fix. To him, this deteriorated the amount of competition students with math anxiety may feel when completing their work. He stated, “I really feel that there is some form of comfort for students when they are completing math tasks online because they are like, so involved and when it’s wrong they just simply correct it on the spot.” A specific cause of math anxiety is related to the emphasis on always getting the “right” answer (Chernoff & Stone, 2014), but in Joshua’s belief, he visions learning more focused on the process of getting to the answer, rather than just coming to the correct answer. Additionally, technology is a tool that improves both the teaching and learning process as it opens new opportunities for inquiry and adapting needs to particular students (OECD, 2010). This allows for the students to take a lead in their learning and experiment around math concepts, enhancing their mathematical understanding.

4.3.3 Participants indicated that integrating technology in mathematics can make the learning process multimodal

Both participants indicated the importance of making math visual for students, a technique that was said to be “mastered” through technology. Providing a learning process that is multimodal allows for material to be learned or understood through different modes of learning. For example, learning how to add can be learned through visual strategies or kinesthetic
strategies. This is a way to better meet the diverse needs of your students, and supporting every learner in the process of their understanding.

Rebecca indicated that there are “various excellent software programs that can make math very visual and very dynamic, and kind of accessible in a way that it’s different from paper/pencil and textbook.” She specifically used laptops, desktop computers and iPads in her classroom and gave an example that “if you wanted to do stop motion or if you wanted anything to do with coding, anything I could possibly want to do, I could do it if I wanted.”

Similarly, Joshua described his strategies as a mixture of all types of teaching and learning strategies, further commenting, “I love to find ways to teach math in like different ways that allow students to relate to whether it be using computers, apps, or just flat out humour and storytelling.” Specifically document cameras, the highlighters and magic pens on the SmartBoard, virtual manipulatives are all ways Joshua helps students visually see what is going on in math. However, he stressed that in order to enhance and develop their understanding, it was important to start with what they already know about the concept, but then think of different and engaging ways to teach it.

Technology in mathematics influences what content is being taught and how the teacher is utilizing it in order to benefit student learning (Polly, 2014). According to Aksan and Eryilmaz (2011), many mathematics educators believe that instructional technology materials are not useful for their teaching of mathematics. This is due to the fact that there is a belief that hands on learning with manipulatives is best for learning math content. On the other hand, both Rebecca and Joshua observed the benefits of using technology as an instructional method and individualized learning tool that enhances math understanding through the benefits of making math visual and dynamic, skills that are reflective of more learning modalities.
4.4 Educators Indicated the Personal and Academic Benefits of Incorporating Technology in Math Instruction for Both the Teaching and Learning Process

There are a variety of benefits on the teaching and learning process through incorporating technology into the classroom environment. Participants specifically focused on the personal and academic benefits that incorporating technology has in math instruction. Both participants determined the high level of engagement technology has for mathematics learning. Further, they described the benefits and enhancement of teacher pedagogy in the subject.

4.4.1 Participants signified a relationship between technology integration in mathematics and student engagement in the subject

Participants explained that utilizing various forms of technology in the classroom enhances student engagement in a variety of forms. Rebecca particularly focused on their socio-emotional state when using technology in the class. She specified,

I think technology, if its used well, can really enhance the instruction and it can be very engaging for the kids. So if they’re engaged and they feel like they are having fun, they’re enjoying what they’re doing and you’re using the technology as the tool or as your method, then I think it can be very effective.

The engagement in the learning process seems to be, to Rebecca, a key indicator for level of achievement and level of anxiety the students experience.

Joshua focused more on the positive aspects that technology entices in the learner. He described the difference he observes in the learning process when technology is involved. He stated, “The students seem to be more independent and willing to learn with the technology and have become better critical thinkers, which is great.” As Joshua uses technology more on the
instruction end, he feels that the learning process is really hitting the 21st century learning outcomes.

Furner and Berman (2003) describes the use of technology as bringing about fun ways to engage students in mathematics. An example can be when Rebecca introduced coding to students and their task was to create a game on the Scratch application that integrated geometry and spatial sense. Further engaging students in higher order thinking and problem solving leads to deeper learning beyond rote learning, which is a cause for anxiety (Saavedra & Opfer, 2012). This is one way you can dig deeper in technology, through utilizing technology to create tasks in the “redefinition” stage of the SAMR model (Jude, Kajura & Birevu, 2014). This will allow for engaging tasks for the students to feel they are learning math in a fun way, while also creating tasks that are involving critical thinking through the communication of ideas.

4.4.2 Participants signified a relationship between technology integration in mathematics and the enhancement of teacher pedagogy in the subject

Both participants stated that educators play a vital role in the education of their students and can have negative implications on their mathematics learning. Both Rebecca and Joshua spoke to the importance of the educator being a positive role model for students, but in many cases they may contribute to their anxiety. For example, Joshua stated, “many teachers say that they can’t do math…which is really funny because teachers never say I cant read or write....” Similarly, Rebecca focused on teachers’ instruction putting some students at a disadvantage, stating, “certain instruction that makes it maybe emphasizing performance or grades or um just not being in an encouraging atmosphere.” She further described parents being a factor, as many parents would say to her “I wasn’t good at math – and you’d never said that about reading or writing.” This is key in the development of the learner as the teacher needs to take a role in
educating parents on the impact of the negative attitudes about mathematics being a factor of a
students math anxiety. Both Rebecca and Joshua reflected on these experiences and enhanced
their teaching philosophy and pedagogy, focusing on educating the whole learner. This is done
by meeting their needs academically, as well as socially and emotionally.

Rebecca focused her mathematics pedagogy on removing textbook learning and pulls
most of her resources from the internet. She explained that the use of the internet has helped her
on the “instruction side” and taking the time to plan meaningful lessons that relate to their life.
Similarly, Joshua noted that he also does not tend use textbooks in his math class. He stated,

I really don’t like textbooks, so the technology like brings them to a whole new world. This
goes beyond the textbooks and they can relate to current practices. It is really our job to
give them these experiences. Like come on, new technology is basically being introduced
daily. We need to keep them as current as possible, and textbooks are not current.

Joshua believed that just teaching from a textbook does not enhance mathematics knowledge.

Teaching straight from a textbook is one common teaching technique that causes math
anxiety, as it further leads to assigning the same work for everyone and not according to
individual needs (Furner & Duffy, 2002). Incorporating different forms of instruction and
assessments leads students to develop a broader understanding of the concepts. Further,
educators with a high self efficacy tend to use more approaches to teaching, differed how
students were learning concepts and adapted teaching practices (Isikal, 2010). Chernoff and
Stone (2014) concluded that teachers internally held beliefs about their own math skills and how
they delivered math instruction plays a huge role in how their students are learning math in the
classroom. Therefore, existing research supports the role of technology in mathematics as it
provides a different form of instruction and learning environment, one in which both Rebecca and Joshua are continuously moving towards.

4.5 Conclusion to the Chapter

Through the analysis process, the most important factor influencing teachers’ use of technology in mathematics appears to be their knowledge of how to use the technology and how they believe it will support student learning for the particular lesson. Further, participants support the integration of technology into mathematics as it assists both the educator and the learners in explaining and understanding math concepts. Through their use of technology in mathematics, students receive more one-to-one support and individualized programs where they were able to make mistakes and easily fix their answers in a supportive environment. With all the positive aspects technology brings to mathematics, students with math anxiety experience more of a hands on, visual and dynamic approach to learning, where both participants felt that may lower their students’ level of anxiety. Going forward, more research needs to be done on how to make teachers more aware of the positive impact of technology in mathematics for students with math anxiety as it does individualize the program, allow for trial and error and engages students to learn more. Next, in Chapter 5 I discuss the implications for these findings, give recommendations and note areas for further research.
Chapter 5: Implications

5.0 Introduction to the Chapter

In this chapter, I discuss the overall significance and implications of this research study. I begin by reviewing the key findings on how teachers’ integration of technology in mathematics benefits student learning and engagement. Then, I discuss the implications of my findings, both for the educational community and my own practice as a beginning teacher and researcher. With these aspects in mind, I make recommendations for policy and practice, including various stakeholders in the educational community. Finally, I identify important areas of further research and summarize my findings, while speaking to the significance of these findings.

5.1 Overview of Key Findings and their Significance

As discussed in the previous chapter, I organized my findings into four themes. Firstly, both participants spoke to the importance of past personal and professional encounters with technology that has helped shape their current view on the benefits of technology integration. Specifically, access to past professional development was a specific area of growth in their current ability to integrate technology, as well as their own self-learning. This assisted participants in gaining a deeper understanding of how technology assists students’ learning on a deeper level. They also spoke to the level of support they received from their school environment, including the various positive relationships with their colleagues and technology team in the school. Specifically, this area helped shape their understanding through the high level of motivation they acquired from their supportive school community, as well as the amount of technology access available to the classroom.

The participants utilize a variety of curriculum and material supports within their school environment, when currently integrating technology in mathematics. Specifically, a big
influential factor for their ability to incorporate technology in mathematics was based on the amount of support they had in their school environment. This varied based on school wide initiatives, as well as divisional and grade team learning goals. Further, reliable access to technology and strong Wi-Fi connections supports the amount of technology used in the classroom, as well as their confidence continually integrating it.

Teachers observed and reported the unique and positive impacts that integrating technology into mathematics had on students displaying signs of math anxiety. Specifically, technology in mathematics was stated to help individualize the learning process, which alleviated the anxiety of students racing to get to the correct answer first. The way in which participants used technology helped foster inquiry and experimentation where students were encouraged to make mistakes and learn from them through trial and error. In addition, the technology made the learning process multimodal, where there were various modes of learning the content. Some examples provided by participants included different forms of software that were explored online as well as different forms of technology that were utilized.

Finally, participants explored the various personal and academic benefits that were specific to the teaching and learning process with technology. Specifically, they noted the high level of engagement with technology as well as personal benefits and enhancement of teacher pedagogy in the subject. Both participants stated the positive aspects that technology entices in the learner, specifically with their willingness to learn math. While this was an important factor in the academic benefits, they also stated the important role of the educator in the learning process is to specifically be a positive role model. This included improving their pedagogy and making math more meaningful to students’ lives. Supporting the insights from my participants, previous literature (National Council of Teachers of Mathematics, 2011; Polly, 2014; Saavedra
& Opfer, 2012) supports the role of technology in mathematics as it provides a different form of instruction and learning environment, one in which both participants are continuously moving towards.

5.2 Implications

In this section, I outline the implications of my research for both those in the educational community—including the Ontario Ministry of Education, Ontario Faculties of Education and both principals and teachers in Ontario—and my own practice as a teacher and researcher.

5.2.1 The education community

The unique strategies of technology integration used in mathematics can successfully support student learning and teacher development. According to the Ministry of Education’s Achieving Excellence: A New Vision for Education in Ontario (2014), there has been a decline in student performance in mathematics within Ontario. Further, the uses of technology that our students are connected with needs to become more sophisticated, as there “continues to be too much inconsistency in the way technology is used in the classroom” (Ontario Ministry of Education, 2014a, p. 2). Given this and both participants’ acknowledgement that technology in mathematics is an important addition to improving engagement in mathematics, there is much literature on the inability for educators to integrate technology because of inadequate funding or lack of knowledge (Christensen, 2002; Glazer, Hannafin, Polly & Rich, 2009; Green, 2014; Jude, Kajura & Birevu, 2014). Thus, the findings of this study are greatly significant to the educational community.

Firstly, I believe these findings are pertinent to the Ontario Ministry of Education, as there are now initiatives in place to support technology integration into the classroom. The current research displays the various benefits to technology integration, as well as my
participants. Specifically for mathematics, my participants noted the high levels of engagement in content that students have when technology is integrated into mathematics, as well as the ability to individualize the learning. With my own experiences in the classroom, I feel there is such a continuum of student learning and abilities that by individualizing learning in this way, we are differentiating instruction based on students needs. With that in mind, as previously stated, many educators do not feel confident integrating technology into the classroom because of their lack of knowledge. Therefore, with initiatives in place, there are still various reasons as to why technology is not being integrated into the classroom and the main reasoning is due to teachers’ lack of knowledge.

Secondly, as the research states many teachers lack the knowledge of how to integrate technology into the classroom, my participants specifically stated they had no educational experiences in this area until they took the initiative to learn about it. These findings are important for the Ontario Faculties of Education, as it was noted that more support for pre-service teachers would develop a better understanding for how technology can be incorporated into the classroom (Christensen, 2002). From my own experiences at the Ontario Institute for Studies in Education, I had a twelve-week course dedicated to technology, where we learned about various software programs available and how it can be implemented in the classroom in a meaningful way.

Lastly, teachers and principals in Ontario need to be aware of these findings, specifically the benefits technology brings to planning instruction and student learning. Both the current research and my participants’ knowledge supports the various benefits that technology brings, some including higher level of engagement, critical thinking, anxiety reduction and individualization. With these benefits in mind, principals need to be aware of them and also of
the lack of knowledge some teachers have in regards to how to implement technology in a meaningful way. Further, current research promoting access to technology also acts as a factor of implementing technology, as it is stated that those with more access tend to use technology more frequently than those with less access (Miranda & Russell, 2011). These all act as critical factors in which the broader educational community should be aware of.

5.2.2 Implications for myself as a teacher and researcher

In this section, I identify and discuss the implications for me as a teacher and as a researcher. I believe as an educator, there is a need to abide by professionalism and provide current teaching practices that engage all learners, in order for them to succeed. With technology being a big part of students’ lives, as well as a big part of the future, I feel educators can use this to their advantage in their teaching and learning processes. After conducting research on technology integration in mathematics, I am confident that I have furthered my own understanding of how this could be implemented.

After hearing the perspectives of a small group of educators who integrate technology in their mathematics program, it is evident that individual professional development is key. The participant outlined their past and current professional development practices that support their understanding and development of strategies to integrate technology in mathematics. In the future, I will use these resources and strategies as a way to help develop my own repertoire of understanding to enhance my teaching practice. This will help me stay current in teaching practices, as well as meet individual student needs.

Overall, what I have learned will impact my own classroom practice. I will be able to vary my teaching instruction and student learning by using different methods to help students understand and engage in mathematics. Further, what I have learned will also impact my
research practice. I believe as an educator, we need to be a lifelong learner in that we are always learning ways to improve our practice and relating it to the group of students we teach. As a teacher, it is important that I continue to do my own research to find more strategies to help support students in mathematics. This will allow me to stay updated in current practices, as well as helping me in my own practice.

5.3 Recommendations

In order for educators to be able to implement policies in place, changes need to be made in how they are expected to do this. I make recommendations based on my research and learning to ensure that these policies are being put into practice. I have organized my recommendations into three key areas: Ontario Ministry of Education, school boards and teachers.

5.3.1 Ontario Ministry of Education

It is important for teachers to receive proper training and education to be able to teach students with the most current practices. Technology integration is a practice that is new to many teachers, but one that is important in building the skills for 21st century learners. Providing Additional Qualification (AQ) courses for educators that are more affordable can be one way to promote learning in this area. Specifically, providing a reimbursement of a certain amount as is done with some other AQ courses can provide an incentive for educators to enroll.

5.3.2 Ontario school boards

Within the school board, it is essential that there be a strong focus on technology integration as it is a ministry initiative. I think that it is important to place funds in this area and provide access in all schools to some form of technology. Also, providing professional development opportunities such as workshops and in school technology team leaders can help support the development of teachers and students within their school. To make schools
accountable for their process of integrating technology, there can be a board meeting every couple of months for the technology team leaders to display work that is being done in their school and share how students are engaging in the learning process.

5.3.3 Teachers

Teachers need to be able to take the initiative in their own learning and professional development by registering themselves in AQ courses or workshops/webinars to increase their knowledge of how they can integrate technology meaningfully in a variety of subjects. They should be able to learn about their classes needs and fit in technology where it can be beneficial for learning. Specifically for mathematics, teachers need to move away from paper and pencil tasks, where students are racing to get the right answer, and allow them to explore mathematics online where the process can be individualized for student needs. As future teachers enter the school system, they can also act as advocates for technology integration and role models for teachers who may not have as much knowledge in this area.

5.4 Areas for Further Research

In this section, I outline areas of further research based on my research findings and what I have learned. One area for further research is a focus on how technology in mathematics supports communication skills (one area of mathematical process in the Ontario curriculum). The National Council of Teachers of Mathematics (2011) strongly supports the integration of technology into the classroom on a daily basis due to the advance in mathematical thinking, sense making, problem solving and communication that occurs. On the other hand, one of my participants specifically believed that the downside to technology in mathematics was the lack of communication of their ideas due to the amount of clicking and attention being focused on the technology. The impact on communication skills in mathematics is a gap in the research that
would need to be further explored, and what strategies teachers can use to promote mathematical communication with technology.

Both of my participants displayed a commitment to providing students with a variety of ways to learn mathematics, specifically with technology. They spoke to the possible benefits for students with math anxiety, being that the learning is individualized and they can make mistakes without others noticing. However, they did not know how to specifically use technology to benefit students with math anxiety as a way to alleviate their anxiety. There is a gap in the research in this area, and could be a focus of research in the future. Specifically, in what ways does technology integration in mathematics benefit students with math anxiety in elementary school?

5.5 Concluding Comments

In this chapter, I provided a short summary of my findings as outlined in Chapter 4, specifying educators strong commitment to and passion for supporting students who struggle in mathematics through providing different modes of learning, specifically through technology. Through my exploration of the research literature and my interviews with Rebecca and Joshua, I have become more aware of the challenges I will face when integrating technology in my classroom, but more importantly, how beneficial the differentiated instruction is on student learning. The challenges of math anxiety can be addressed by shifting our focus on the teaching and learning process in mathematics to focus on the 21st century principles that meet a variety of learners. I believe that I have received a variety of positive findings that can help inform others about the benefits of technology in mathematics, but I feel gaining more information on how it supports students with math anxiety needs to be further explored. This study has inspired me to
incorporate technology in mathematics to further support all students, while specifically focusing on those with math anxiety.
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Retrieved from


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http://www.oecd.org/edu/ceri/inspiredbytechnologydrivenbypedagogyasystemicapproachtotechnology-basedschoolinnovations.htm


Appendix A: Letter of Consent

Date:

Dear _______________________________,

My Name is Ashley-Anne Barry 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 elementary teachers integrate technology in math, and learning from them what outcomes they observe from students who typically experience math anxiety. I am interested in interviewing elementary teachers who have been teaching for a minimum of 5 years and who integrate technology into their math curriculum. 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. I may also present my research findings via conference presentations and/or through 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. Any information that identifies your school or students will also be excluded. The interview 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 Angela MacDonald. 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 during the interview. 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 to participation, and I will share a copy of the transcript with you shortly after the interview 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,

Ashley-Anne Barry
Course Instructor’s Name: Angela MacDonald
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 Ashley-Anne Barry 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

Thank you for participating in my research study. The data collected in this interview will contribute to my Masters of Teaching Research Paper, a requirement for completing my teaching degree. The aim of this research is to learn how a sample of elementary teachers are integrating technology into the mathematics classroom, and how they see it benefiting students with math anxiety. This interview should take approximately 45-60 minutes, and is comprised of approximately 19 questions.

The interview protocol has been divided into 5 sections, beginning with the participant’s background information, followed by questions about their experiences with math anxiety, experiences with technology, connection between technology and mathematics and concluding with questions regarding supports, challenges and next steps for teachers. I want to remind you that you can choose not to answer any question, and can remove yourself from participation at any time. Your participation is greatly appreciated and everything you say is confidential. Do you have any questions before we begin?

Background Information:

1. What is your current position and how long have you been teaching?
2. What grade(s) have you taught and which are you currently teaching?
3. Can you tell me about the demographics and program priorities of your current school? *probe size of school, SES, student to teacher ratio, program priorities (like tech)
4. How did you become interested in technology integration? What experiences inform your interest and commitment to this area?
   a. What experiences and resources helped prepare and support you in this work?
5. What is your educational background? *probe: undergrad study – major/minor
   a. Where did you complete your teacher education program?
   b. Was technology integration a component of your teacher education program? Please elaborate. Probe: specific courses, instruction, conferences, practicum experiences
   c. How did you learn how to integrate technology into the classroom?
Beliefs about and experience with math anxiety:
6. How would you define math anxiety? What does this term mean to you?
7. Have you had experiences teaching students who suffer from math anxiety?
   a. If yes, What were some of the signs that these students were suffering from math anxiety? What indicators of math anxiety did you observe?
   b. In your experience, how common is math anxiety?
8. What factors do you think lead to math anxiety?
9. Have you ever experienced math anxiety?

Experience with technology:
10. In your experience, what effects does the use of technology have on your students in terms of learning and engagement generally speaking?
12. Can you describe some advantages/disadvantages of technology use in the classroom?
13. Do you use technology across subject areas, or predominantly in certain ones? *Probe further as necessary
14. What range of technology do you tend to use in your classroom teaching, generally speaking?
   a. Can you give me some examples of how you have used these technologies?

Technology and Mathematics: Beliefs and Instructional Practice
13. How do you use technology to support math learning within the classroom and why?
14. Can you give me some examples of how you have used different technology to support students’ learning in math?
15. Why do you use technology to support student learning in math? Why do you believe that it is important to integrate technology into math?
   a. How do students typically engage with technology in math?
   b. What outcomes do you observe from students who typically experience math anxiety?
   c. Can you give me an example of a lesson whereby you integrated technology in math and engaged students with math anxiety?
16. What challenges, if any, do you experience when integrating technology in math? How do
you respond to these challenges?

**Supports and Next Steps:**

17. What advice would you give to an educator who is committed to supporting students with math anxiety, but does not have access to technology in their classroom?

Thank you for your time and considered responses 😊