Combating Math Anxiety: Taking a Look into Teacher Perceptions Regarding the Use of Technology in Elementary Math Classrooms

By

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Abstract

This is a qualitative study aiming to gain a better understanding of the technological strategies that can be used to support mathematics learning in the classroom. It focuses on teachers’ perceptions of the use of technology as a teaching and learning tool and its impact on student math anxiety in elementary classrooms. It involves an in-depth analysis of three data sources: a comprehensive literature search on the topic, a professional journal of observations, and three interviews of experienced elementary teachers. The findings of this study are grounded in three themes; technology implementation, the challenges of its application, and its impact on student math anxiety. The insights and views shared by the participants conclude that the implementation of technology as a teaching tool is highly engaging and can therefore help reduce student anxiety. This study also examines approaches the participants use to infuse technology meaningfully in their practice to effectively teach mathematics.

Key words: Math anxiety, mathematics, technology, elementary education, supporting student learning, strategies, teacher perceptions and attitudes
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Chapter 1: INTRODUCTION

Introduction to the Research Study

“Neglect of mathematics works injury to all knowledge, since he who is ignorant of it cannot know the other sciences or the things of the world.”
- Roger Bacon.

The vast majority of people would agree that one of the main goals of schooling is for teachers to develop in their students an understanding of the basic mathematical concepts and procedures. These basic mathematic skills are important for success not only in school but in an individual’s everyday life as well. Research indicates that classroom practices can influence the goals and views students adopt regarding mathematics (Furner & Gonzalez-DeHass, 2011). From various studies researchers have found that mathematics is considered to be the most difficult subject in school for many adolescents. Such sentiments can contribute towards a lack of confidence in a student’s mathematical abilities and in turn result in a feeling of anxiousness when performing in mathematical situations (Stuart, 2000). This phenomenon will be referred to as “math anxiety” in this study.

Over the last decade studies have been conducted to determine the cause of these negative emotions in students. Various strategies and best practices employed by educators have been explored, in hopes of determining ways in which teachers can help reduce and change these negative attitudes associated with mathematics. A strategy that is being increasingly fostered in countering such negative sentiments is the integration of technology within the classroom. The arrival of the information age has seen our education and daily lives become increasingly rooted
in the use of technology. Many research studies have attempted to explain how technology based innovations can form the basis of effective teaching approaches which help students who have difficulty engaging in numeracy and consequently suffer from math anxiety. They state that technology can be used within classrooms to enrich student experiences and in some sense or another result in positive emotions.

Math anxiety in the classroom has been a recurring concern that deserves further consideration. Hence, this research study investigates teachers’ perception of the effects of technology on math anxiety. It provides insight into factors contributing to math anxiety and explores strategies employed by teachers to reduce student apprehension towards mathematics. More specifically, this research focuses on examining ways that ICT’s (Information and Communications Technology) can be used to help students who are math anxious and support their mathematics learning while investigating the alignment of teacher perceptions with current research.

**Purpose of the Study**

This study aims to gain a better understanding of the technological strategies that can be used to support mathematics learning within elementary classrooms. It focuses on examining teachers’ opinions about the effectiveness of particular ICT-based strategies for supporting students suffering from math anxiety.

If the basic mathematical skills are not grounded appropriately in the early years, it can have a detrimental impact on the long-term professional success of individuals. For this reason gaining insight into how one can alleviate math anxiety can be beneficial for life beyond the classroom. According to psychology professor Sian Beilock, at The University of Chicago, as
quoted by Harms (2012) “early math anxiety may lead to a snowball effect that exerts an increasing cost on math achievement by changing students' attitudes and motivational approaches towards math, increasing math avoidance, and ultimately reducing math competence” (para. 6). Sheila Tobias (1993), a researcher of math anxiety, furthers this notion by claiming that millions of adults lose out on professional and personal opportunities because they fear or perform poorly in mathematics.

Our lives continue to be transformed by the use of digital technologies. Educators therefore are increasingly encouraging and supporting the integration of technology as a tool for learning in all classrooms. Students of today are what Marc Prensky (2001) refers to as “digital natives”. They need to be taught in an environment that engages and supports their learning needs, while effectively preparing them for success in the future. This study is therefore grounded in shedding light into the following: Are teachers’ perceptions aligned with the research? Can technology be used to help ease high levels of math anxiety in our students? Can it make their learning more engaging and less daunting?

In today’s world it is increasingly important for children to have confidence in numeracy (their ability to do mathematics). And it is the responsibility of educators to explore and discover ways in which they can make this possible for their students.

**Research Questions**

The main focus of this research study is to determine the effects of technology on math anxiety. More specifically, it investigates how technology can benefit students in the area of mathematics. The research aims to find answers to the following three questions:
1. What factors help teachers identify students who may be suffering from math anxiety?

2. How are teachers currently using technology to support math learning for all students?

3. What are some of the specific ways that technology can help support students who are math anxious?

**Background of the Researcher**

My research interests broadly stem from my firsthand experiences as a student. Throughout my elementary, middle and secondary school years I personally faced severe math anxiety. I experienced feelings of nervousness and tension when dealing with mathematics in the classroom. Eventually, this “fear” of mathematics was transferred from the classroom to the outside world. The negative experiences I encountered continue to stay with me and have caused a lack of understanding of mathematical concepts.

Having personally been affected by this phenomenon, I was curious to find out if this was an isolated experience or something that other individuals could relate to. I began reading current research on the topic and solicited my friends, family and colleagues for insight into their experiences with mathematics. To my surprise, I observed that math anxiety, in fact, is an emotion which has affected many people in their lives. Research shows only about 7% of Americans indicate that they do not experience math anxiety and that it can begin as early as fourth grade and continues throughout their educational experiences including the college level (Furner & Duffy, 2002).

As teachers are being increasingly encouraged to incorporate technology into their teaching approaches, I became interested in exploring the effects of integrating technology in the
mathematics classroom. Having worked at a school with a grade six teacher, I was able to observe high levels of engagement as students used iPads, Smart Boards, web 2.0 etc. to practice mathematical concepts. This made me wonder how this integration of technology could support the learning of students suffering from math anxiety.

Taking into consideration my personal experiences, those of others, and reading current literature on this issue, I realize the importance of a strong mathematical foundation. I also recognize the detrimental impact that a lack of basic mathematical skills can have on individuals and their long-term professional success. In addition, working towards becoming an educator myself, I wanted to investigate current teachers’ experiences teaching numeracy with the integration of technology and gain knowledge of best practices that I could take with me to my classroom as a teacher. I was curious to explore the factors that contribute towards math anxiety and ways in which teachers can alleviate such emotions within their students.

Overview

Chapter 1 includes the introduction and purpose of the study, the research questions, as well as how I came to be involved in this topic and study. Chapter 2 contains a review of the literature on this topic. Chapter 3 provides the methodology and procedure used in this study including information about the participants, data collections instruments, and limitations of the study. Chapter 4 presents the findings and describes the data as it addresses the research questions. Chapter 5 includes what was learned, insights, recommendations for practice and further areas of study. References and a list of appendices follow at the end.
Chapter 2: LITERATURE REVIEW

This issue of math anxiety has been around for decades. Renowned researchers such as Sheila Tobias (1993) have explored this topic extensively; defining the term, measuring instruments for mathematics anxiety and even offering strategies that teachers can employ to help students combat this negative emotion. However, the issue remains prevalent, affecting the learning and attitudes of students towards mathematics. In this study, a specific focus on the integration of technology as a tool used by teachers to help alleviate this apprehension towards mathematics is explored.

What is Math Anxiety?

“Math Anxiety” is a phenomenon that has been given numerous names some of which include fear of math, math phobia and, math panic. All these names essentially refer to a negative emotional response causing a reluctance to do mathematics. Sheila Tobias (1993), a pioneer in this field has defined math anxiety as “the panic, helplessness, paralysis and mental disorganization that arises among some people when they are required to solve a mathematical problem” (p. 65). It has also been referred to as “an illness that is an emotional and cognitive dread of mathematics” (Fiore, 1999, para. 1). For many this response to mathematics results in “feelings of tension and anxiety that interfere with the manipulation of numbers and solving of mathematical problems in a wide variety of ordinary life and academic situations” (Richardson & Suinn, 1972, p.551). This reluctance towards mathematics evolves from an emotional predicament that affects individual’s intellectual learning. In order to suggest ways in which to overcome or reduce math anxiety, it is important to understand the causes of this phenomenon.
Sources of Math Anxiety

Math anxiety can be caused by several factors. Each student experiencing math anxiety may do so based on different reasons. A review of the literature on this topic presents the causes of math anxiety to be one of two categories: intrinsic, specifically the failure of cognition, or extrinsic, the negative emotion transferred from other people, such as parents and teachers (Sun & Pyzdrowski, 2009).

Anxiety Caused by Intrinsic Factors

This source of math anxiety derives from the poor performance and lack of ability to perform well in mathematics, which generates negative attitudes in students towards the subject (Furner & Duffy, 2002). As presented by Sun & Pyzdrowski (2009), mathematics anxiety is caused by a failure to learn or an inadequate preparation in the mastery of fundamental skills. Looking at attitudes of boys and girls, Tobias (1993) observes that the majority of boys use lack of preparation as an excuse for failure, while girls believe that they are not “smart” in mathematics. These attitudes can be internalized by students, leading to higher levels of math anxiety and lower interest in the subject area. Additionally, if students are not interested or motivated to learn mathematics, they may view their poor performances as an endpoint instead of an area requiring improvement and growth. This self-perception of ability may then result in increased levels of anxiety in students (Clark, 2012).

Anxiety Caused by Extrinsic Factors

Tobias (1993) states that a negative encounter or experience with a mathematics teacher can also contribute to math anxiety. In a literature review of factors causing math anxiety Furner
& Berman (2003) further elaborate and present ways in which teachers and schools can be seen as the perpetuators of math anxiety. They reveal that teachers can impart their fear of mathematics through modeling their own discomfort with the subject. Employing specific teaching strategies such as assigning the same work to all students, working from the textbook problem to problem, discouraging mistakes, assigning math problems as punishment, lack of exposure to everyday application of taught material and excessive amounts of time spent relearning can all contribute towards negative attitudes regarding mathematics (Furner & Berman, 2003).

Familial influences from parents who expect their children, typically their daughters, to have a natural inability in mathematics (Tobias, 1993) can also foster negative emotions in the form of pressure received from parents. Parents like teachers, may also impart their negative attitude towards, or limited experience with mathematics to their child (Scarpello, 2007).

**Suggested Strategies for Teachers to Reduce Math Anxiety**

The literature offers various strategies that educators can use in their classrooms to help students develop positive attitudes toward mathematics and overcome anxiety related to this subject. Similar to the effective teaching practice in other subjects, mathematics too requires opportunities for collaborative learning (Tobias, 1993). Teachers can engage students in interactive mathematic activities which foster positive attitudes about numeracy and encourage students to collaborate and support each other in their learning (Tobias, 1993). This can help reduce math anxiety in students as it alleviates the desire for competition and instead promotes cooperation and collaboration in the learning process.
Math anxiety can also be reduced by encouraging students to express their feelings about mathematics by writing in journals and creating “math stories” (Hackworth, 1992; Tobias 1993). Hackworth (1992) recommends encouraging students to develop calming, positive ways to deal with fear of mathematics through visualizations, positive messages, relaxation techniques and “frustration breaks”. Allowing students the opportunity to explore their feelings about mathematics in a safe environment helps them cope with their negative attitudes towards this subject (Tobias, 1993). The teacher can then address issues regarding the apprehension towards mathematics on an individual basis by tailoring his or her instruction for each student.

Effective strategies to help students suffering from math anxiety can be adopted by teachers as they familiarize themselves with sound pedagogy and good mathematics instruction. First and foremost, a teacher needs to be aware of the diversity in learning styles and needs within a classroom. The teaching needs to be catered to a wide variety of learning styles and accommodate differentiations accordingly. In doing so, teachers realize the strengths and weaknesses of their students and can then engage in differentiated instruction. This allows a teacher to accommodate for different levels of readiness, varied interests and learning styles (Tomlinson, 1999). This practice of differentiating instruction supports student success and furthers their academic growth (Landrum & McDuffie, 2010).

Teachers can also make mathematics relevant to students by bringing real world examples of mathematical concepts into the classrooms. This allows students to relate to the traditional mathematical processes in a less intimidating manner which helps reduce anxiety (Stuart, 2000). This has been noted to be effective in helping students understand mathematic content as well as ease high levels of math anxiety. Teachers are also encouraged to present new mathematical concepts in a way that allows the students to make connections with their prior
knowledge and experiences (Furner & Duffy, 2002). The use of manipulatives to represent symbolic mathematical ideas is also promoted (Sun & Pyzdrowski, 2009).

As is evident from the above, there are numerous strategies that have been recommended to teachers for utilization in their classrooms to reduce math anxiety for their students. However, math anxiety continues to be an issue of concern in mathematics education. As many as 2 million children are believed to be affected by math anxiety as cited in The Guardian (Brian, 2012). One additional strategy that may alleviate math anxiety is the implementation of technology in the classrooms. This study therefore specifically focuses on the uses of technology to help alleviate math anxiety in elementary students.

**Technology: What does this mean?**

In the 21st century technology is everywhere. It can be found in our homes, our communities and also in our schools. Technology refers to a multitude of ideas. The term technology in this study refers to the technological tools used by teachers to promote, support and extend student learning in the mathematics classroom. The technology discussed in this study includes interactive whiteboards, student response systems, and mobile learning through tablets, iPads and laptops, as well as, Web 2.0s encompassing project-based activities and online problem solving challenges. More generally, it encompasses computer software and Internet applications used by teachers to support instruction and student learning. These technological tools can be used in a myriad of ways; visualizing and modeling concepts, presenting and solving critical thinking challenges, reaching different types of learners, assessing student knowledge and understanding and most importantly motivating students to learn mathematics (Sun & Pyzdrowski, 2009).
Use of Technology in the Classroom

Integration of technology into the classroom is encouraged by researchers and educators (Macdonald, 1999; Long, 2013; Boles, 2012; Roschelle et al., 2000; “Technology for Teaching”, 2011). The current generation of students is what Prensky (2001) refers to as “digital natives”. These students have grown up in a society that is grounded in and values technology. Predominantly, this generation is proficient in using the technological devices available (Prensky, 2001). Therefore, teachers need to make their learning relevant by incorporating technology into the classroom. According to John Schacter and Cheryl Fagnano (1999) students in technology-rich environments experience positive effects on achievement in all major subject areas. They also found that students in such settings demonstrated increased achievement in preschool through higher education, and their attitudes toward learning improved consistently when computers were used for instruction (Schacter & Fagnanos, 1999). Roschelle et al. (2000) cited research indicating computer technologies can help support learning, and are especially useful in developing the higher-order skills of critical thinking and analysis (p. 76). They presented research stating learning to be most successful with the presence of four key characteristics: (1) active engagement, (2) participation in groups, (3) frequent interaction and feedback, and (4) connections to real world contexts (Roschelle et al., 2000, p. 79).

Seeing that students learn best when they are actively involved with study material, as opposed to passive learning, it is understandable that technology, when used in an interactive way, is a beneficial tool for learning. Sarah Davis (2011), a researcher and an educator of mathematics focuses mainly on the “networked classroom technology” aimed at transforming the classroom into a dynamic environment supporting discussion of mathematical ideas and concepts (“Technology for Teaching”, 2011). She is an advocate for technology use in the class, offering...
powerful methods for teachers to enhance mathematical understanding (“Technology for Teaching”, 2011, p. 6). It not only engages students but also provides opportunities for them to control their learning in their practices and discussions (Sun & Pyzdrowski, 2009; “Technology for Teaching”, 2011). Roschelle et al. (2000) furthers this notion stating “students who participate in computer-connected learning networks show increased motivation, a deeper understanding of concepts, and an increased willingness to tackle difficult questions” (p. 81). As a result, the integration of technological tools to serve purposeful and meaningful teaching can have positive effects on our students’ learning and thus its adoption should be promoted in classrooms.

The Use of Technology to Support Math Learning

Merrilyn Goos (2010) indicates three core ways that teachers can use technology to support numeracy in their classrooms. First, teachers can set tasks for students (using technology to improve speed, accuracy, access to a variety of mathematical representations). Secondly, it can be used to foster classroom interactions (using technology to improve the display of mathematical solution processes and support students’ collaborative work). Lastly, technology can be used to teach the subject by supporting new goals or teaching methods within the mathematics classroom.

The current generation of students as a whole, particularly in developed countries, has more opportunities to engage with technology. This can present them with opportunities to develop proficiency using technology for learning purposes, making them feel at ease when exploring new mathematical concepts (Prensky, 2001). Technology is also engaging, exciting
and motivating for students who fear the anxiousness that traditional paper and pencil based methods produce (Schacter & Fagnano, 1999).

This engagement piece leading to a change in student attitudes is seen to be essential by many educators (“Technology for Teaching”, 2011; Roschelle et al., 2000). Once students are engaged teachers can rely on their professional skills to create authentic learning experiences, making it easier to stress important concepts like critical thinking. A researcher quoted in the Research within Reach magazine “Technology for Teaching and Learning” (2011) article believes that providing students with the opportunities to interact online changes classroom culture. It creates a shift where students move from working independently to solve problems to one that is built upon collaboration and discussion amongst students to deepen their thinking about mathematical concepts (“Technology for Teaching”, 2011). This goes beyond the confines of the classroom and can in fact entail “simultaneous learning and sharing of knowledge across borders and continents” (Roscelle et al., 2000, p. 84). It can provide students with a tool to apply concepts in a variety of contexts, breaking the “artificial isolation” of school subject matters from real-world situations (Roschelle et al., 2000, p. 82). This allows students to see the value of a subject like mathematics and how it applies to their lives outside the classroom. It then becomes a subject that may seem more useful and relevant to students who are anxious or fearful of mathematics.

As well, various technological tools can be incorporated by mathematics teachers to investigate and analyze mathematical concepts, communicate understanding, assess student knowledge, engage students in active learning, encourage critical thinking skills and offer richer environments for learning (Sun & Pyzdrowski, 2009). It can also be used in the mathematics classroom to support learning by providing visual representations of abstract concepts such as
three-dimensional objects, allowing students to focus on their thinking (Schacter & Fagnano, 1999).

On the other hand, it is important to bear in mind that using technology to make learning easier, efficient and motivating is not sufficient. It needs to add value to the lessons and in order for it to support mathematics learning it needs to be purposeful in nature (“Technology for Teaching”, 2011). Schacter & Fagnano (1999) argue that “ease and efficiency should not be the leading criteria for advocating and implementing computer technology in schools” (p. 330). They emphasize that to produce meaningful learning experiences for students, computer technologies used need to be educational and grounded in sound learning pedagogy. To further this notion, Goos (2010) cites an argument presented by Olive and Makar in the 17th ICMI Study on Mathematics Education and Technology claiming, “if one considers mathematics to be a fixed body of knowledge to be learned, then the role of technology in this process would be primarily that of an efficiency tool, i.e., helping the learner to do the mathematics more efficiently. However, if we consider the technological tools as providing access to new understandings of relations, processes, and purposes, then the role of technology relates to a conceptual construction kit” (p. 68). This can present our students with more powerful learning experiences and enable them to develop a deeper understanding of mathematics that they can then add and build upon.

Keeping this in mind, Davis in the magazine article titled, “Technology for Teaching and Learning” (2011) states, “while the technology may be new, the goal of learning really hasn’t changed” (p. 7). Teachers need to ensure they are not only using technological tools to reiterate traditional teaching practices such as drilling and repeated practicing when they employ technology in their classrooms. Instead a call for teachers to change the way they teach is
advocated, so that they can take advantage of the tools available (Roschelle et al., 2000). Several studies speak to this idea of knowing how to integrate technology based on sound pedagogy and learning theories (Schacter & Fagnano, 1999; Crisan, 2004; Ha, 2008). They also encourage teachers to make informed judgements regarding the tools they use in their classroom to ensure they are best suited to enhance student learning and achievement (Schacter & Fagnano, 1999).

The Use of Technology to Reduce Math Anxiety

Before delving into the benefits of technology in the math classroom, it is important to recognize that students who are unfamiliar with technology may in fact experience greater anxiety than their counterparts (Sun & Pyzdrowski, 2009). Although this phenomenon will be overlooked in this study, it is a noteworthy one to consider for future studies.

Having explored the topic of math anxiety and the various factors contributing towards it, it is reasonable to say that there is no “one-size-fits-all” approach to overcoming anxiety. Teachers need to cater to the diverse students in their classrooms and they need to do so by incorporating a multitude of tools, techniques and strategies into their teaching. According to Furner & Duffy (2002) integrating technology in the classroom can help reduce math anxiety. It can enhance students’ learning ability and overcome the anxiety caused by the cognitive failure (Sun & Pyzdrowski, 2009).

Integration of technology can thus change the nature of school mathematics. From the traditional educational practices of rote memorization, paper and pencil methods and no differentiation, to one that engages students in more active mathematical practices. It individualizes the education processes to accommodate the diverse needs, interests and learning styles of the students, and uses a collaborative approach to increase student engagement and
stimulate receptive learning by students. Teachers can employ techniques such as experimenting, investigating and problem solving that bring depth to student learning and encourage them to ask questions rather than only look for answers (Goose, 2010). Using technology in mathematics instruction can thus help reduce math anxiety, when used in a meaningful manner by teachers.

Teachers can use technology to enforce fundamental skills and concepts, assisting in strengthening student cognition (Sun & Pyzdrowski, 2009). Online forums and discussions present students with an opportunity to express their feelings and attitudes regarding numeracy, which helps relieve anxiety as noted by Hackworth (1992). The use of websites and software programs to provide virtual manipulatives and hands-on activities, easy access to resources, quick retrieval of information and presentation of multiple strategies and solutions can be used by teachers, students and parents to inform their understanding about concepts. This can help lessen anxiety which transpires from external factors such as familiar influences contributing to mathematics anxiety in students (Sun & Pyzdrowski, 2009).

The literature review conducted has informed this study and has helped to provide insights into the factors causing math anxiety and what strategies can be employed to help alleviate such negative emotions in students. This research focuses on the teachers’ perceptions of the use of technology as a tool in combating math anxiety. It highlights teachers’ views and attitudes towards the effectiveness of incorporating technology to support math teaching and learning in the classroom, specifically focusing on students suffering from math anxiety in Ontario schools.
Chapter 3: METHODOLOGY

Procedure

This research study has adopted a qualitative approach. It involved a comprehensive literature review on the topic, a professional journal of observations, and interviews conducted with three experienced elementary teachers. These three sources provided insights into the use of technological strategies teachers practice in their classrooms in hopes to help alleviate math anxiety for their students. An in-depth analysis of the data collected from these sources was then conducted, followed by a summary of the findings and a discussion on the topic, which are presented in this paper.

Instruments of Data Collection:

This research has been informed by three key instruments of data collection. First, the research was grounded in a literature search, which was conducted prior to primary data collection, using the following databases ERIC, CBCA, Google Scholar and Summon (a University of Toronto database). This search was conducted to gain knowledge of factors causing math anxiety and how technology can be used within the classrooms to alleviate such tensions. General themes were explored in the literature review and used as reference when comparing the findings from the interviews. This literature search forms the basis of this study. Relevant sources of information include academic articles, government reports, opinion pieces, and professional development literature. Sources considered ideal were peer-reviewed, no more than ten years old, and focused on the integration of technology in mathematics.

A professional journal of personal observations was also used to supplement research. These notes came from practicum placements in a grade four, grade six and grade two
elementary classrooms, where the researcher was able to immerse in the environment under study. The information gained here allowed the researcher to observe, explore and further inform the research topic within context, while triangulating data. These notes are referenced in the analysis of data collected from the interviews.

The third component, and the primary method of data collection, was through formal face-to-face semi-structured interviews of three elementary teachers. According to Turner (2010), “interviews provide in-depth information pertaining to participants’ experiences and viewpoints of a particular topic”, (p. 754). Hence, the interviews were focused on the personal experiences of three selected teachers and the technological strategies they incorporated in their classrooms to help reduce math anxiety.

The interviewer was given a paper-based interview guide with some core questions that were going to be addressed. The interview was conducted with a fairly open framework which allowed for focused conversational two-way communication. This allowed both the interviewer and the respondent the flexibility to probe for details or discuss issues in further detail where needed (Turner, 2010). The interview started with more general questions and gradually through discussion narrowed down to more specific inquiries. See Appendix A for a full list of interview questions.

The interviews were tape-recorded and later transcribed for analysis. According to Turner, “…interviews coupled with other forms of data collection provide the researcher with a well-rounded collection of information for analysis” (p. 754). Therefore, the interview transcripts were used to analyze the data provided in conjunction with the data collected through the literature reviews and personal observations. The analysis of all data collected is presented in this paper.
Participants

To maintain a focused and constructive foundation for the research, participants were selected based on a specified criterion: elementary teachers who were aware of the issue of math anxiety and actively working towards solutions in his or her classroom using technology were approached and asked to participate in interviews. Selecting to interview primary and junior mathematics teachers of grade three and four was pertinent to this study. Research reveals that math anxiety tends to surface in these grades, if not sooner (Jackson & Leffingwell, 1999).

Three participants were chosen all of whom taught mathematics as a core subject and integrated technology into their lessons on a daily basis. The first participant, Sabrina, has been teaching math for 10 years as a homeroom teacher. In the last two years, the school decided to switch teaching the Geometry and Spatial Sense strand of the curriculum from using the traditional paper and pencil method, to employing a more technology oriented approach. Sabrina’s classroom is unique in nature as she teaches all grades 1-6, the Geometry and Spatial Sense strand of mathematics using technology (mainly computers and iPads). She focuses on creating an entirely paperless classroom, meaning all learning takes place on an online Google Docs platform set up by the teacher. Here she is able to provide students with opportunities to access manipulatives, websites, video lessons online and engage students in collaborative learning that can be accessed from outside the confines of the classroom. She defines math anxiety as “students coming into a math classroom having a negative attitude” and consciously tries to support these students using several strategies.

The second participant, Jennifer, teaches grade 3 and has been teaching mathematics for 5 years as a homeroom teacher. She incorporates the Promethean board, iPads, Laptops and other online websites/programs to support mathematics learning in her classroom. She defines math
anxiety as “something that manifests itself both in physical reaction, avoidance of task or looking for help, reluctance or aversion to do math”.

The third participant, Harriet, teaches grade 2 and has been teaching numeracy for a total of 4 years as a homeroom teacher. She primarily uses the Promethean board, iPads, web 2.0 and flip-video cameras to engage and enhance student learning in the mathematics classroom. She describes math anxiety as “a fear of math…lack of participation based on negative emotions associated with the subject”.

All participants provided insight into their experiences as teachers of mathematics and their perceptions of the effects of incorporating technology to support math anxious students. Examining the various strategies these teachers employed, shed light into the effectiveness of technology as a solution to math anxiety.

Data Collection and Analysis

Data collected during the interview was audio recorded and later transcribed verbatim. This data collected was organized into a chart for in-depth analysis; placing the question at the top, the key points and responses provided by the participants were compiled in columns below. This structure facilitated the analysis by providing an opportunity to examine and explore the data in a controlled and methodical way.

Analyzing data by highlighting, color coding, and sorting data into categories, and reviewing the records thoroughly and repeatedly, allowed the researcher to compare the responses of the participants, assisting in uncovering common themes. This process required numerous revisions and “continuous refinement” of data before looking at the “big picture” (Wellington, 2000). “Contrasts, paradoxes and irregularities” within the data were brought to
surface, helping triangulate the data with the literature review, and substantiating the themes found. The important thing to remember is that in Qualitative Data Analysis, one might not always get the full picture or a solution to the research question. Instead it tends to identify further questions and areas of exploration.

As a result of this rigorous process, connections were made between each participant’s responses and key findings were identified based on the following themes: technology implementation, the challenges of its application, and its impact on student math anxiety all of which will be presented here.

**Ethical Review Procedures**

This study followed the ethical review approval procedures for the Master of Teaching program. Participants were recruited on a voluntary basis. A letter of consent was prepared and reviewed with the participant prior to the interview stage (see Appendix B for a copy of the Informed Letter of Consent). This letter outlined information regarding the data collection process, how the data will be used and the confidentiality of the information provided. The letter was signed and a copy was kept by both the participant and the researcher. Any questions posed by the participants relating to the research topic or the interview process were timely addressed, ensuring a safe and comfortable environment for all participants.

During the interview and observation process, full efforts were made to ensure participants comfort and willingness to participant. The participants were ensured that there was no right or wrong answer and that the purpose of the study was to gain knowledge about their experiences and observations within the classroom regarding the use of technology and its effects on students who may be math anxious. The participants were also informed of their right
to skip or refrain from answering a question, and/or returning to any of the questions or issues discussed at any point in the interview. Furthermore, the participants had the right to exclude any data he or she did not want used. The participants were also made aware that the research supervisor will be the only other party who will have access to the raw data before the completion of the research study. The raw data was stored safely on a computer with restricted access. The concept of confidentiality was reiterated to ensure full willingness of the participant to partake in the study.

The information presented here reflects the anonymity of the participants along with any students’ names that may have been referred to during the interviews through the use of pseudonyms. The data collected is used specifically for research purposes and to inform the topic under study.

**Limitations**

Like all studies, the research presented here has limitations. Firstly, the literature review is selective given the time constraints and the requirements of the Master’s program. Therefore, there are some research areas that might have been overlooked in the process. However, the articles, journals and books referenced are relevant to the topic under study, and offer an overview of important emergent themes in the literature discussing the use of technology to alleviate math anxiety. This shortcoming can be justified however, as the selective nature of the research makes the study more focused.

Secondly, I recognize that the sample size is limited in scope. Interviewing more participants would offer a more comprehensive perspective, however once again, due to the structure and the time constraints present, interviewing fewer participants was deemed expedient. The three participants interviewed presented their personal views on the topic being analyzed for
the purpose of the study in order to gain a subjective and focused perspective. Taking this limitation into account, it can then be asserted that this constraint opens up avenues for future researchers wanting to explore this topic and gaining a more comprehensive understanding of the subject in the future.
Chapter 4: Findings

The chapter will highlight and discuss the key findings from each of the three interviews conducted. All interviewees had experience dealing with students suffering from math anxiety and integrating technology into the mathematics classroom at the primary and junior levels. They offered valuable insights based on their professional experiences and education, which will be explored in this chapter.

Technology Implementation: how teachers are using technology in their classroom to support math learning

During the interviews all three teachers mentioned that they use various technological tools such as the computer, Web 2.0, social media, applications etc, to gather and have access to useful resources which they then incorporate in their lessons to teach particular mathematical concepts. These resources included but are not limited to online manipulatives, websites, video lessons, cameras, mathematical software programs etc.

Two of the teachers viewed technology as a peripheral part of their classrooms. They referred to utilizing technology as an “add-on” to their lesson, a means to get the students more interested and engaged, to assess their understanding, and not as the primary mode of lesson delivery. Harriet mentioned using flip-video cameras as well as the camera and video feature on an iPad as an assessment tool. Getting students to take pictures of their work, record their problem solving procedures helped her review and assess student understanding even after students had left the classroom. She also found great value in using applications on the iPads to have students practice basic numeracy skills. Jennifer added to this by referring to the use of
games for quick recall and drilling practices. She stated, “You know, that has its place in terms of different ways of having better automaticity...it helps students when they are working on more complex problems”. This view complements those of Sun and Pyzdrowski (2009) who emphasize the importance of incorporating technology for a variety of purposes including but not limited to drilling practices and quick recall games.

On the other hand, Sabrina’s mathematics lessons which focus primarily on the Geometry and Spatial Sense strand are solely based on a technological approach, entailing a unique “paperless” classroom. She supported this idea by describing technology as “...another tool that offers resources. It’s the kind of age you are living in now. Our students have a lot of access to resources and tech and they should be accustomed to accessing these resources.” She therefore tries to limit the “paper pencil method” of doing mathematics and justifies engaging in online learning based on inquiry and student collaboration. Like Heather and Jennifer, she too sees it as a valuable resource and addition to the learning that takes place within the mathematics classroom. She uses technology as a resource to support mathematical concepts being taught in class and from home:

“Video lessons are great and there are tons of them online...it reinforces learning. Sometimes I show videos and they can revisit these...a hundred times if they have to (even from home)...if they don’t get it. Then there’s always a follow up activity which shows me if they have understood or need further assistance with the material.”

Jennifer shares this view of technology as a tool that complements and supplements student learning outside the classroom, “…I suggest to parents that BBCkids has really good math games so that is one thing I would keep in mind for certain students to recommend for home...engaging with concepts in a playful way and in their own time.” Having access to these resources allows students to practice and exercise skills at their own level and at a pace that best
suit them. This can help alleviate pressures that some students may encounter within the classroom as they begin to compare their progress, speed and accuracy with classmates. Jennifer therefore finds herself advocating parents to recognize the usefulness of mathematical games and applications.

Without exception, all three participants acknowledged and praised the increased levels of student engagement and motivation brought about by the integration of technology in the math classroom. This finding was not a surprise. It, in fact, echoed the claims made by various researchers who have explored the integration of technology in the classroom (Schacter & Fagnano, 1999; Sun & Pyzdrowski, 2009; “Technology for Teaching”, 2011). Like them, the participants of the study, all strongly believed that incorporating technology in the classroom motivates students to actively engage in their learning. Jennifer for example noted the following on the use of technology:

“It engages them [students] more, sort of more immediately or obviously. Like iPads are coming out, laptops are out, whiteboard is turned on and the students are so much more quieter...ready to listen... it grabs them in more.”

She continues to say that although it engages students, she is unsure of whether it directly affects their thinking of the material being studied,

“...does it actually engage their thinking more than working on some kind of problem and inquiry piece in a more hands on way?...I think not necessarily...Which is why I think it’s important to have both...”

It is interesting to note that Sun and Pydrowski (2009) consider technology to engage students in a way that presents them with opportunities to control their learning in their practices and discussions. This, they feel, engages their thinking and thus contributes to better understanding of mathematical concepts (p.334).
Harriet spoke about the importance of “hooking” the students by utilizing something that they are familiar with in their daily lives: bringing it in to the classroom sparks interest in the subject being studied. She described technology, “as a gimmick. It’s more fun; they can work on and incorporate different features... It’s all about how you hook the students in.” This brings to light the question of whether students are more interested in learning mathematics or in the technology being used. If they are more interested in using technology they might consequently be more inclined to engage with the concepts being explored.

With the integration of technology Sabrina also found a decrease in discipline issues. She described technology to be “part of the equation”. Seeing as she teaches the geometry and spatial sense strand, she was of the opinion that “it’s a fun strand to ever have to teach. A lot of exploration so can’t go wrong.” She found her students’ attitude was positive as well, claiming “A lot of students say “Ms. W I love your class.” And I think they love that you can do math differently. Math on computers is not just math games. Computers are a tool, it’s not the silver bullet it’s not the be all and end all.” Although all three teachers see the value and advantages of incorporating technology in the classroom, they also take into account the importance of providing students with opportunities to collaborate in person, gain hands on experience with manipulatives, talk and write about what they are learning etc.

In terms of specific strategies or tools used in the classroom in regards to technology, all three teachers interviewed talked about the change in the way we teach mathematics. They spoke of learning mathematics by providing students with relatable meaningful experiences, of which, communication and collaboration were the cornerstones. Harriet opined:

“It’s the social aspect you know...in math we are talking more, partners and collaboration and social interaction that aids student learning. Kids love talking and sharing ideas and so that too has a positive influence. I think more than anything it is the shift in the way we are approaching teaching.”
More specifically by communication and collaboration the interviewees suggested encouraging students to express their ideas and understandings, sharing their knowledge with their peers, and working together to discuss different ways of analyzing and problem solving (Roschelle et al., 2000). In “Technology for Teaching and Learning” (2011) Dr. Cheah Horn Mun, Director of the Educational Technology Division at the Ministry of Education in Singapore is quoted supporting this shift in teaching professing, “I can fundamentally change the way in which teaching and learning interactions take place in ways that I cannot do so without the support or use of technology” (p. 1). Mr. Steven Wong, a Head ICT teacher at a Secondary School in Singapore, further acknowledges this idea: “technology actually gives students and teachers a different taste of learning- a more holistic type of learning. They can do more in the virtual world and thus expand beyond the linear way of thinking” (“Technology for Teaching”, 2011, p. 8). He therefore advocates for “balanced learning environment”. One where collaboration and communication take place side by side facilitated in person as well as online.

Sabrina used ‘Google Docs’ as the classroom “hub”. This was designated as the digital intersection of student work, student communication, sharing of resources and knowledge building. It not only provided a forum through which she was able to communicate with students providing them with inquiry-based tasks, such as problem solving questions and video lessons, it also served as a communication tool amongst students and between the teacher and students. It served as an avenue through which they could interact in meaningful and authentic ways with each other. Sabrina posed,

“Collaboration’s...a big piece. Letting them work in groups...working with friends helps. Some people will say that they aren’t doing their work, but I feel they are increasing their knowledge even if they are at the point of “I’m not sure if a triangle has 2 sides, to I am sure a triangle has three sides.” Then you have increased your learning. I’ll evaluate you on what you have understood and learned from that work.”
It also communicated their growth since she was able to track their progress as they completed their tasks online,

“...because I give them a Google Doc... I have a spreadsheet to show me who answered what and how and I can then compare it to how they answered after they went through their learning process.”

Sabrina furthered this discussion by talking about setting up “math blogs” in which she encouraged students to talk or write about their learning. This was another feature she found useful in communicating of student understanding. She used blogs as an instructional tool to have students write and express their mathematical ideas. It was a place for students to voice their questions, share their insights, and was seen as a discussion place for mathematical thinking and communication.

On the other hand, Harriet and Jennifer saw technology as a tool that assisted and facilitated students in demonstrating their methodology, understanding and knowledge to the class. Harriet expressed,

“The video is good because they can solve a problem and then demonstrate the procedure with their partner…say they come up to explain and they don’t remember how they started, it’s hard and can be embarrassing. But with the video, it’s right there and helps them reinforce and jog their memory. This way we also get to watch each other’s work and students feel involved and are more likely to take ownership of their work.”

She elaborated,

“They can share what they know with the class and this way they get to see 10 different solutions and ideas...something that may work for one group may not be the same way the other group solved a problem. It shows them there are different solutions, and answers. Not just one way...which makes it more fun!”
When expanding on this discussion, concerning the strategies and tools Jennifer used in her mathematics program, she emphasized the benefits of incorporating the Promethean Board by revealing, “one really great thing about interactive whiteboard that makes it different from a piece of paper or blackboard is how you can save, print and go back to things that the students have annotated on the screens”. This she articulated, leaves you with “snap shots of thinking through time” and can therefore be used to review and demonstrate different strategies of how to solve mathematical problems. This she found helped scaffold certain concepts for students, which she capitalized on by allowing students to engage in peer teaching encouraging them to collaborate, communicate and consequently expand their thinking. This aligns with the research presented by Roschelle et al., (2000) claiming “teachers can focus less on memorizing facts and performing routine calculations and more on developing ideas, exploring consequences, justifying solutions, and understanding connections, all of which are at the heart of mathematics” (p. 3). For the aforementioned reasons the Promethean Board was deemed constructive in student learning of mathematics. All three teachers saw technology, in some capacity or another, as a positive asset, needing to be explored and incorporated into the mathematics classroom more frequently.

**Impact on Student Math Anxiety**

The teachers viewed math anxiety as any behavior that negatively impacted a normal use of numeracy or mathematical skill or detracts from the learning of new skills. An *emotional reaction* preventing learning of mathematics skills is therefore considered math anxiety. Jennifer saw it as, “something that manifests itself both in physical reaction, avoidance of task, looking for help, reluctance and aversion to math.” All three teachers saw it as negative attitude rooting in a consistent reaction of worry, apprehension, or nervousness when learning and engaging in
numeracy and mathematics. Their definitions aligned entirely with those outlined by Tobias (1993) and Fiore (1999) in the literature review.

When asked to explain the different factors perceived to contribute towards math anxiety, all three participants agreed that self-perception played a significant role (Clark, 2012). Jennifer said students thinking that, “everybody’s faster than me at doing this”, or, “people are understanding and I don’t”, brings about a sense of fear or nervousness which can contribute towards increased anxiety in the mathematics classroom. She noted that this attitude “causes students to early on have these labels that make them think “I’m not good at it, so why bother””. Harriet had similar thoughts to share, “It’s like any other subject, if you feel like you haven’t or aren’t experiencing success in it, or if you feel like other people around you are able to find the answer quicker or faster than you, then you develop this negative attitude and self-perception.” This attitude is then further damaged as the student encounters a lack of success in comparison to others in the class.

Jennifer was the only participant that mentioned the importance of a student’s family as a source of anxiety. She expressed, “I have chatted with parents about siblings who are the same way...somehow they have developed a sort of math anxiety that has translated to younger siblings or the opposite. Things are a breeze for them and then the younger sibling feels like why isn’t this coming so easily to me.” This too corresponded to the self-perception of the student in comparison to their sibling at home. This finding, although demonstrating that families can impart anxiety onto the student, also reveals that unlike Tobias’s (1993) view of parents pressuring their child, imparting their own anxieties and negative attitudes, or expecting their daughters to perform poorly in mathematics, was not applicable (Scarpello, 2007). It was more-so the idea of comparing performance levels amongst siblings that she found to be of an issue.
Such negative attitudes and self-perceptions gradually accumulate and contribute towards the students’ negative experiences relating to mathematics (Clarke, 2012). Sabrina spoke of this impact of students’ prior experiences which paralleled what Jennifer and Harriet mentioned in their interviews: “their previous experiences...it’s hard to say what those might have been but different things that didn’t work for them maybe” can be seen as a factor contributing to math anxiety. Here, the core issue is that there is an emotionally-based negative feeling that interferes with the cognitive function of learning. This may indicate that students internalize their repetitive failures in math and conclude that their efforts will not result in success. Harriet declared, “People do not like the feelings associated with failure or limited success” and this can play a role in our students’ learning in the mathematics classroom.

In terms of gender, Harriet did not find any differences in levels of math anxiety, “My class is representative of both boys and girls (10 boys, 10 girls). And I can say that it is pretty equal and goes both ways. Not one sided doing better or worse than the other.” Jennifer also reiterated this lack of difference saying, “Gender hasn’t played a role which is really good.”

For Sabrina, anxiety is more apparent in younger grades: “... you notice it more in the younger grades because they are more open. You have some students who get really frustrated and you can see this visibly, like panting, banging the table with their books etc...” Some of the other behaviors of students suffering from math anxiety that the teachers described were:

a. Avoidance of task and avoidance of participation

b. Verbal remarks and negative self-perception, (“math is difficult”, “I’m not good at math” etc)

c. Self-given labels (“I’m stupid”)

d. Looking for help and seeming unfocused
e. Acting out in the classroom

f. Students not advocating for themselves

A common thread between all three interviews was that all the teachers generally had positive experiences teaching mathematics and their perceptions of student learning experiences were predominantly positive as well. As per Harriet,

“I actually find that kids love math...if we ask our students now, they would say that this is something they look forward to the most in the day...this might have to do with the shift in the way we teach, we have moved away from rote style of teaching math, where you were given a formula, and if you didn’t understand what was going on, you were left behind.”

This change in teaching, from rote to a more social constructivist learning approach, was evident in the responses provided by Sabrina and Jennifer as well (Goos, 2010). In their classes, all three teachers encouraged and participated in learning based on inquiry and problem solving. They promoted the idea of collaboration with peers, oral and written communication as key to explaining their process and consolidating understanding of concepts, relating their learning to life experiences, etc. Harriet was of the opinion that,

“As teachers we are always looking for kids to show us their understanding. When you change what you are emphasizing and that is more about, “we have this problem and there are 12 different ways to solve it”, it’s open and leaves them with the opportunity to explore for themselves. This shift in math and the way we approach it, the kids start to see that there are a lot of different ways we can access this information. Now, if you say there is ONE answer but 12 different ways to get to it, it takes some of the anxiety away and this doesn’t affect technology or the use of it.”

Jennifer shed light into the importance of differentiating instruction and planning the mathematics program based on the interests and needs of her students. She spoke about incorporating an online mathematics software program called ‘Mathletics’. According to Jennifer this program has helped her, “…monitor the progress of each student by viewing everything. It’s
something worthwhile doing, something fun... people are doing it across the world and the fact that you can get better was the message of it.” As the teacher she highlighted that, “you can change levels and differentiate it based on the needs and abilities of your students” and this makes it extremely beneficial in the classroom. The value placed upon integrating a variety of tools to cater for the different learning styles and multiple intelligences was deemed important in this new approach to teaching and learning by all teachers. This individualization of education catering to the diversity present within our schools allows teachers to plan in ways that better accommodate the diverse needs, interests, learning styles, and differing levels of math knowledge (Goos, 2012). This takes away the demands placed on students when teaching is catered to the “average student”.

This change in pedagogy also highlighted the significance of teacher knowledge and understanding of how to integrate and best plan lessons with technology as a central component. All teachers mentioned that if a teacher’s knowledge of a technology’s affordances is limited, then that would affect the learning with that technology (Schacter & Fagnano, 1999). Sabrina mentioned “...the incorporation of technology in the math classroom is not simply enough...” A teacher needs to have the appropriate “know-how” and effective reasoning for bringing in technology. It is only when the teacher truly understands and appreciates the value that technology can add in the classroom, that it begins to give results.

What then can teachers do to help students with math anxiety? During the interviews all three teachers spoke about creating positive experiences for students in their mathematics classrooms as a way to overcome math anxiety. At different points of the interview each teacher mentioned the importance of motivating students and providing them with meaningful experiences that engage their interest and encourage them to be invested in the learning process.
In an attempt to counter the negative attitudes and self-perceptions of students with math anxiety, all three teachers spoke about the importance of two factors. (1) Creating a safe space and (2) Positive reinforcements. The first entails setting the tone at the beginning of the year. Sabrina believed in informing students at the start “we are all here to learn and no one is better than anyone else”. She continued “not picking on students or putting them on the spot” is of importance in fostering positive experiences for all students. Jennifer agreed suggesting praising students for the things they have done right helps build their self-esteem. The second factor involves the idea of celebrating progress. In Jennifer’s words,

“A big thing that is really important is celebrating progress. Not just in math, but in all areas. Rather than looking at end results, and if someone answered the question perfectly, saying this is something that you’ve been working hard on. Look at what you did today, and looking back at what they thought at the beginning and really trying not to compare with other people but to look at themselves.”

The importance of getting to know students and structuring lessons and the mathematics program based on their interests, needs and abilities was another strategy shared. Sabrina recognized “each child is different and comes to the class with a different collection of experiences that have made them”. She was of the opinion that it is therefore the responsibility of the teacher to identify the nature of the anxiety; whether it is learning issues, classroom dynamics, parental influence, language barriers, cultural etc. With this information, “student profiles” were created that allowed teachers to better understand each student. This then allows teachers to design learning activities that are engaging and relevant for their students, leading to quality learning experiences.

Finally, technology they felt provided them with a means to create positive learning experiences that engaged students and effectively combated anxiety. Harriet expressed,
“Any iPad day we have they are excited about it. They have experience with it at home...mom has an iPad etc... Also as I talk to parents, I feel that they are seeing the educational side. They see the value of it and the apps that are there because they use them at school. It can support their learning in the school and at home. It parallels their learning. But the speed factor might add anxiety for some. I feel like a lot of kids pause the game, get the answer, and then continue. They develop other strategies. I am not sure that that is really making them more anxious.”

She elaborated on the importance of reading comprehension in understanding and performing well in mathematics. She claimed, “If you sit down to write a math quiz and you can’t read and understand the question to understand what it is asking you, it becomes less about math and more about reading comprehension.” This she felt added to the anxiety for students suffering math anxiety. Sabrina further expanded on the same issue stating, “I feel a lot of the students who have a hard time with reading comprehension will also have a hard time problem solving.” She expanded, “...there are tools that help students read online. They can get headphones, so that the program can read the questions to them and things like that.”

On the other hand, Jennifer was a teacher who did not consciously think of integrating technology to alleviate math anxiety. Nonetheless, she believed that technology was important to value and utilize in the mathematics classroom. She thought an effective classroom that aimed to present students with positive learning experiences should have “different things going on.” When asked if she thought technology increased anxiety, she answered, “From my perspective, I wouldn’t say it (technology) causes more anxiety. It would be less because it’s something they associate with.” She spoke of using iPads as a tool to work one-on-one with students to build on their understanding. She saw it as something that allowed students to “...play games for recall, quick drills to increase automaticity, and develop specific skills like adding or subtracting while they are having fun and engaged”.

In her classroom she also used it to engage students in “content creation” through applications such as Educreations and Explain Everything. These programs allow students to share their understandings, their processes, and explain their thinking step-by-step. This she felt allowed students to develop their own mathematical identity, giving them flexibility to demonstrate understanding in different ways. Sabrina echoed this idea “I don’t just try to give them a worksheet... I let them bring themselves in... in a way they put their own identity, they put their own stamp on their work and I think that really is good for students because it builds their self-esteem...” It also reinforces the notion that there are more than one way to solve a problem, not forcing students to demonstrate their understanding in one way or another. Jennifer in addition to Sabrina and Harriet deemed these approaches effective in engaging students and consequently lowering anxiety.

For Sabrina, integrating technology also meant providing students with a means to access resources that could help them stay calm, focused, and productive (Hackworth, 1992). She acknowledged, “...they can listen to music to calm them down and/or tune out of what their friends are doing or working on, and really focus on their math.” She also found watching videos and lessons online was valuable. Students could revisit these lessons both, inside and outside the classroom. This she maintained was crucial and extremely useful in helping students repeatedly review and understand material at their own pace, subsequently having a positive effect on reducing anxiety caused by the lack of understanding, pace of learning etc. She also referenced the importance of modelling behaviors to manage negative emotions as a practical strategy to overcome anxiety. Some of these included taking a break, talking to a peer, writing down feelings in a journal, breathing exercises etc.
Another finding was the idea that through technology a subset of students who may normally be hesitant to speak in class and share their ideas or comments with their peers would more comfortably share these in the online environment. The teachers noted that students were less worried about sharing their ideas online than orally in front of their peers. Thus, incorporating technology in the mathematics classroom in a “blended learning” environment presents students who may be anxious, with a way of participating more than they would given a traditional “non-blended” classroom.

**Challenges of Technology Implementation**

Although all the three participants interviewed agreed that technology was beneficial in the math classrooms, there was a general consensus regarding the frustration experienced amongst students and teachers. This frustration was rooted in the technical difficulties that they encounter with the integration of technology. All three teachers saw this as a challenge they are continuously faced with when using technology in their classrooms. According to Sabrina, for students “more of the anxiety also comes from frustration of using the technology sometimes. You know if you are not getting Wi-Fi, or you can’t log on...and that’s where I try to say, “That’s okay, just stay calm and relax”... and... I brainstorm ways to overcome anxiety felt by use of technology failing them”. This coping strategy promoting calming relaxation techniques and “frustration breaks” supports what Hackworth (1993) and Tobias (1993) have suggested in their research as ways to combat the anxiety experienced in classrooms.

Harriet furthers this idea of technological inconsistency stating, “There are always technical difficulties that come with technology. Sometimes it is annoying. You go in and have a great lesson plan, and you press the button and it doesn’t work, the internet can’t connect and the
kids get annoyed. That can be discouraging for teachers especially if you are not well acquainted with it.” Jennifer was of the same opinion and said,

“The question of “is it working”... I have yet to have a Smartboard that has worked consistently. Sometimes you have a lesson and you are so excited but the pen isn’t working, the screen isn’t working, the internet isn’t working or the Wi-Fi so... I mean... I guess as a teacher you still have to have other things up your sleeve...I don’t ever count on only using technology...I think it’s important to have different things going on. But I also think it’s something that stops some teachers to incorporate technology because it’s hard to count on like you would on books, blocks and so forth...”

Regardless of this shortcoming, all teachers advocated for the use of technology in the teaching and learning of mathematics. They stressed the importance of perseverance as one uses such tools to augment teaching programs. Sabrina emphasized, “You have to persevere with it...it is not going to solve all your problems, or every student’s math anxiety problems...see it as something that can augment your program, but it can’t BE your program.” Jennifer concurred with this by affirming, “Don’t let the technology and the inconsistency of it let you get down. Don’t give up and I think it’s important to understand that it is a learning curve.”

All three teachers, acknowledged the frustration that comes with the technical difficulties of using technology, however claimed that in their experiences math anxiety was not evident due to the integration of technology or the teaching strategies in place.
Chapter 5: Discussion

This present study was grounded on the premise that math anxiety is experienced by over 90% of people (Furner & Duffy, 2000), and that technology is an integral part of our students’ lives. This research in the area of investigating teachers’ perceptions of the use of technology to alleviate math anxiety for students in mathematics classrooms has provided new insights and reinforced prior understandings on the topic. The findings of this study conclude that technology can be used in the classroom as a resource, a supplement, a student motivator, a facilitator of communication and collaboration and, as an instrument that offers supports to students suffering from math anxiety. From this, best practices regarding the infusion of technology to support students in elementary mathematic classrooms have been identified which I hope to implement in my own teaching practice. This chapter focuses on my discussion of the findings and professional implications for my practice and that of other mathematics teachers. I conclude by discussing questions that can be explored for further studies in this area.

From the Literature Review and the Findings chapter, I have been able to understand and appreciate the value of integrating technology to support learning for all students in a mathematics classroom. As educators it is important not only to employ varied approaches within classrooms but to actively see and acknowledge the gains presented with the infusion of technology in mathematics instruction. Prior to engaging in a discussion based on the constructive benefits of technological integration, it is important to discuss and validate the importance of understanding and being familiar with pedagogy as highlighted by the participants of this study.
As mentioned by the teachers interviewed, the use and integration of technology in the mathematics classroom is futile without the effective teaching skills. Technology is therefore seen as merely part of the equation. Based on the content being explored in the classrooms, teachers chose the appropriate technology that best supported student learning. All three participants strongly acknowledged the importance of “good pedagogy” stating that simply using technology because it is “new and different”, or to repeatedly drill mathematical concepts and keep students “busy” was not sufficient. This aligns with current literature presented by Schacter and Fagnano, 1999, Crisan, 2004 and Ha, 2008, all of whom place a strong emphasis on the importance of effective mathematics instruction based on pedagogy. Designing meaningful learning activities that presented students with the opportunities to explore mathematical concepts, build on prior knowledge, develop critical thinking and problem solving skills, and cater to student interests through the use of technology was therefore deemed most worthwhile by all three teachers.

Keeping away from the “traditional” teacher-directed approach to teaching, and moving towards a student-centered social constructivist approach was a belief echoed and reiterated by all participants involved in this study. This, they referred to as knowledge building based on the collaboration and communication of mathematical concepts amongst students (Tobias, 1993; Roschelle et al, 2000; Goos, 2010). They therefore perceived technology as having the potential to help students realize that learning mathematics is neither an isolated experience nor best achieved through rote memorization. All three teachers referred to the teaching of mathematics as a blend that calls for engaging experiences that are relevant and meaningful for 21st century students; experiences that are anchored in the developing of logical thinking skills by means of problem solving, inquiry and the sharing of ideas and differing perspectives through the use of
technology. This aligns well with the study presented by Roschelle et al., (2000) focusing on changing how students learn through the use of computer-based technologies. This was further emphasized by the participants of this study as having the potential to foster positive experiences by incorporating different teaching techniques such as infusing technological tools that help support learning, and as a result, alleviate anxiety for some students.

Teachers in the study used various mathematical software programs such as Mathletics, iPads and content creation applications (Educreations and Explain Everything), online games for developing fluency and accuracy, camera and video features of the iPad to document student learning and communicate understanding and problem solving processes. These technological tools were highly regarded by the participants of the study. They perceived them to be educational, relevant and most of all motivating for their students. This idea draws a strong parallel to literature claiming student success to be contingent upon teachers providing students with positive, meaningful and engaging experiences in real-life contexts (Roschelle et al., 2000, Goos, 2010; Sun & Pyzdrowski, 2009).

Consequently, the findings of this study conclude teachers’ to consistently perceive technology as a useful tool to support mathematics learning and combat math anxiety. They viewed the infusion of ICTs as relatable to students, engaging their interests, allowing for differentiated instruction, and offering access to resources that the students could utilize effectively both inside and outside the classroom (Roschelle et al., 2000; Schacter & Fagnano, 1999). This convenience of having access to additional support and resources available online provided supplementary benefits for students of the participants interviewed. Furthermore, technology was found to be most praised for the high levels of engagement in students learning mathematics (Roschelle et al., 2000; Schacter & Fagnano, 1999). It is therefore evident that
integration of technology is considered extremely effective in fostering positive experiences by motivating students and serving as a tool that enhances and supports mathematics learning.

On the other hand, it is important to mention that with the integration of technology, teachers acknowledged the challenges facing educators and students alike. Technical difficulties and student frustrations with these tools were noted. However, these sentiments did not increase anxiety levels for the students as stated by the participants. In fact, the benefits of integrating technology outweighed its shortcomings for these teachers. They cited the importance of incorporating different strategies and having “different things going on” so as not to be entirely dependent on ICTs. The importance of perseverance, “having fun”, and always challenging yourself were all brought forth as teachers talked about technology integration in the mathematics classroom.

From the study, it was concluded that the teachers developed a variety of strategies that they considered effective in helping students cope with math anxiety. It was demonstrated that technology can be incorporated in a multitude of ways. It gives teachers the flexibility to utilize the plethora of resources at hand as a result of having access to various ICTs. These strategies are presented in the following Recommendations section.

To conclude, teachers perceived math anxiety to be at a minimum in their classrooms. This they contributed to the change in pedagogy and the increased integration of technology as a resource, a student motivator, a facilitator of collaboration and communication and as an effective tool combating math anxiety. It was successfully seen to support student learning and therefore a tool that was encouraged to be infused within mathematics instruction in elementary classrooms.
Recommendations

The literature review and the data collected strongly deem technology as having the potential to make math engaging and interesting for students. It can present students with a less intimidating environment, one that they may be more accustomed to or interested in exploring; one that steers away from rote memorization and in fact promotes independent thinking and collaboration, all of which can ease student anxieties and increase student understanding of mathematical concepts.

Compiled here is an extensive list of recommended practices. These summarize some of the effective practical strategies shared by teachers in this study and found to alleviate math anxiety for students in their classroom. It is important to keep in mind that a truly effective teacher needs to have content knowledge and strong pedagogical knowledge of how to infuse technology into their classroom in order to engage students and have a successful mathematics program.

Technological Strategies to Support and Ease Math Anxiety

- Establish a class wiki: hub of the classroom – a digital intersection of student work, student communication, sharing, resource sharing and knowledge building. Allowing for real, collaborative knowledge building.
- Set up “Math Blogs” in which students can talk or write about their learning. This can be a place for long term sharing, storing and seen as a discussion place for mathematical thinking and communication
- Incorporate video lessons and podcasts explaining mathematical concepts reinforcing student learning inside and outside the classroom
- Use the Camera and Video feature on the iPad or a Flip-Video Camera for students to document the procedure used when solving a mathematical problem. Then have them share their solutions with the others encouraging them to learn from each other the idea that one problem can have many different solutions.

- Use the Promethean board to explain mathematical concepts and scaffolding the process step-by-step. Subsequently saving and printing these pages gives one snapshots of thinking through time, allowing students and teachers to assess their progress.

- Draw on iPads for content creation using applications such as Educreations and Explain Everything. This gives students ownership of their work and encourages them to explain and demonstrate their understanding.

- iPads can also be used to play games for recall and quick drills to increase automaticity and building on specific skills like adding, subtract etc

- Incorporate Mathletics (a mathematics software program) where students create their own accounts and engage in solving mathematical problems building on their previous knowledge and understanding. It helps differentiate levels based on individual students needs and abilities and allows students to connect with others around the world

- Incorporate reading software programs that can help students read problems online, taking away the burden of deciphering words and focus on the reading of problems. Instead it lets students engage with the math problems at hand

- Allow students to listen to music and wear headphones to lessen distractions and help promote calm
- Encourage parents on the usefulness and effectiveness of mathematical games and applications. Suggesting educational websites such as BBCkids to practice certain concepts at home
- Encourage peer-to-peer collaboration and exploration of concepts online through platforms such as Google Docs

Furthermore, in terms of broader recommendations it is suggested that teachers, both in pre-service and in-service programs, receive professional training on the effective applications of technology and develop pedagogical understanding of its uses. They must see technology as a tool that enhances student learning, allowing students to explore, collaborate and engage with material to process and understand content knowledge. They must be trained to utilize technology in a way that fosters communicative learning, based on problem solving, critical analysis, sharing of perspectives with appropriate teacher-led and student-centered

Areas for Further Study

This topic is one that deserves further attention. This study provides insight into teacher’s perceptions of the effectiveness of technology on students in the mathematics classroom. However, to gain an enhanced understanding of its value in the mathematics classroom, a study focused on the students’ perceptions and attitudes towards the integration of technology in the mathematics classroom would be important. Investigating student perceptions of technology will further provide constructive insights into its usefulness and impact on student math anxiety.

Furthermore, while everyone in this study had access to technology it is important to be aware that not all communities, schools and families have similar levels of access. Choosing
such a specific sample may have left this study limited in scope and might not be generalizable to the society at large. Therefore, further studies focusing on different communities and schools, and their integration of technology into the math classroom are recommended.

Lastly, more research could also be done on teachers and their level of comfort engaging with technology. Seeing as all three participants of this study enjoyed and felt comfortable engaging with technology, it would be interesting to compare their responses to others who may have a different view on the subject. The question, *does a teachers’ perception of technology affect the way they use technology in their classrooms?* Is a question worth exploring.
REFERENCES


Appendix A: Interview Questions

Hi my name is Ameena Hak. I am a Master’s of Teaching candidate at the University of Toronto. I’d like to start off by thanking you for participating in the interview today. The data collected in this interview will contribute to my Masters of Teaching Research Paper which is a requirement for completing my teaching degree. I would like you to know that what is said here today including your answers, specific examples and or any personal identifiers will be kept confidential. The information used will be generalized in my writing to specifically conceal the identities of the participants involved.

The topic we are going to discuss today is math anxiety and how teachers use technology in the classroom to support student learning and alleviate math anxiety. The purpose of this interview is to talk about your experiences with this issue and get an understanding of your perspective on the topic. I will use the responses provided to study this phenomenon, inform my understanding and support my thesis. I have 16 set questions that I would like to ask you and they will take approximately 1 hour. I want you to feel comfortable. So if at any point you feel uncertain about what I am asking, you need clarification or if you would like to pass a particular question, please feel free to let me know and I will be more than happy to comply. I would also like to record this interview; do I have your consent to do so? Before we get started do you have any questions for me?

Background Information:

1. How many years have you been teaching math?
2. Tell me about how you became a math teacher?
Personal experience with math anxiety:

3. In your opinion, how would you define “math anxiety”? (Fear of math, stress related to numbers etc.)

4. Have you had experience teaching students who suffer from math anxiety? What were some of the signs that these students were suffering from math anxiety?
   a. If yes, in what ways does math anxiety affect the students and their learning? Can you give me an example?

5. From your time in the classroom as a mathematics teacher what factors do you think lead to math anxiety in students?

6. As a practicing math teacher, what do you do in your classroom to alleviate math anxiety?

Technology - General

7. In your opinion how can technology be used to support math learning within the classroom?

8. From your observations, what effects does the use of technology have on your students in terms of learning and engagement?

9. Can you describe some advantages of the use of technology in your math classroom?

10. Can you describe some disadvantages of the use of technology in your math classroom?

Technology and Math Anxiety:

11. Can you describe how you’ve used technology in your classroom, specifically to support students with math anxiety?
12. From the ones you have just described, what is the best strategy for you and your students and why?

13. How do you typically assess the effectiveness of these strategies?

14. Can you tell me about 1 or 2 resources (e.g., websites, software programs, tools) that you have used to support your classroom instruction that has been beneficial to math anxious students?

Future Prospects:

15. If you could give one piece of advice to other teachers looking to help math anxious students in the classroom, what would it be?

16. Do you have anything else you would like to share?
Appendix B: Letter of Consent for Interview

Date: ___________________

Dear ___________________,

I am a graduate student at OISE, University of Toronto, and am currently enrolled as a Master of Teaching candidate. For the purpose of investigating an educational topic as a major assignment for our program, I have chosen to focus on exploring the technological strategies used by educators to support mathematics learning within elementary classrooms. More specifically I am examining teachers’ opinions about the effectiveness of particular ICT-based strategies for supporting students suffering from math anxiety. I think that your knowledge and experience will provide great insights into this topic.

I am writing a report on this study as a requirement of the Master of Teaching Program. My course instructor who is providing support for the process this year is Dr. Kimberley McKinnon. My research supervisor is Dr. Cathy Marks-Krpan. The purpose of this requirement is to allow us to become familiar with a variety of ways to do research. My data collection consists of a 40 minute interview that will be tape-recorded. I would be grateful if you would allow me to interview you at a place and time convenient to you. I can conduct the interview at your office or workplace, in a public place, or anywhere else that you might prefer.

The contents of this interview will be used for my assignment, which will include a final paper, as well as informal presentations to my classmates and/or potentially at a conference or publication. I will not use your name or anything else that might identify you in my written work, oral presentations, or publications. This information remains confidential. The only people who will have access to my assignment work will be my research supervisor and my course instructor. You are free to change your mind at any time, and to withdraw even after you have consented to participate. You may decline to answer any specific questions. I will destroy the tape recording after the paper has been presented and/or published which may take up to five years after the data has been collected. There are no known risks or benefits to you for assisting in the project, and I will share with you a copy of my notes to ensure accuracy.

Please sign the attached form, if you agree to be interviewed. The second copy is for your records. Thank you very much for your help.

Yours sincerely,

Ameena Hak
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 at any time without penalty.

I have read the letter provided to me by _________________________(Ameena Hak) and agree to participate in an interview for the purposes described.

Signature: ______________________________________

Name (printed): ___________________________________

Date: ___________________________